Processes Influencing the Successful Adoption of New Technologies by Smallholders

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Abstract

Many studies have examined the particular farm-level factors affecting the adoption of new technologies by smallholders. Using an 'actor-oriented perspective', this paper focuses on the larger processes at work in the development, dissemination and adoption of improved technologies. Three case studies of upland soil conservation projects in the Philippines are used to illustrate the argument that successful adoption depends on more than careful planning in research and the use of appropriate methodologies in extension. It depends on the timely formation of coalitions of key actors whose interests converge sufficiently that they can focus their resources and efforts on achieving change in agricultural systems. It also depends on critical external factors that are largely unpredictable. Newer approaches such as 'participatory technology development' are based on an appreciation of the evolving, adaptive and inherently participative nature of agricultural development processes. However, a broader, more flexible approach is needed which gives explicit recognition to the personal, cultural and political dimensions of coalition-building for technology development.

AN UNDERSTANDING of the processes leading to the adoption of new technologies by smallholders has long been seen as important to the planning and implementation of successful research and extension programs. This paper draws on observations and experiences gained during the SEARCA-UQ Uplands Research Project (ACIAR Project 9211), which used surveys, case studies, participatory appraisal techniques, and bio-economic modelling to investigate the factors affecting the adoption of recommended soil conservation technologies by upland farmers in various locations in the Philippines (Cramb in press). The principal technologies encountered in the field were variants of Sloping Agricultural Land Technology (SALT) (Partap and Watson 1994), involving the cultivation of annual crops such as maize in alleys between contour hedgerows, usually of multipurpose shrub legumes such as *Leucaena* and *Gliricidia.* The principal means of promoting these technologies was the Integrated Social Forestry Program (ISFP) of the Department of Environment and Natural Resources (DENR), the agency which has jurisdiction over the extensive Public Forest Lands where most upland farming occurs.

At one level, that of the individual farm household, the results of the SEARCA-UQ project were unsurprising. A number of farm-household factors were associated with adoption, such as the age, education, and personal characteristics of the household head; the size, location and tenure status of the farm; the availability of cash or credit for farm investment; access to urban markets; and so on (Cramb and Nelson 1998; Cramb et al. 1999; see also Garcia 1997; Pandey and Lapar 1998). However, at the village level and beyond, more interesting and significant issues arose: Why was there widespread adoption in one village but not others in the same general location? Why did one project lead to apparently successful adoption, but another, following the same procedures and promoting the same technologies, result in failure? Answers to these questions are likely to be more useful in achieving widespread agricultural development, particularly in what have been termed the 'complex, diverse and risk-prone' farming systems of the uplands.

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The approach taken in this paper is to focus on these higher-order factors affecting successful adoption of technologies. Drawing on the 'actor-oriented perspective' in rural sociology (Long and Long 1992), it is argued that successful examples of adoption at this higher level are not merely a function of the technology, nor of the research and extension methodology, but result from a complex conjunction of people and events, with outcomes which may have been quite unanticipated at the outset. From this perspective, research and extension projects and programs are viewed as arenas in which social actors – village leaders, farmers, researchers (local and international), aid officials, municipal agents, extension workers, traders, etc – each pursuing their own short- and long-term objectives and strategies, manoeuvre, negotiate, organise, cooperate, participate, coerce, obstruct, form coalitions, adopt, adapt, reject, all within a specific geographical and historical context.[1] Out of this process, improved technology *may* be developed, disseminated, and incorporated in farming systems, and many of the actors *may* be made better off as a result (farmers may earn more income or gain more prestige, landowners may conserve their soil, extension agents may be rewarded, researchers may be applauded, published, even promoted, traders may do more business, mayors may be re-elected, aid officials may achieve their targets). However, there is nothing predetermined about this outcome. Hence a detailed, 'all things considered', case history approach is needed to understand and explain the patterns of success in achieving beneficial technical change.

The paper aims to illustrate the fruitfulness of this approach with three case studies undertaken during the SEARCA-UQ Project. The case studies all relate to village-level upland development projects which had been previously identified as 'successful' in terms of farmer adoption of a variant of SALT or other conservation measures. The projects were located at Domang, Nueva Vizcaya, in Northern Luzon; Guba, Cebu, in the Visayas; and Managok, Bukidnon, in Mindanao.

Before proceeding to the case studies, however, it is useful to review briefly the way we think about the development, dissemination, and adoption of agricultural technologies, from an actor-oriented perspective. This review highlights some important themes which help in the interpretation of the case studies, and hopefully of other experiences reported in this volume.

[1]In this sense, research and extension interventions have always been 'participatory'.

Rethinking the Development, Dissemination and Adoption of Agricultural Technologies

(a) Technology development

In the conventional or 'central source' view of agricultural research and development, technology emanates from 'upstream' activities in the formal research system and is adapted by 'downstream' research until it is ready for dissemination to farmers (Biggs and Clay 1981; Biggs 1990). Anderson and Hardaker (1979) use an analogy from home economics rather than hydrology, speaking of quarter-baked (notional), half-baked (preliminary) and fully-baked (developed) technology. In a similar fashion, Scherr and Muller (1991) refer to the development of agroforestry technologies in terms of experimental, prototype and off-the-shelf technologies. All of these analogies imply a linear process of technology development and dissemination, culminating in the adoption of new technologies by farmers.

However, in practice, as Biggs (1990) demonstrates, agricultural innovations derive from multiple sources, not only from the laboratories and research stations of the national and international centres. These sources include research-minded farmers, innovative research practitioners at the local level, research-minded administrators, NGOs, private corporations, and extension agencies. In the 'multiple source' model 'technology is made up of many old and new components; it has evolved and been modified over time, and will continue to do so' (Biggs 1990:1487). Consequently, and in contrast to the notion of 'transfer of technology', there is no 'unambiguous, one-way progression in the research, extension and adoption process' (Biggs 1990:1481)

One implication of this perspective is that the process of technology adaptation cannot be separated from the process of technology adoption by farmers (discussed below). As Anderson (1993) notes, adoption and adaptation are intertwined in that adaptation of the technology frequently occurs in the process of implementing it on-farm – a phenomenon which Rogers (1995) terms 'reinvention'. Sumberg and Okali (1997) go further, arguing that such adaptation is the norm, resulting from an on-going process of 'farmer experimentation'. This experimentation is not confined to a few research-oriented farmers, but is the process by which almost all farmers incorporate technology into their farming systems. Technology supplied by the formal research and extension system thus becomes 'raw material' for farmer experimentation (Sumberg and Okali 1997). In terms of the above analogies, rather than acquiring a 'fully-baked' technology 'off-the-shelf', farmers can be viewed as shopping around for 'ingredients' or technological components which they incorporate into their own recipes. In other words, technology is only fully developed or adapted as part of a specific, operational farming system.

Thus, from an actor-oriented perspective, technology development is a complex, multi-stranded, and multi-directional process, involving many actors other than scientists in the formal research system. Moreover, as Biggs and Smith (1998) argue, the emergence of a particular technology depends not only on its scientific merits but on the actions of what they term 'development coalitions' – loose groupings of actors who combine their resources to push for a particular path of technical change. Hence, while it is appropriate to evaluate a given technology in itself, 'the result is a necessarily incomplete account of the requirements for 'successful' technology development and dissemination. In addition to good luck, the latter typically involves networking, advocacy, lobbying and other activities – here called coalition building – which are mainly excluded from conventional technology development narratives' (Biggs and Smith 1998:6). These authors cite the example of the wheat 'green revolution' in India, based on the highly risky importation of quantities of largely untested exotic wheat seed from Mexico. There was debate in the 1960s concerning the desirability of this approach, but a 'coalition of scientific, farmer, donor, administrator, and political actors who were committed to advocating and promoting a particular type of science and technology strategy, focused on dwarf wheats,' prevailed (Biggs and Smith 1998:5).

The complex pathway of technology development is evident in Harold Watson's first-hand account of the development of SALT, a long and involved process which began with the attempts of a church-based NGO to find practical solutions to farmers' problems in the remote uplands of Mindanao:

> Obviously, a farming technology that could conserve the topsoil and, if possible, improve its fertility and productivity was needed for these uplands [of Mindanao]. Recognising this problem, from 1971 the [Mindanao Baptist Rural Life Centre] started to conceptualise a system now known as Sloping Agricultural Land Technology, or SALT. After testing different intercropping schemes and observing *Leucaena*-based farming systems, both in Hawaii and at the Centre, efforts to develop the first-ever SALT prototype model commenced in 1978 … By 1980, MBRLC had acquired the confidence that SALT could fulfil the objectives adequately. But, it took about four more years of testing and refining before SALT could be heralded as 'applicable'(Partap and Watson 1994:29,30).

Partap and Watson go on to acknowledge that the technology has been further modified and adapted to suit individual farmers' conditions; in fact, they state that 'on-farm experimentation with SALT is an essential element' (Partap and Watson 1994:91). The subsequent promotion of SALT throughout the Philippine uplands by DENR and other agencies can be seen as resulting from a loose but effective coalition of actors, including university scientists, DENR officials, international and local NGOs, and public and private donor agencies. The factors leading to the success of this coalition warrant further study.

(b) Technology dissemination

Conventional extension theory, based on the central source model of technology development and diffusion, examines the role of various organisational arrangements and communication techniques in persuading farmers to adopt a recommended technology (Van den Ban and Hawkins 1996). The Training and Visit System, promoted extensively (and expensively!) by the World Bank in the 1970s and 1980s, exemplifies this approach (Antholt 1998). The 'transfer of technology' view of extension has been superseded (in the literature, if not widely in practice) by more participatory, community-based methodologies, reflected in the currently fashionable approaches of Participatory Rural Appraisal (PRA), Farmer Participatory Research (FPR) or, more generally, Participatory Learning and Action (PLA) (Chambers et al. 1989; Okali et al. 1994; Scoones and Thompson 1994; Chambers 1997).

Such participatory methodologies have now been incorporated in development agency manuals and training courses world-wide. Biggs and Smith (1998) quote a recent set of guidelines for watershed development produced by the Ministry of Rural Development in India: '[Project staff] need to be trained in the tools and techniques of project management, Participatory Rural Appraisal (PRA) methods, community organisation and other administrative and accounting procedures'. Such statements hint at the rigid, top-down enforcement of 'participatory' procedures. The DENR has also incorporated such community participation techniques into its official procedures for the ISFP (Gerrits 1996). While institutional endorsement of innovative participatory approaches is to be welcomed, there is a concern that a preoccupation with methods (described as a 'manual mentality') and, in particular, their institutionalisation within both government and non-government agencies, will lead to unrealistic expectations of their general efficacy and distract attention from the complex requirements for successful research and extension projects (Biggs and Smith 1998).

Tendler (1993) examined a dozen success stories in agricultural research and extension in poverty-stricken Northeast Brazil. She found that success was not well correlated with adherence to 'best practice' with regard to, for example, an emphasis on client-oriented, participatory research, or close coordination between research and extension institutions. Agencies which had not been performing well, and which subsequently lapsed into poor performance, were typically galvanised into effective action by a particular set of circumstances, including a strong demand from farmers or local development agencies for a solution to a particular problem (such as a pest outbreak) within a limited time frame. Other elements in the success stories were that 'localised credit subsidies played a surprisingly important role in bringing about rapid and widespread adoption by small farmers in a short period of time' and that 'municipal-level actors and institutions played important roles … unexpected because they were not included in the project design' (Tendler 1993:1577). However, notwithstanding this apparent support for decentralisation, Tendler notes that 'standing behind each strong local actor was a more centralised government agency – offering financial incentives, talking up the desired new approaches, providing technical assistance, rewarding the good performers and keeping funds away from the bad ones' (Tendler 1993:1577).

These observations fit well within an actor-oriented framework. As Long and Van der Ploeg (1989) argue, rural development interventions, such as agricultural extension projects, involve a variety of social actors, with diverse histories and agendas, from both within and beyond rural communities. Hence a project intervention needs to be recognised as part of 'an ongoing, socially-constructed and negotiated process, not simply the execution of an already-specified plan of action with expected outcomes' (Long and Van der Ploeg 1989:228). Moreover, as Biggs emphasises, 'all technology generation and promotional activities take place in a historically defined political, economic, agroclimatic, and institutional context' (Biggs 1990:1487). The influence of these contextual factors may be crucial in determining the outcome of a particular extension project.

Thus, for example, in evaluating the role of participatory technology development in the Forages for Smallholders Project in Malitbog, Bukidnon, in Mindanao, it is important to consider the role of local and extra-local actors such as a progressive (cattle-owning) mayor, an entrepreneurial farmer and village leader, an experienced and well-regarded extension worker, and visiting national and international scientists, as well as the apparently decisive influence of other development initiatives, notably various livestock dispersal programs which are contingent on the establishment of forage plots.

(c) Technology adoption

Conventional research into farmer adoption of new technology explains the adoption-decision and its timing (early or late) primarily in terms of the decision maker's perceptions and inherent characteristics, with 'innovators' at one extreme and 'laggards' at the other (Rogers 1995). However, farmer decision-making is generally more complex than this implies. As Scherr (1995) emphasises, farmers have multiple objectives (including food security, adequate cash income, a secure asset or resource base, social security) and select 'livelihood strategies' to pursue these objectives with the resources available to them (Ellis 1997). Both the objectives and the available resources vary between farmers and change over the life-cycle of the farm household (e.g. some farmers at some times may rely on off-farm work as a major source of livelihood, restricting their capacity to invest in labour-intensive conservation measures). Thus farmers in the same environment may have different objectives and livelihood strategies, and so respond differently to a given technology. Hence, Biot et al. (1995:24) suggest that 'different behaviour [with respect to soil conservation] may be as much a function of different opportunities and constraints as of different perceptions'.

The conventional adoption framework further simplifies the analysis of the adoption-decision by its implicit assumption of an individual 'decision-maker'. Within the farm household, the ability to make decisions regarding resource use and technology varies according to age, gender, and other categories, and actual decisions can depend on a complex bargaining process among household members (Ellis 1993, ch. 9; Jackson 1995; Biot et al. 1995). Beyond the household, group processes and the ability to harness them can play a crucial role in adoption decisions, particularly with regard to conservation practices (Chamala and Mortiss 1990; Frank and Chamala 1992; Pretty and Shah 1994; Chamala and Keith 1995). Moreover, decisions about new technology are frequently prompted by an intervention of some sort, typically in the form of a project. As discussed above, such interventions draw farmers into a wider arena in which various social actors are pursuing their personal and institutional strategies. Hence the outcomes in terms of adoption decisions will be highly contingent on the interplay between these actors, including such factors as the creation of a sense of obligation to a respected extension worker, or the development of conflict between contending factions within a community.

Thus an actor-oriented perspective leads us to expect a range of responses to the promotion of an agricultural technology such as SALT, not merely a clear-cut decision to adopt or not. Differences between the environment in which the technology was developed and the environment of the 'target' community will prompt farmers to adapt the technology in the process of adopting it. Differences within a given community in farmers' goals and circumstances, hence livelihood strategies, and the complexity of intra-household, group, and project interactions and decision-making, will result in a variety of adoption-adaptation behaviours, which should be investigated on their own terms and not pre-judged by labelling them as 'poor adoption' or 'non-adoption'.

Three Case Studies

(a) The Domang story[2]

Domang is a sub-village or hamlet (*sitio*) of 87 households located in Kasibu Municipality in the northeast of the province of Nueva Vizcaya in northern Luzon. Rainfall in the uplands of Nueva Vizcaya averages about 2400 mm and occurs throughout the year, with a somewhat drier period between December and March. Regular typhoons result in intense rainfall events. Sitio Domang occupies about 200 ha on a ridge descending from Mt Gusing (1455 m), at elevations ranging from 50 to 1000 masl. The topography is heavily dissected and gently to steeply sloping, with dominant slopes between 30% and 50%. Soils are predominantly acidic clay-loams and erosion is moderate to severe.

The population density is relatively low at around 50 persons per sq. km; hence, the mean farm size is close to 4 ha and tenancy as such is non-existent. Domang is only moderately accessible, requiring a journey on foot or carabao of up to an hour to reach a roadhead where jeepneys can provide transport to market towns. Market access has improved since Domang was settled in the 1970s and the farming system now includes both subsistence and commercial crops – rainfed bunded rice on terraced land, upland rice, maize, a variety of vegetable and field crops (beans, tomato, ginger, taro, etc.), and banana and other fruit crops.

The Domang area is Public Forest Land and was logged commercially in the 1950s and 1960s. Ifugao and other migrants from the Central Cordillera began arriving from the early 1970s, practicing shifting cultivation of upland rice in the logged-over lands. In the mid-1970s, the community came into conflict with officers of the then Bureau of Forest Development, who charged the settlers with illegal occupation and sought forcefully to evict them. Six members were arrested and others took refuge in surrounding areas, until the local mayor intervened on their behalf. In the early 1980s, the community had to contest several claims to the land and repeatedly sought to have the land reclassified as Alienable and Disposable, with full titles issued. However, a presidential decree in 1984 prevented any further release of Public Forest Lands in the province.

A local forester advised the community to apply for inclusion in the government's Integrated Social Forestry Program, enabling them to be issued with Certificate of Stewardship Contracts (CSCs), a conditional 25-year lease of Public Forest Land requiring farmers to establish agroforestry measures for soil conservation. A minority faction opposed this move as it undermined their campaign for full title to the land. Nevertheless, Domang became an ISF project site, and by 1986 CSCs for 179 ha were issued to 64 residents.

Extension activity under the ISF began in 1986 – a nursery was established and training was conducted in SALT and other conservation farming practices. However, there was little or no adoption until 1990 when the site was selected as a Model Site. This involved higher levels of funding and extension support – an energetic and well-regarded extension worker visited frequently, staying at the site for up to three days per week, and farmers were paid P6 per metre of hedgerows established. One participant's farm was used as a demonstration farm and training site. By 1991 the majority of residents had adopted contour hedgerows. After this, a change in policy meant that ISF projects no longer paid farmers to plant hedgerows.

The project recommended using *Leucaena leucocephala* and *Gliricidia sepium* as hedgerow species. Inadequate local supplies of planting materials forced farmers to approach lowland farmers for cuttings, but they met with resistance because lowland farmers were using their limited stocks as a source of fuelwood and wood for fencing. Also, they disliked the fact that the ISF participants were using the cuttings for hedgerow development and receiving a monetary incentive to establish them. The limited availability of planting material for the recommended species induced farmers to look for alternatives. They adopted *Hibiscus* sp. (*gumamela*) as the major hedgerow species and, to a lesser extent, banana. Hibiscus was locally available as it was commonly used as an ornamental plant around homes as well as around the school. The use of hibiscus as a hedgerow species resulted from the experimentation of one of the early adopters and the encouragement of the ISF extension worker. Cuttings struck easily and quickly when planted in

[2]This section draws on results of a survey conducted in May 1996 which are reported in more detail in Garcia et al. 1996.

moist soil. Nonetheless, the supply of planting materials was still limited and farmers were expected to use in-fill planting to increase plant density within the hedgerow once the first cuttings had become established.

The Domang ISF site was devolved to the local government in 1993, after which extension activity practically ceased. However, at the time of the SEARCA-UQ survey in 1996, there were 78 adopter-households or 90% of the Domang population. Non-adopters included those (dubbed *pilosopo* or 'recalcitrants') who had refused to join the ISF project on principle. Hedgerows were being maintained but there was no expansion onto additional land. The alleys were being used for maize, upland rice, and a range of commercial vegetable and field crops. Diffusion beyond the village was almost non-existent and where adoption did occur it was not well implemented due to poor understanding of the principles and techniques involved. It should be noted that bunded rice terraces (an indigenous technology for the Ifugao members of the village population) were being constructed before the project began and continued to be developed at the time of the survey.

Successful adoption of contour hedgerows in Domang occurred due to a set of circumstances at a particular juncture – the dependence on CSCs for tenure security (after a decade or more of harassment and threat of eviction), the allocation of an energetic extension worker on almost a full-time basis for a concentrated period, and the payment of a subsidy for hedgerow establishment. This combination of circumstances induced rapid and widespread adoption within the community. Farmer experimentation helped resolve the problem of shortage of preferred planting materials, resulting in successful adaptation of the recommended technology. The impetus given by these circumstances appeared to be sufficient to get farmers to the point where they were prepared to maintain the hedgerows, indicating 'genuine' adoption. Thus the ISFP, generally regarded as an unsuccessful program, was galvanised into making a brief but significant impact in this location (consistent with Tendler's [1993] findings in Northeast Brazil). However, once the conditions which gave rise to the initial wave of adoption ceased to exist, the wider 'diffusion' of the technology did not occur.

(b) The Managok story[3]

Barangay Managok is a village located in Malaybalay Municipality in the centre of Bukidnon Province in Northern Mindanao. The annual rainfall of 2500 mm is fairly evenly distributed throughout the year, apart from a relatively dry period from December to March. The village occupies 1872 ha at elevations ranging from 400 to 1000 masl. The area encompasses a narrow plain lying between two ranges of hilly to mountainous terrain with slopes of 10% to 70%. The soils are predominantly acidic clays showing moderate to severe erosion.

The population density of the upland *sitio* of Managok is around 100 persons per sq. km (twice that of Domang). The population comprises *dumagat* or immigrant groups (75%) and *lumad* or indigenous groups, namely the Tala'andig and Manobo (25%). The opening of the upland areas to in-migration through logging resulted in rapid population growth in the late 1970s and early 1980s. Most of the land in Managok is Alienable and Disposable, though in the uplands farmers typically have no formal title and 30% of farmers are share-tenants or mortgagees. Farm size averages 2.9 ha. Farmers have moderate access to markets; the Managok township is 14 km by gravel road from the main north-south highway through Bukidnon, and 24 km from Malaybalay, the provincial capital. Smaller feeder roads provide access to upland *sitio*, and farmers use carabao and horses to transport produce to the road.

The farming system in the uplands is based on two crops of maize per year, which is both the staple crop and the main source of cash income. In addition, farmers cultivate vegetables, field crops and tubers, perennial cash crops, and fruit and forest trees. Livestock are raised for draught, transport and sale. Erosion control measures used by some farmers (apart from the introduced measures discussed below) include cultivating and planting across the slope, piling of stover in furrows across the slope, strip planting, tree planting, placing debris in gullies, and construction of rock walls.

At Managok, an Integrated Social Forestry Project (ISFP) of the DENR began in 1983 and the MUSUAN project was implemented by a team from Central Mindanao University (CMU) and Xavier University between 1988 and 1992. Initially, DENR activities were limited to surveying farms, issuing CSCs, and conducting lectures on the conditions attached to the CSCs and on recommended technologies for farming the uplands, principally SALT. By the time the MUSUAN project began, the DENR had issued CSCs to 106 farmers, 10% of whom had planted *Gmelina arborea* on their land, but none had adopted SALT.

The MUSUAN project was implemented in four sites in Bukidnon Province with funding from the Ford Foundation (US$200 000). A consultant from the College of Forestry, University of the Philippines,

[3]This section draws on results of a survey conducted in August-September 1994 which are reported in more detail in Garcia et al., 1995.

Los Baños, who helped prepare the MUSUAN proposal to the Ford Foundation, recommended the use of ISFP sites for the project. With the help of local DENR staff a short-list of possible sites was identified, including Managok. The project initially intended to focus on one *sitio* in Managok where slopes were steep and farming was more intensive. However, a desire to include more *lumad* farmers saw expansion of the project to include two more remote *sitio* where shifting cultivation was still practised.

Recommended technologies were derived from the Mindanao Baptist Rural Life Centre (MBRLC) in Davao del Sur and the Mag-uugmad Foundation Inc. (MFI) in Cebu (see below), and were collectively labeled Slopeland Technologies for Agroforestry Resources (STAR). These included contour hedgerows (SALT), contour canals, contour rock walls, and bench terraces. Various combinations of these technologies were presented as packages for selection and adoption by farmers. Most opted for contour hedgerows and cultivation of fruit and timber trees.

The recommended hedgerow species were forage tree legumes such as *Leucaena leucocephala*, *Leucaena diversifolia*, *Flemingia macrophylla*, *Desmodium cinerea* (= *D. rensonii*), *Gliricidia sepium*, *Bauhinia monandra*, and the forage grasses, napier grass (*Pennisetum purpureum*) and guinea grass (*Panicum maximum*). However, in practice, wild sunflower (*Tithonia diversifolia*), a common weed on fallowed lands and roadsides, was the major hedgerow species used. Its use developed fortuitously. Farmers first used sunflower cuttings as stakes to mark the contour along which recommended hedgerow species (especially *Flemingia* and *Desmodium*) were planted. Hedgerow establishment failed but the sunflower cuttings struck and formed hedgerows themselves. This then became the recommended practice.

Preliminary project activities included construction of the nursery site, introduction of the project, and selection of lead farmers. Initially there were 22 lead farmers of whom 10 were *dumagat* and 12 *lumad*. Lead farmers attended various seminars and workshops and were taken on three cross-farm visits, including one to the MBRLC in Davao del Sur and one to the MFI in Cebu. Once the lead farmer had selected a technology package, the farmer and the MUSUAN team prepared individual farm plans and a schedule for implementation. In addition, the team assisted lead farmers (and subsequent adopters) with field implementation of contour hedgerows, provided planting material for hedgerows and fruit and forest trees, and distributed limited quantities of production inputs such as maize and vegetable seed.

Once lead farmers had successfully established contour hedgerows on their own landholdings, they were encouraged to act as extension agents and were provided with a monetary incentive for successful establishment of contour hedgerows on other farmers' land. Farmers who had not adopted the technology would be approached by MUSUAN staff and/or lead farmers. If the farmer agreed, MUSUAN staff, the lead farmer, and the farmer concerned would establish contour hedgerows on the farm. Some farmers commented during the survey that they had limited knowledge of the hedgerow technology because the lead farmers took responsibility for implementing it. Farmers were initially organised into small labour-exchange groups of three farmers with adjacent lots to facilitate layout and establishment of contour hedgerows, but these dispersed after an initial learning period. Farmers cited differences in their work habits as reasons for disbanding the groups.

The DENR continued to provide funding during the MUSUAN project, for lead farmers to participate in the cross-farm visit to Cebu, for construction of an access trail and a reservoir, and for extension of the nursery. DENR staff also assisted in seedling production and extension of the technology. Between 1989 and 1991, it was DENR policy to provide ISF project participants with a subsidy for the establishment of conservation measures (P6 per metre of double-row hedgerows and P2 per metre of single-row hedgerows). However, the MUSUAN project opposed these payments, citing the detrimental effects of providing monetary incentives to farmers. Farmers claimed they signed papers acknowledging receipt of payment but never actually received any funds. Moreover, confusion regarding the ownership of most of the land over which CSCs had been issued resulted in their cancellation in November 1993, though few farmers surrendered their documents.[4] The DENR simultaneously transferred the status of Model Site to another barangay.

By the end of the MUSUAN project in 1992, 60 farmers were reported to have implemented contour hedgerows throughout their maize farms. However, at the time of the survey in 1994 there were only 47 adopters (several farmers indicated that hedgerows had been ploughed in or abandoned after the project ceased to operate). This represented 20%–40% of upland households within the project's target area; there was little adoption in the more remote and

[4]It was discovered that an area of 200 ha for which CSCs had been issued had been reserved for an agricultural school and in fact belonged to CMU. The affected farmers have an informal agreement with CMU allowing them to remain on the site, but legally they are deemed to be squatters.

extensively farmed *sitio* where *lumad* farmers predominated, and there was no evidence of wider diffusion. Farmers' stated reasons for adopting the technologies included increasing yields, supply of forage, and control of erosion. Non-adoption was explained in terms of farmers' lack of interest, lack of planting material (in the case of leguminous hedgerows) and lack of land ownership (i.e. tenancy). Farmers felt that access to extension, secure land ownership, and a sole dependence on upland holdings contributed to higher rates of adoption.

The MUSUAN project in Managok (and elsewhere in Bukidnon) was reported to be a successful example of a participatory approach giving rise to the development and adoption of a new package of agroforestry technologies (STAR). An actor-oriented perspective helps account for this success, beyond merely attributing it to 'best-practice' methodology and technology. At the same time, this perspective highlights the limited prospects for ongoing adoption. The impetus for the project came from a coalition of university scientists (including the UPLB consultant), local DENR staff, and the Ford Foundation. The interests and backgrounds of the actors in this coalition accounted for the emphasis of the project on participation (including the attempts to involve *lumad* farmers) and agroforestry (which was seen to be scientifically acceptable, in line with DENR's mandate for Public Forest Lands, and supported by an established NGO network). In reality, the STAR package was a repackaging of existing technologies, principally SALT, and thus, in Biggs's (1990) terms, was an example of the generation of 'new' technologies through 'labeling'. Serious problems with hedgerow establishment, which may have been fatal for the project, were forestalled by the fortuitous discovery of *Tithonia* hedgerows – the one distinctive element in STAR. Notwithstanding the participatory rhetoric, the workshops to identify lead farmers and get them to choose their preferred technologies, and the formation of farmer groups to implement the technologies, the project involved strong elements of the 'transfer of technology' approach, with project staff and lead farmers actively persuading other farmers to 'adopt' and taking a major role in the establishment of contour hedgerows on their farms. This activist approach proved quite successful, even in the absence of DENR subsidies, but in the end only a minority of farmers responded – excluding most *lumad* and tenant farmers – and the prospects for diffusion (or even maintenance) were not good. Confusion over the tenure status of much of the land led to conflict between the DENR and many project farmers, the cancellation of CSCs, and the loss of Model Site status. This, combined with the inability of CMU to gain further funding for the project, meant that extension activities at Managok lapsed.

(c) The Guba story[5]

The project site considered in this case includes Barangay Guba and nine other upland *barangay* (villages) in the hinterland of Cebu City. Together these *barangay* occupy an area of 78 km^2 on the island of Cebu in the Central Visayas Region. Annual rainfall is 1600–1800 mm, with no distinct dry season. The site is 200–600 m above sea level and the terrain ranges from rolling to very steep. Soils are heterogeneous but primarily acidic, heavy clay-loams with slight to severe erodibility and susceptibility to water-logging. The area is about 25 km northwest of Cebu City centre and can be accessed by a network of gravel roads.

The population density in 1990 was 239 persons per sq. km, considerably higher than at Domang or Managok. Average farm size is 1 ha with a range of 0.25 to 2 ha. Lands in the project area are a mixture of Alienable and Disposable Lands and Public Forest Lands. Most land is privately owned (with or without a formal title). However, about 30% of farmers rent part or all of their land under a share-cropping arrangement. Most of these have stable, long-term tenancy agreements with local or absentee landlords.

In the early 1980s, the farming system was dominated by the cultivation of maize for subsistence and the production of perennials (mango and banana) and livestock (cattle, goats, pigs and chickens) for sale. There were two croppings of maize per year. The increasing accessibility of the site has seen farmers restrict maize cultivation to the first cropping and utilise the second cropping period for the cultivation of vegetables and flowers. Some are planting vegetables in both seasons and purchasing most of their maize requirements.

In 1981, an expatriate staff member of World Neighbours, an international NGO focusing on rural community development, approached officials from the Department of Agrarian Reform (DAR) and the Department of Environment and Natural Resources (DENR) for assistance in selecting upland sites which would benefit from a soil and water conservation program. Barangay Guba was one of those recommended. Preliminary meetings introduced World Neighbours and discussed farmers' problems and their underlying causes, i.e. loss of soil fertility due to soil erosion and lack of nutrient cycling. As a result of these discussions, the Cebu Soil and Water

[5]This section draws on results of a survey conducted in December 1996 which are reported in more detail in Gerrits et al. 1997. See also Cramb et al., in press.

Conservation Program (CSWCP) was initiated. Funding for the CSWCP was initially provided by World Neighbours. Most of the on-going funding has come from World Neighbours and the Ford Foundation, as well as from training programs and consultancies. In 1988 participants in the CSWCP and a related coastal development program combined to form the Mag-uugmad Foundation Inc. (MFI), *mag-uugmad* being a Cebuano term for tiller, farmer, or an advocate for change or development. In 1989, the MFI established a training centre at Guba and, largely as a result, it continues to have an active presence at the site.

CSWCP activities in Guba focused on the introduction of soil conservation technologies which had been implemented in World Neighbours projects elsewhere. Contour canals, contour bunds and contour hedgerows were the main soil conservation technologies promoted. Using the A-frame, farmers identified and marked contour lines at regular intervals down the slope. These were ploughed and the loosened soil removed and placed above the contour line thereby forming the contour canal and the contour bund. Next, grasses and leguminous shrubs were planted on the bund to form contour hedgerows. Initially most adopters planted napier grass (*Pennisetum purpureum*) hedgerows. The vigorous growth of napier grass led to its partial replacement with leguminous shrubs. Trimming of hedgerows was to occur every one to two months. Trimmings were to be fed to livestock or applied as a mulch to the alleys.

The method of extension of conservation technologies in Guba was based on the organisation of farmers into work groups (*alayon*) and the utilisation of successful adopters as part-time farmer instructors. Farmers interested in implementing soil and water conservation technologies on their farm organised or joined a work group which then worked on each of their farms in rotation. On each farm the owner and farmer instructor designed a suitable farm plan, and the latter then demonstrated how the technology should be implemented. Each group and its individual members initially received some material or financial support, which formed the basis of a revolving fund.

The process of adoption began in 1981 when a leading farmer at Guba formed a five-member *alayon* with his siblings to implement some of the conservation techniques promoted by World Neighbours. In 1982 the group expanded and established the new technologies on 23 farms. In 1983 increasing farmer interest led to the formation of three more groups. As farm development occurred, farmers in neighbouring *barangay* also enquired about the technologies. Maximum expansion of the project occurred during 1983 and 1984. The project supported 20 farmer-instructors in eight of the ten upland *barangay*. Each farmer-instructor managed three to four *alayon* groups. At the peak of the project there were over 70 *alayon* groups operating in the project area and over 1000 farmers had adopted the hedgerow technology. Thus the project became widely known as the most successful conservation farming project in the Philippines.

Adoption of contour bunds, canals, and hedgerows, and ploughing of the resultant alleys, resulted in rapid development of terraces. Once terraces had formed, contour canals were no longer necessary and consequently were not maintained. Terraces were used for maize and vegetable cultivation and, to a lesser extent, cut-flower production. The effects of hedgerow adoption and terrace development as reported by farmers were: reduced soil erosion, better maintenance of soil fertility, a consequent reduction in inorganic fertiliser requirements, crop diversification, increased crop production, a supply of fodder for livestock, and an overall increase in household welfare.

Following the end of the project in Guba and surrounding *barangay*, farmer-instructors no longer received wages and their activities correspondingly decreased. Similarly the activities of the *alayon* groups diminished, mainly because most, if not all of the *alayon* members had established the soil conservation measures on their farms. Farmers reported that the *alayon* groups had no further tasks to accomplish, although some continued to assist members in everyday farm operations.

Several problems relating to the on-going utilisation of the technologies (particularly contour hedgerows) had emerged at the time of the SEARCA-UQ survey in 1996. The development of contour canals and terraces resulted in greater retention of water on the field. In other contexts the resultant increase in soil moisture would be considered desirable because it extends the cropping season and reduces production risk. However, the project area had heavy clay soils. During the second cropping when rainfall was higher, greater retention of water resulted in water-logging problems throughout the area, particularly in Barangay Guba which had the heaviest soils. Some farmers dealt with the problem by constructing temporary drainage canals which were subsequently ploughed out. Other farmers suggested the need for permanent drainage canals. MFI staff were recommending the use of raised beds.

A more general issue was that, throughout the project area, hedgerow quality was observed to be in decline. Where hedgerows still existed, weed species were becoming dominant. In many farms hedgerows no longer existed and, while some terraces were stable, others were reverting to the natural slope.

Several fields appeared to be in long-term fallow or abandoned. The explanations offered by farmers were as follows:

(a) Hedgerows were difficult to maintain. This was because some hedgerow species were short-lived; hedgerows were adversely affected by two droughts (1987 and 1989); large ruminants were frequently tethered on the terraces during the dry season, often without the landowner's permission, resulting in overgrazing of the hedgerows and damage to the terraces; and hedgerows were difficult to re-establish once cogon grass (*Imperata cylindrica*) had taken hold.

(b) Some farmers felt that hedgerows no longer needed to be maintained once soil erosion had been controlled and the terraces had formed.

(c) At the peak of adoption, farmers established contour hedgerows over their entire farm. Later it was found that land was required for alternative purposes, e.g. tethering of livestock, and farmers consequently abandoned some of their hedgerows.

(d) In some cases land was left idle because of household labour shortages, old age, illness, death, or out-migration.

The widespread adoption of conservation technologies at Guba clearly demonstrates that project interventions need to promote appropriate technologies (those that address the farmers' needs directly) at the appropriate time (as determined by the stage of evolution of the farming system) and with the genuine participation of farmers (utilising farmer-instructors and small, close-knit working groups), though not necessarily of the whole community. That is, the 'right' technology and extension methodology are important. Success was also due to a number of site-specific factors, including good communications, close community interaction, stable land tenure, increasing accessibility and market linkages, and the evolution of the farming system towards new enterprises (Cramb et al. in press).

Within this context, however, successful adoption at Guba was ultimately due to the effectiveness of a coalition of actors, including staff from World Neighbours, DENR and the Ford Foundation, and leading farmers at Guba, coming together to address a pressing problem and focusing resources, ideas, and energy from within and beyond the community. The formation of the Mag-uugmad Foundation helped to keep this coalition in place, and extend it, as new technical and institutional problems and needs emerged. This does not mean that all emerging problems were being dealt with as rapidly or effectively as was the soil erosion and fertility problem in the 1980s, but the Guba story clearly indicates the long-term, evolving nature of farm technology problems, hence the need for on-going linkages if initial success with technology adoption and adaptation is to be sustained.

Conclusion

The successful development, dissemination and adoption of improved technologies for smallholders depends on more than careful planning of research and the use of appropriate methodologies in extension. It depends on the timely formation of coalitions of key actors – including key farmers as well as a range of key outsiders, researchers and others – whose interests *converge* sufficiently that they can focus their resources and efforts on achieving change in agricultural systems, if only locally and only for a period. As Biggs and Smith (1998:10) emphasise:

> The development coalition is a curious, opportunistic grouping, loosely constructed through friendship and other ties, reflecting both idealistic and self-interested impulses. It is pervasive enough to pass unnoticed but remains remarkably significant in affecting outcomes of development processes, as well as in influencing the way those processes and their histories are seen.

Successful adoption of technology also depends on critical external factors – climatic events, market fluctuations, the availability of subsidies for planting hedgerows, livestock dispersal programs, edicts on land tenure – which enhance (or undermine) the effectiveness of a development coalition in pursuit of its strategy. It also depends on a good deal of luck.

Recognising the role of diverse social actors, the coalitions they form, and the critical elements (many of them unique to a given context) conditioning their success, helps our understanding of the social dimension of technical change in agriculture, particularly from a historical perspective. Harnessing this understanding to enhance the process of future technical change is more problematic. Many of these factors fall outside the scope of conventional planning and management concepts and frameworks. Newer approaches, such as participatory technology development and particpatory monitoring and evaluation, while giving greater recognition to the evolving, adaptive, and inherently participative nature of agricultural development processes, can themselves become 'manualised', causing us to overlook the importance of personal, cultural, and political factors which may be crucial to success (Biggs 1997). A broader and more flexible approach is needed which gives explicit recognition to the role of development coalitions and to the personal, cultural, and political dimensions of coalition-building for technology development.

References

Anderson, J.R. 1993. The economics of new technology adaptation and adoption. Review of Marketing and Agricultural Economics, 61, 301–310.

Anderson, J.R. and Hardaker, J.B. 1979. Economic analysis in design of new technologies for small farmers. In: Valdes, A., Scobie, G.M. and Dillon, J.L. ed. Economics and the Design of Small-Farmer Technology. Ames, Iowa State University Press, 11–26.

Antholt, C.H. 1998. Agricultural extension in the twenty-first century. In: Eicher, C.K. and Staatz, J.M. ed. International Agricultural Development, 3rd Edition, Baltimore and London, Johns Hopkins University Press, 354–369.

Biggs, S.D. 1990. A multiple source of innovation model of agricultural research and technology promotion. World Development, 18, 1481–1499.

Biggs, S.D. 1997. Livelihood, coping and influencing strategies of rural development personnel. Project Appraisal, 12, 101–106.

Biggs, S.D. and Clay, E.J. 1981. Sources of innovation in agricultural technology. World Development, 9, 321–336.

Biggs, S.D. and Smith, G. 1998. Beyond methodologies: coalition-building for participatory technology development. World Development, 26, 239–248.

Biot, Y., Blaikie, P., Jackson, C. and Palmer-Jones, R. 1995. Rethinking Research on Land Degradation in Developing Countries. World Bank Discussion Papers 289, Washington DC, The World Bank.

Chamala, S. and Keith, K. ed. 1995. Participative Approaches for Landcare, Brisbane, Academic Press.

Chamala, S. and Mortiss, P. 1990. Working Together for Landcare: Group Management Skills and Strategies, Brisbane, Academic Press.

Chambers, R. 1997. Whose Reality Counts? Putting the First Last, London, Intermediate Technology Publications.

Chambers, R., Pacey, A. and Thrupp, L.A. ed. 1989. Farmer First: Farmer Innovation and Agricultural Research, London, Intermediate Technology Publications.

Cramb, R.A. in press. Conservation Farming Technologies for the Philippine Uplands: Socio-Economic Perspectives. ACIAR Monograph Series. Canberra, Australian Centre for International Agricultural Research.

Cramb, R.A., Garcia, J.N.M., Gerrits, R.V. and Saguiguit, G.C. 1999. Smallholder adoption of soil conservation technologies: Evidence from upland projects in the Philippines. Land Degradation and Development, 10, 405–423.

Cramb, R.A., Garcia, J.N.M., Gerrits, R.V. and Saguiguit, G.C. in press. Conservation farming projects in the Philippine uplands: Rhetoric and reality. World Development, 28.

Cramb, R.A. and Nelson, R.A. 1998. Investigating constraints to the adoption of recommended soil conservation technology in the Philippines. In: Penning de Vries, F.W.T., Agus, F. and Kerr, J. ed. Soil Erosion at Multiple Scales: Principles and Methods for Assessing Causes and Impacts, Wallingford, UK, CABI and IBSRAM, 99–120.

Ellis, F. 1993. Peasant Economics: Farm Households and Agrarian Development. 2nd Edition, Cambridge, Cambridge University Press.

Ellis, F. 1997. Household strategies and rural livelihood diversification. Paper presented at Annual Conference of Development Studies Association, University of East Anglia, Norwich, England, 11–13 September 1997.

Frank, B.R. and Chamala, S. 1992. Effectiveness of extension strategies. In: Lawrence, G., Vanclay, F. and Furze, B. ed. Agriculture, Environment and Society: Contemporary Issues for Australia, Melbourne, Macmillan, 122–140.

Garcia, J.N.M., Gerrits, R.V., Cramb, R.A. and Saguiguit, G.C. 1995. Soil Conservation in an Upland Farming System in Bukidnon: A Socio-Economic Survey, SEARCA-UQ Upland Research Project, Survey Report No. 3. Los Baños, Philippines.

Garcia, J.N.M., Gerrits, R.V., Cramb, R.A. and Saguiguit, G.C. 1996. Soil Conservation in an Upland Farming System in Nueva Vizcaya: A Socio-Economic Survey, SEARCA-UQ Upland Research Project, Survey Report No. 6. Los Baños, Philippines.

Garcia, Y.T. 1997. Analysis of Decision Models for Upland Soil Conservation in Argao, Cebu. PhD dissertation, University of the Philippines, Los Baños.

Gerrits, R.V. 1996. The Philippine Government's Approach to Upland Development: The Integrated Social Forestry Program, SEARCA-UQ Uplands Research Project, Working Paper No. 16. Los Baños, Philippines.

Gerrits, R.V., Garcia, J.N.M. and Cramb, R.A. 1997. Hedgerow Adoption in the Hinterland of Cebu City: A Reconnaissance Survey, SEARCA-UQ Uplands Research Project, Working Paper No. 20. Los Baños, Philippines.

Jackson, C. 1995. Environmental reproduction and gender in the Third World. In: Morse, S. and Stocking, M. ed. People and Environment, London, UCL Press, 109–130.

Long, N. and Long, A. ed. 1992. Battlefields of Knowledge: The Interlocking of Theory and Practice in Social Research and Development, London, Routledge.

Long, N. and Van der Ploeg, J.D. 1989. Demythologising planned intervention: An actor perspective. Sociologia Ruralis, 29, 226–249.

Okali, C., Sumberg, J. and Farrington, J. 1994. Farmer Participatory Research: Rhetoric and Reality, London, Intermediate Technology Publications.

Pandey, S. and Lapar, M.A.L. 1998. A microeconomic analysis of adoption of contour hedgerows in the Philippine uplands. In: Penning de Vries, F.W.T., Agus, F. and Kerr, J. ed. Soil Erosion at Multiple Scales: Principles and Methods for Assessing Causes and Impacts, Wallingford, UK, CABI and IBSRAM, 83–98.

Partap, T. and Watson, H.R. 1994. Sloping Agricultural Land Technology (SALT): A Regenerative Option for Sustainable Mountain Farming, ICIMOD Occasional Paper No. 23. Kathmandu, International Centre for Integrated Mountain Development.

Pretty, J.N. and Shah, P. 1994. Soil and Water Conservation in the Twentieth Century: A History of Coercion and Control. Research Series No. 1, Rural History Centre, University of Reading.

Rogers, E.M. 1995. The Diffusion of Innovations, 4th Edition, New York, Free Press.
Scherr, S.J. 1995. Economic factors in farmer adoption of agroforestry: patterns observed in Western Kenya. World Development, 23, 787–804.
Scherr, S.J. and Muller, E.U. 1991. Technology impact evaluation in agroforestry projects. Agroforestry Systems, 13, 235–257.
Scoones, I. and Thompson, J., ed. 1994. Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice, London, Intermediate Technology Publications
Sumberg, J. and Okali, C. 1997. Farmers' Experiments: Creating Local Knowledge, Boulder and London, Lynne Rienner.
Tendler, J. 1993. Tales of dissemination in small-farm agriculture: Lessons for institution builders. World Development, 21, 1567–1582.
Van den Ban, A.W. and Hawkins, H.S. 1996. Agricultural Extension. 2nd Edition, Oxford, Blackwell Science.

Participatory Approaches to Forage Technology Development with Smallholders in Southeast Asia

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Abstract

Conventional approaches to forage technology development have not resulted in substantial adoption of forage technologies by smallholder farmers in Southeast Asia. This paper describes alternative approaches which were developed and implemented by the Forages for Smallholders Project in four countries since 1995. The approaches resulted in a sounder understanding of farmers' perceptions of their problems and opportunities, greater adaptation and adoption of forage technologies than had been previously achieved and gave the project a much stronger bridge into poor farming communities. The challenge now is how to expand the benefits of locally-successful forage technologies to more people more quickly, whilst maintaining active farmer involvement in the expansion process.

THE PHYSICIST Niels Bohr once remarked 'There are only two real sciences – physics and stamp collecting'. His quip (and the elegant response of the Nobel Prize Committee in awarding him the Nobel Prize in Chemistry) has lessons today even for those of us working in agricultural research and development. As with Bohr's work on subatomic structure, where making a distinction between physics and chemistry was neither easy nor useful, unnecessary boundaries have existed between agricultural research and agricultural development which have hindered adoption of agricultural technologies by poor farmers in developing countries.

An example of this is the track record of forage research and development in Southeast Asia. Despite substantial research over the past 40 years, the impact of improved forage technologies on smallholder livestock systems has been generally negligible. Many of us who have been involved in this process have been asking 'Why?' and 'What can we do to improve adoption of promising forage technologies by smallholder farmers in future?' A common conclusion has been that the lack of linkages between technology development on research stations and technology adoption on farms has often resulted in research programs developing technologies that offered few if any solutions to the major problems that farmers faced. This paper describes some approaches that have been taken over the past five years to overcome this problem and the major lessons learned, not only for forage technology development in future, but for agricultural development in general.

Conventional Approaches to Forage Technology Development

'Forage technologies' are combinations of adapted forage varieties and ways of integrating them into farming systems that provide tangible benefits to

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farmers (see Gabunada Jr. et al. 2000, these Proceedings). The conventional approaches that were used to develop forage technologies were similar to those used in field crops. From interviews with key farmers, development workers (often researchers and extension workers) identified problems to research, developed technical solutions to these perceived problems on research stations and demonstrated these 'solutions' through well-supported model farmers, expecting that adoption would occur spontaneously from these carefully managed demonstrations (Figure 1). In most cases this approach, which had worked well with crops such as rice, resulted in poor adoption of forages. There appeared to be many reasons for this poor adoption, including:

- growing forages was a new concept for most farmers (unlike growing rice);
- the need for forages may not have been great in the areas selected for extension;
- forages provide longer-term benefits to farmers that are not as immediately obvious as, for example, the direct cash benefits of improved rice varieties;
- often, planting material of the promising forage varieties was not locally available;
- researchers were often developing feeding technologies based on concepts such as 'increased livestock productivity' and 'improved efficiency of utilisation of feed resources', where farmers decision-making was based on a much more complex set of constraints, opportunities and goals.

In 1995, AusAID provided funding for a new approach to address these limitations. The Forages for Smallholders Project (managed by Centro Internacional de Agricultura Tropical (CIAT) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Tropical Agriculture) worked:

- in seven countries of Southeast Asia to evaluate forage varieties for their adaptation to climate, soils and potential uses on farms in Southeast Asia (Stür et al. 2000; Gabunada Jr. et al. 2000);
- with more than 1700 farmers at 19 sites in four of these countries to develop, implement and modify participatory approaches to forage technology development on smallholder farms (Tuhulele et al. 2000). The participatory approaches used by the FSP were adapted from methods developed by Centro Internacional de Agricultura Tropical (CIAT) in Central and South America (Ashby 1990). These approaches are described in the rest of this paper.

Participatory Approaches to Forage Technology Development

Upland farming systems in Southeast Asia are characterised by great diversity in opportunities and limitations for forages, not only between villages but between individual farmers within villages. What is surprising about this statement is that we are often surprised by it! For example, the FSP worked in a transmigration village (Marenu) in North Sumatra, Indonesia, where two years earlier all farmers had been given equal areas of similar land, an equal number of sheep and a house. Two years later, what was striking was the great divergence of activities that farmers were involved in. Some had planted forages and expanded their sheep numbers, some were concentrating on cash crops and others were supplementing farm incomes with jobs in town. Conventional approaches to forage technology development could not deal with this kind of diversity. As students of statistics, researchers are trained to minimise variation in experiments and compare averages of treatments. 'Average' forage solutions developed on research stations for 'average' farmers, however, fail in diverse environments.

The approach of the FSP to working within these diverse situations was to identify robust, broadly adapted forage varieties, which we regarded as the basic building blocks of promising technologies (Stür et al. 2000). Through participatory approaches we encouraged farmers to evaluate these building blocks and experiment with them in developing integrated forage systems for the particular conditions on their farms. The underlying principle was to give farmers 'ingredients and information, not recipes' that would allow them to make decisions and take action in response to changes in their own farming situations.

The right hand column of Figure 1 summarises the process used by the FSP. Some of the steps involved farmers making the decisions (facilitated by the development worker) and one step was the responsibility of the development worker. However, the main step (evaluating and adapting technology options) required a robust partnership between farmers and the development worker to be successful.

Before applying these approaches, it was frequently necessary to carefully select communities where there seemed to be greatest potential for adoption and impact.

Where should We Work to Maximise the Potential for Impact?

Many development workers and projects are responsible for all agricultural development in their area

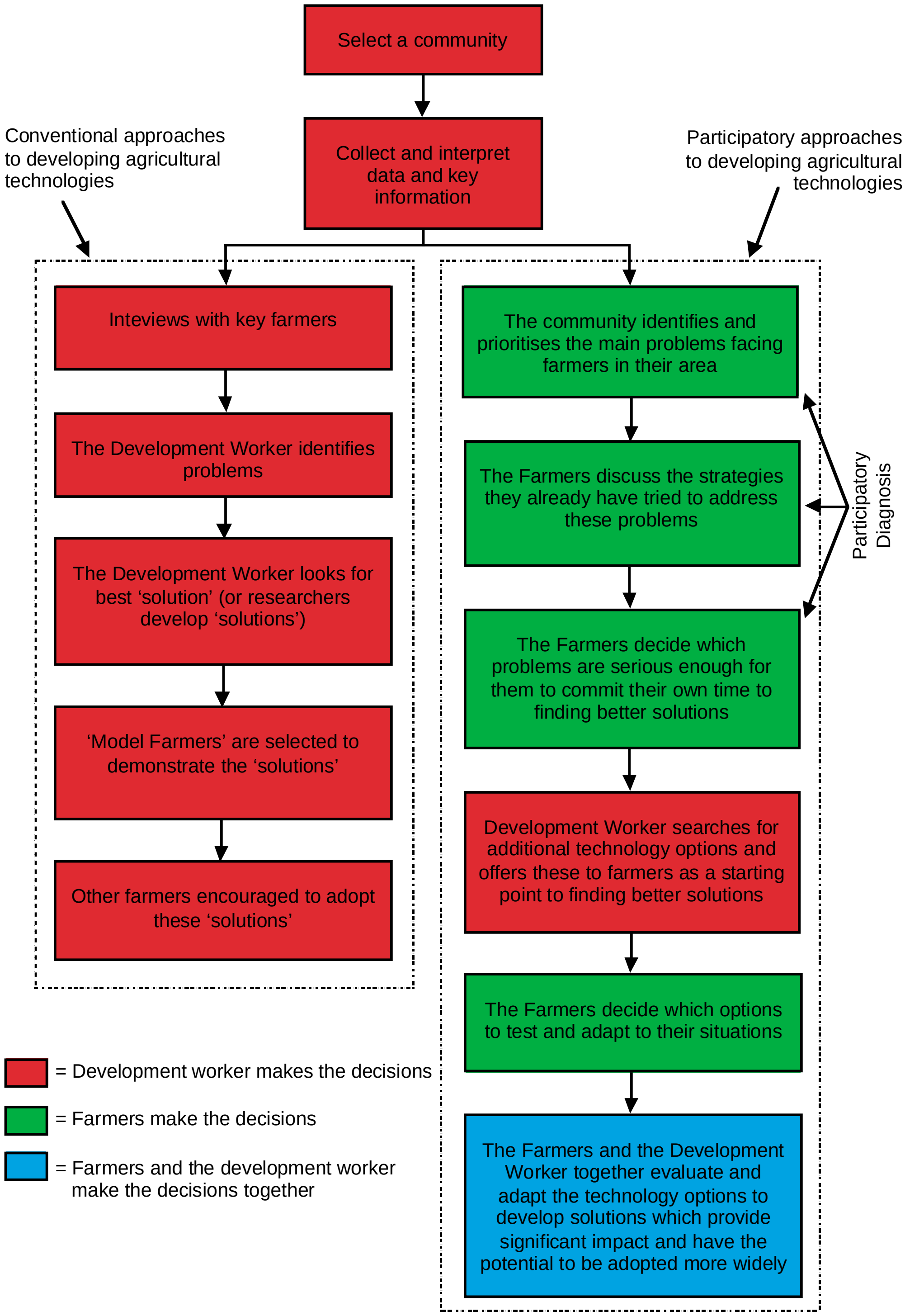

Figure 1. Conventional and participatory approaches to forage technology development.

including agricultural commodities from rice to livestock to fruit trees. Their main priority is to identify the broad range of problems and opportunities for improvement in their area and respond with potentially useful technologies. Other development workers are specialists in a particular field. This means that they have to look for places where their particular technologies have the greatest potential for impact. If the particular technology is a new irrigated rice variety, for example, then this site selection is likely to be relatively easy, targeting farmers who already grow irrigated rice and could benefit from the particular characteristics of the new variety. With forage and livestock technologies, however, the basic concept of the technologies is very often new to farmers. As a result, careful area and community selection was a critical first step in our participatory approaches. It did not matter how good our participatory approaches were if there was no potential for the technologies to have an impact in a particular area!

How can you identify sites and communities where your technology options are likely to have the best potential for impact? Learning from field experience, the FSP developed a set of criteria to help select areas and communities where forage technologies had a greater chance of adoption and impact. These are framed as questions in Table 1, which guided our early work in site selection.

Table 1: Key questions to ask when selecting communities and farmers for on-farm agricultural technology development.

Questions	For successful sites we need
1) Is there a genuine problem?	'YES' is essential
2) Do farmers think that this problem is important enough to commit their time in working towards a solution?	
3) Are there many farmers and other communities who have the same problem	
4) Do we have potential solutions to offer which can provide substantial benefits?	
5) Are there active local individuals or groups who are committed to working with farmers to solve this problem?	
6) Are there farmers who are already trying to solve this problem?	'YES' is desirable but not essential
7) Is there a local enthusiast who would 'champion' the resulting technologies in future?	

At first glance some of these questions appear trivial and self evident, and yet it is surprising how often on-farm technology development fails because these issues have not been addressed. This is best illustrated using some examples from forage technology development in the FSP:

1. Is there a genuine (livestock feeding) problem?

The FSP was asked to work with a group of farmers in one area to evaluate forages for feeding their cattle. When we investigated more-closely, we found they didn't have any cattle! The motivation of the farmers in wanting to plant forages was that it was the requirement of the local cattle credit scheme that they must plant a certain area of forage before they would receive animals from the cattle bank. Without having managed cattle before, these farmers had little idea if they were going to have any problems feeding their cattle. They planted forages, received cattle and abandoned their forage plots. They did not have a genuine problem.

In other situations, we have been directed by planners to areas where there are large numbers of livestock or natural grassland areas where they see a potential for increasing livestock production. Diagnosis with the farmers in such situations has often shown that there is not a gross shortage of feed and farmers see no need to expend effort in developing more intensive forage systems.

2. Do farmers think that this problem is important enough to commit their time in working towards a solution?

One group of cattle farmers asked the FSP to assist them with developing better feeding systems, but by providing seed, a tractor, better cattle breeds, fertiliser and fencing material. There is no doubt that if these had been provided they would have developed an impressive livestock system in the short term, but they would have failed in the long-term when the substantial external inputs dried up. It would also not have been possible for farmers from other areas to adopt the systems that were developed without these substantial inputs. The farmers did not regard the problem as being sufficiently important to commit their time to working towards a more-sustainable solution.

In another area, the farmers clearly had a major problem feeding their cattle in the dry season and were interested in looking at forage options. However, there were so many other more-serious problems with their cropping systems and human health (which were receiving outside support) that the livestock feeding problems were not a high enough priority for them to commit any time in working towards a solution.

3. Are there many farmers and other communities who have the same problem?

At several sites, the answer to questions 1 and 2 was 'Yes' but we found that the farmers we were talking to were a small group and there were no other farmers in the area with similar problems and motivations. The potential for impact and expansion was very limited.

4. Do we have potential solutions to offer which can provide substantial benefits?

Even if there are many farmers with livestock feeding problems that they could alleviate with forages, we have to be sure that we have promising options to offer. In one instance, many farmers in a lowland rice cropping area had started using irrigation to move from growing one rice crop a year to two. These farmers were heavily dependent on their buffaloes for draught power, manure and livelihood security. Previously, the buffalo had grazed on the rice paddies for most of the year and were fed cut grasses from the river banks during the rice cropping season. With two rice crops, there was not enough grass to sustain their buffaloes throughout the year. However, they had no vacant land which could be allocated to growing enough forage to have a significant effect on feed supply during the wet season. We had no potential solutions to offer.

5. Are there active local individuals or groups who are committed to working with farmers to solve this problem?

This was perhaps the most critical factor governing the success of on-farm forage technology development. Active and enthusiastic local development workers, with an empathy for the participatory approaches, can inject a great deal of momentum into the forage technology development even in an area where the potential may initially appear to be limited. This is particularly true for forages, which are a new concept for most farmers and have slow early growth compared with many crops. At one very successful site the development worker said 'it was hard to start with because the farmers needed regular encouragement to look after the small seedlings, but once the plants were tall and they could start to see the benefits, my job became easier'.

6. Are there farmers who are already trying to solve this problem?

All institutions and individuals working in rural development want to work with innovative farmers. We found that identifying and working with farmers who had already been working actively, often on their own to solve their problems, increased the chances of successful technology development. These farmers usually identify themselves during diagnostic sessions with the community.

7. Is there a local enthusiast who would 'champion' the resulting technologies in future?

At several FSP sites, the momentum of local expansion of promising forage technologies came from the involvement of a local enthusiast (sometimes a farmer, sometimes a development worker, sometimes a trader or local official) who actively 'championed' the technologies.

To help answer these seven questions and select 'possible candidate sites' for developing agricultural technologies with farmers, there is a need to collect secondary information. However, it is important to collect only the minimum data set necessary to answer the questions. There is a tendency at this stage of site selection to collect too much irrelevant data that becomes so daunting to interpret that all of the information is ignored. In the FSP, we used:

1. Environmental and census data (from local government statistics)

These helped us understand which forage varieties might be adapted to the area. These data can sometimes be inaccurate and difficult to collect. The most important data for forages were:

- Climate data (average monthly rainfall and max./min. temperatures for the past ten years);
- Livestock data (numbers, location, type);
- Soils data (broad fertility status and pH ranges for the soils in which forages are likely to be planted).

2. Key information and observations (from discussions with key individuals and from field visits)

This information helped us to understand what livestock feeding problems might exist and what possible technology options we might be able to offer. It was generally more useful and easier to collect than the environmental and census data. For forage technology development, there were some key questions we would ask local government officials, agricultural extension workers and individual farmers:

- What are the key problems affecting agricultural development in the area?
- What is the major land use and it constraints?
- Who owns the land?
- How big are the farms?
- Why do farmers keep livestock?
- Who keeps livestock (only certain ethnic groups? only the wealthy?)

- What type of animals and how many do farmers raise?
- What are the main problems with keeping livestock?
- Who is responsible for looking after the livestock (the men? the women? shared?)
- How are the animals fed and managed?
- How do farmers overcome these problems now?
- How are the farming and livestock systems changing?

Having used this information to identify communities where the forage technologies might have potential, we started the process of Participatory Technology Development.

Participatory Technology Development

'Participatory technology development' (or PTD) is a broad concept referring to development approaches which have 'active farmer participation in all stages of the development process' as a central principle.

'If you give a man a fish you feed him for a day, if you teach the man to fish you feed him for a lifetime . . . *but if you ask the man about fishing he may prefer to diversify into tree crops and livestock production*.'

There is a bewildering diversity of tools and approaches that fall under this concept of PTD, but an intriguing convergence of experiences and underpinning principles. This paper does not attempt to cover the many tools and approaches which are well covered in other publications (some recent examples being van Veldhuizen et al. 1997 a, b; and Hagmann 1998) but to summarise the approach used by the FSP and the lessons learned from this.

Figure 2 summarises the PTD concept used by the FSP. The key to this process was active involvement of the community at all stages of technology development (prioritising problems, identifying possible solutions to test, experimentation and evaluation).

Having identified a community where forages appeared to have potential, the first step in PTD was to confirm this potential through a village meeting where the community diagnosed and prioritised the problems they experienced in their farming and livestock systems. This was a process similar to Participatory Rural Appraisal (PRA) and used many of the tools of PRA, but was generally much quicker than PRA as it is usually implemented (taking no more than one day) and was directed towards 'Action' not 'Appraisal'. It moved beyond simply gathering lists of problems into problem diagnosis and action planning.

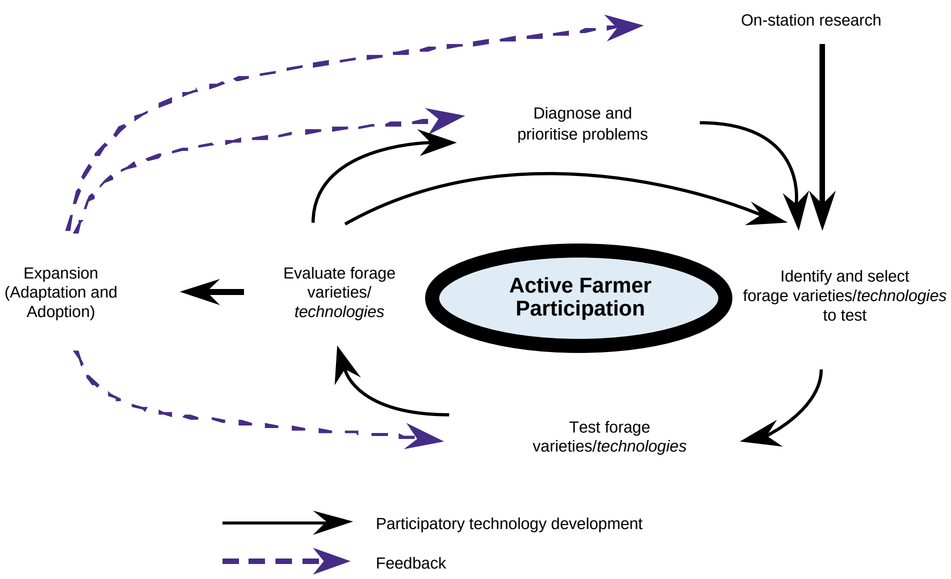

Figure 2. The Participatory Technology Development approach used by the FSP.

There were several common steps in the diagnosis:

a. **Familiarisation** with the area (for example, a village walk to allow the development workers to become familiar with the landscape and farming systems and get some ideas about opportunities and limitations);
b. **Resource inventories** (This was often the first process and involved farmers describing their village resources through mapping, seasonal calendars and historical calendars. It not only served as a basis for discussion of problems in the farming systems but broke down communication barriers in a participatory process that was initially strange to farmers);
c. **Problem identification** (With active facilitation, often using cards on which to write problems, farmers identified the major problems they face in their agricultural and livestock systems);
d. **Problem analysis** (The community would identify causal linkages between these problems);
e. **Current management of these problems** (The community would describe how they have coped with these problems until now. This not only showed which problems they regarded as being important but identified innovative, motivated farmers who have been actively trying to solve these problems in the past);
f. **Prioritisation of problems** the farmers want to work towards solving;
g. **Agreement on a plan of action** between the development worker and the community to evaluate a range of technology options that have potential to alleviate the priority problem(s).

Following diagnosis, individual farmers and, in some cases, farmer groups, would begin planting and evaluating forage varieties, many of which had been selected from on-station research (Figure 2). These farmers were encouraged to plant forages wherever and in whatever ways they wished to test them, although the development workers collaborating with the FSP would provide some suggestions and information on establishment and management. These development workers would then follow-up with participatory evaluations in which the farmers described which forage varieties/technologies they preferred and why. In many areas the development workers were able to work with existing farmer groups or form special interest groups of farmers who were interested in evaluating forages. Ultimately, however, each farmer wanted to grow forages on his or her own land and individual follow-up was very important to support on-farm development at all sites. Farmer groups do not always exist or in such cases may not be appropriate for particular situations, and the FSP worked with individual farmers.

It was common that some farmers would quickly see benefits of particular varieties and expand their plots and neighbouring farmers would spontaneously start planting forages ('Local expansion' – Figure 3). Others would maintain their plots without expanding or would abandon them if the benefits were not immediately obvious. Regardless of the farming system, however, we found that farmers always wanted first to test varieties in small plots, usually near their houses, and only with time (usually after one or two seasons when some farmers became convinced of the potential benefits of particular varieties) would they begin to experiment with novel ways of integrating forages onto their farms ('forage systems' – see Figure 3). These are the farmers who became the 'core' that drove the technology development process of the FSP.

In some cases, as their experience with forages increased, farmers found new problems to solve with forages or developed new opportunities for forages by changing their farming systems. An example of this kind of innovation occurred in northern Vietnam, where we started working with farmers to evaluate forages for feeding their buffalo in the dry season. Most farmers were initially impressed with the forage varieties that they tested but did not want to allocate a lot of valuable crop land to planting forages. The FSP almost withdrew from the site because of the lack of potential when several farmers started feeding their fish (carp) with forage grasses. This caused great interest among other farmers in the area since most farmers had fish ponds and there was a severe shortage of feed available for fish. Forages in backyard plots for cut and carry feeding of fish are now expanding rapidly in this area. Some farmers are replacing dryland crops with forages to expand their fish production. The farmers taught us a valuable lesson: 'If you don't feed your buffalo in the dry season, they get thin, but they get fat again in the wet season. If you don't feed your fish, they die'. Some of the earlier farmers are now planting forages to fatten cattle, another source of cash income.

Expanding to New Areas – More Benefits for More People More Quickly

One measure of success is when farmers expand their areas of forage and neighbouring farmers spontaneously adopt the new forage technologies. We have seen this occur in many sites and examples are given in other papers in these Proceedings (e.g. Gabunada et al. 2000; Nacalaban et al. 2000; Ibrahim et al. 2000). For example, at Malitbog, Philippines, the number of farmers evaluating forages expanded from 15 farmers in the first year to more than 170 farmers in the third year, and almost 50 farmers had expanded their forage areas considerably. Our present concern is how we can most rapidly expand to new areas.

The participatory approaches promoted by the FSP are not part of a process that has a clear end where development workers eventually withdraw, but are part of a process that demands changing roles of farmers, development workers and institutions in an evolving partnership. As local expansion starts to occur, the roles of development workers evolve more towards that of being facilitators of farmer-to-farmer exchange of ideas and planting material. The challenge facing us now is how to expand more benefits of locally successful forage technologies to more people more quickly. How can we expand impacts but maintain the participatory approaches and principles of active farmer involvement that are 'inherent in smallness and cannot simply be replicated' (IIRR 1999). It is evident that this has to involve not only a scaling-out of geographic impact but a scaling-up of institutional capacity and the formation of strategic alliances or development coalitions.

Some Lessons Learned

The participatory approaches being developed by the FSP are an on-going learning experience for all involved, based on a cycle of field activities followed by reflection on outcomes and modification of the approaches. There are no shortcuts to this learning process. The approaches do not constitute a series of steps that can be rigidly followed but are more 'a complex conjunction of people, events and luck, often with unanticipated outcomes' (Cramb, 2000). As such, it was often difficult for development workers to adopt the new approaches. With time, however, they found that, although 'the participatory approaches are time consuming and require a lot of legwork, … [it is] … through participatory methodologies we have finally found a way to bring forage technologies to the farmer' (Staples and Roder 1998).

Despite these benefits, the participatory approaches are currently fragile. This is partly because there are few experienced development workers who can confidently operate within such an unstructured framework. Training courses do not necessarily change this. What is needed is a program of field experiences and mentoring that will give those development workers who already have an empathy for participatory approaches, the decision tools, methods and skills they need to work more confidently with farmers in the field. 'We shouldn't try to standardise innovation but systematise it' (Uphoff, quoted in IIRR 1999).

The participatory approaches are also fragile because of pressures within national organisations and projects for 'quick results'. This results in pressures to reproduce or 'photocopy' locally successful technologies from one site to another using the conventional extension approaches. This is rarely successful (as has been widely experienced by development projects that have tried to promote contour hedgerows in the uplands of Southeast Asia).

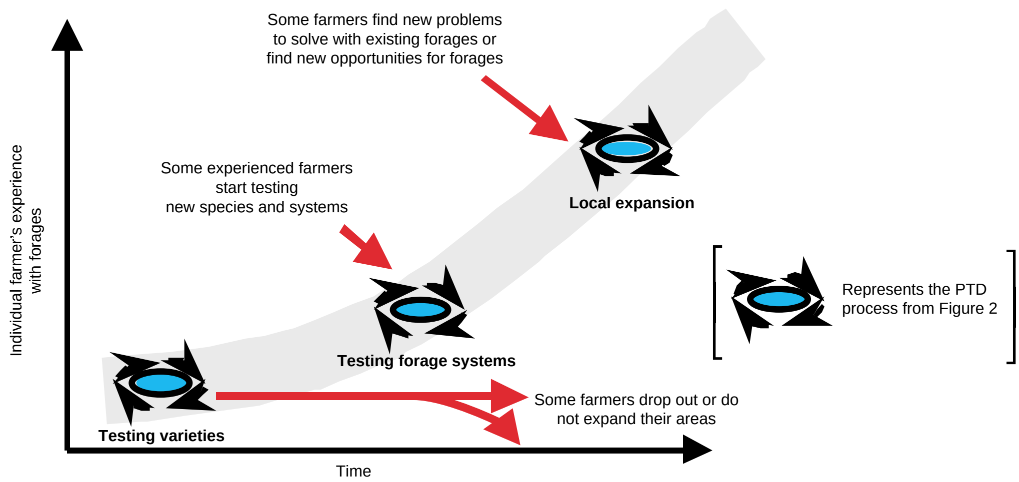

Figure 3. The process of development of integrated forage systems on farms.

Farmers in a new area will want to experiment with 'strange' new varieties just as much as did the original farmers. However, new farmers may start immediately evaluating forage systems (not simply varieties) in an area where there are many experienced farmers already using forage systems. Finding ways of scaling-up locally successful technologies within a participatory framework is the next major challenge in methodology development (see IIRR 1999; Cramb, 2000; Connell, 2000).

There is no doubt that the participatory approaches have given FSP a much sounder understanding of farmers' perceptions of their problems and opportunities, and given us a much stronger bridge into poor farming communities … a bridge based on trust and mutual respect. Many other researchers, extension workers and project personnel in Southeast Asia are familiar with the benefits of these approaches and the concepts of implementation, but are looking for practical guidelines on how to implement them in the field.

References

Ashby, J.A. 1990. Evaluating technology with farmers. A Handbook, Colombia, CIAT, IPRA Project, 95 p.

Connell, J.G. 2000. Scaling-up: The roles of participatory technology development and participatory extension approaches. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

Cramb, R.A. 2000. Processes influencing the successful adoption of new technologies by smallholders. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

Gabunada F. Jr., Heriyanto, Phengsavanh P., Phimphachanhvongsod V, Truong Thanh Khanh, Nacalaban W., Asis P., Vu Thi Hai Yen, Tugiman, Ibrahim and Stür W. 2000. Integration of adapted forages on farms in Southeast Asia – experiences from the Forages for Smallholder Project. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

Hagmann, J. 1998. Learning together through Participatory Extension. A Guide to an Approach developed in Zimbabwe, Harare, Zimbabwe, AGRITEX/GTZ,. 59 p.

Ibrahim, Truong Tan Khanh and Heriyanto. 2000. Forage technologies for smallholders in grassland areas. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

IIRR 1999. Scale-Up! Highlights and Synthesis of Proceedings of the CGIAR NGO Committee Workshop on Scaling Up Sustainable Agriculture Initiatives, held in Washington, October 22-23 1999, Cavite, Philippines, International Institute for Rural Reconstruction, 56 p.

Nacalaban, W., Le Van An, Asis, P., Moneva, L. and Balbarino, E. 2000. How do forages fit into smallholder farms in mixed upland cropping systems? In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

Staples, R. and Roder, W. 1998. Report of the external mid-term review of the 'Forages for Smallholders Project', Vientiane, April 1998, Philippines, CIAT.

Stür, W.W., Ibrahim, T., Tuhulele, M., Le Hoa Binh, Gabunada, F. Jr., Ibrahim, Nakamanee, G., Phimphachanhvongsod, V., Guodao, L. and Horne, P.M. 2000. Adaptation of forages to climate, soils and use in smallholder farming systems in Southeast Asia. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

Tuhulele, M., Le Van An, Phengsavanh, P., Ibrahim, Nacalaban, W., Vu Thi Hai Yen, Truong Tan Khanh, Tugiman, Heriyanto, Asis, P., Hutasoit, R., Phimmasan, H., Sukan, Ibrahim, T., Bui Xuan An, Magboo, E. and Horne, P.M. 2000. Working with farmers to develop forage technologies – field experiences from the FSP. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. ACIAR: These Proceedings, see Contents.

van Veldhuizen, L. Waters-Bayer, A and de Zeeuw, H. 1997a. Developing technology with farmers: a trainer's guide for participatory learning, Netherlands, ETC, 224 p.

van Veldhuizen, L. Waters-Bayer, A., Ramirez, R., Johnson, D. and Thompson, J. 1997b. Farmers' Research in Practice: Lessons from the Field, London, Intermediate Technology Publications,320 ph.

Farmer Participatory Research in Latin America: Four Cases

A.R. Braun[1] and H. Hocdé[2]

Abstract

Farmer Participatory Research (FPR) emerged in response to limitations of top-down R&D approaches. In Latin America, the principles and concepts of FPR are rooted in earlier participatory research experiences in fields such as education, sociology and health, usually played out within a community-development context. Contributions of Paulo Freire and Orlando Fals Borda are discussed briefly. To analyse these experiences, a typology based on decision-making locus in research, farmers' and scientists' roles, and the style of research conducted was used. Three approaches were distinguished: scientist-led, farmer-led and interactive research. Four cases are analysed: (1) Farmer-to-Farmer program, Nicaragua, founded in 1987 by the National Farmers and Ranchers Union (UNAG) based on volunteer farmer-promoters. The focus is on low external-input agriculture. (2) Diagnosis, Investigation and Participation (DIP), formed in 1994 by a multi-disciplinary team with linkages to the Veterinary Medicine and Animal Science Faculty at the Autonomous University in Yucatan, Mexico. Their objective is to improve the quality of life of indigenous communities at the forest-agriculture interface through participatory innovation based on local resources. (3) Farmer Experimentation, initiated by PRIAG (Regional Program for Reinforcement of Agronomic Research on Basic Grains) in Central America, in 1991. The objective is to increase the self-reliance of small- and medium-scale producers in generating and disseminating technology. (4) Local agricultural research committees (CIALs), first launched by CIAT in Colombia in 1990, to strengthen rural communities' capacity as decision-makers and innovators of agricultural solutions and to exert demand on the formal R&D system. The discussion focuses on similarities and differences in the processes, principles, roles and relationships underlying these experiences and key lessons learned.

IN THE development context, participatory research may be defined as a process whereby a group or a community identifies a problem or question of interest, reviews what is known about it, conducts research on it, analyses the information generated, draws conclusions and implements solutions (modified from Selener 1997). In this definition, the locus of decision-making rests implicitly within the group or community involved. Farmer Participatory Research (FPR) is understood by many to be one element in a larger participatory development agenda that aims to change the orientation of existing research and development (R&D) structures, develop sustainable community-based research capability and create new social and political institutions (Okali et al. 1994).

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Intellectual Roots of FPR in Latin America

Participatory research approaches have been developed and applied in four broad areas: (1) community development, (2) action research in business and industry organisations, (3) action research in schools and (4) farmer participatory research (Selener 1997). FPR emerged as a response to the limitations of earlier top-down agricultural research approaches that often failed to deliver significant improvements in levels of well-being for the poor in complex, risk-prone environments (Chambers et al. 1989; Conway

1997). FPR draws upon concepts from earlier participatory research experiences, involving a broad diversity of disciplines including non-formal adult education, sociology and health (e.g. Gianotten and Wit 1985; Lammerink and Wolfers 1994). FPR in Latin America is particularly strongly rooted in concepts that emerged from participatory research experiences in community development. Paulo Freire and Orlando Fals Borda rank importantly among the protagonists of participatory approaches and made major contributions to the community development field in the late 1960s and early 1970s.

A major break from traditional concepts of adult education occurred in Brazil, catalysed by Freire (1970, 1973), who was appalled by the situation of the illiterate poor. Freire conceived education to be a tool for changing society structurally. Knowledge, which he equated with power, had traditionally been monopolised by an elite that sought to protect its interests. The learner was considered a passive recipient of knowledge, deposited by an educator, just as money is deposited in a bank.

Freire organised a multidisciplinary team to develop educational materials that would stimulate the poor to reflect on their lives and on the underlying causes of their conditions. People were organised in 'cultural circles' in order to recover their identity and indigenous knowledge. Dialogue on controversial issues such as land tenure rights was the central process, followed by reflection and then action. Thought-provoking photographs were used to initiate this process, which Freire called *concientização*, a Portuguese word that implies a liberating process, whereby oppressed people evolve towards a state of critical consciousness. Threatened by his efforts to change society structurally, the Brazilian government jailed Freire, who eventually sought exile in Chile. He later worked in Portuguese-speaking African countries.

Another militant who sought to construct a new social order was the Colombian sociologist, Orlando Fals Borda (Fals Borda 1985). Coming from an academic setting, Fals Borda was isolated from the realities of rural life. Motivated by the desire to find a balance between reflection and action, he and a group of university intellectuals went out into the field to bring science to rural people. At first, communications barriers and differences between their concepts of reality caused the farmers to reject Fals Borda's group. Moreover, the technological solutions developed by the university researchers were not applicable to rural conditions. After a process of deep reflection, Fals Borda radically reoriented his work, no longer treating rural people as passive 'objects', but encouraging them to become active 'subjects' or agents of their own liberation. For a period, he was involved in militant action research, collaborating with an aggressive association of small farmers that had invaded lands belonging to large cattle ranches in northern Colombia. Fals Borda continued to try to improve local access to technical and scientific knowledge by providing systematic feedback to researchers about farmers' needs. The establishment of feedback mechanisms between farmers and scientists, and the awakening of intellectuals to new perspectives on the realities of rural life were among the most valuable outcomes of his work (Fals Borda 1987).

FPR draws upon a number of concepts that originated in the work of Freire and Fals Borda and other early pioneers – the most notable being:

- the iteration or repeated cycling of reflection and action;
- the breakdown of subject-object polarity;
- the rejection of passive knowledge banking in favour of active knowledge acquisition and generation through participation in research and analysis, and application of the results;
- facilitation of the development of critical consciousness by external actors.

The Emergence of FPR

The term *Farmer Participatory Research* was coined by Farrington and Martin (1987). FPR emerged as a response to the limitations of earlier agricultural research and extension approaches such as on-farm and farming systems research and the 'Training and Visit' extension model. In these earlier approaches, farmers were often considered as research subjects, components of the system under investigation, or passive recipients of extension messages. FPR has received increased attention and recognition since the 'Farmer First' (Chambers and Ghildyal 1985; Chambers et al. 1989) and Participatory Technology Development (Haverkort et al. 1988) concepts were first introduced in the 1980s. In contrast to earlier agricultural research and transfer-of-technology approaches, FPR advocates farmers' involvement as decision-makers at all stages of the process, including the early stages of problem definition, prioritisation and the setting of research objectives.

It should be stressed that there is no single model, prescription or recipe for the process that we are calling FPR. Not surprisingly, an often-confusing array of approaches, methods, platforms, tools, relationships and terms is associated with FPR. In his analysis of the historical development of participatory research, Selener (1997) emphasised:

> 'The realisation that there is an array of participatory research approaches may be disconcerting at first. But it is clear that no single approach can address the multiple realities existing within society.'

A Typology of Agricultural and NRM Research Strategies

A simple typology of agricultural and NRM research approaches[1] was developed to facilitate the analysis of FPR experiences. The typology draws upon concepts from earlier classifications (Biggs 1989; Pretty 1994; Mikkelson 1995; Ashby 1996; H. Hocdé and B. Triomphe, unpublished; S. Sherwood, unpublished) and on recent analysis by the CGIAR[2] Systemwide Program on Participatory Research and Gender Analysis (see Lambrou 2000; Probst 2000). It is based primarily on the locus of decision-making with respect to the research process and secondarily on the respective roles of farmers and scientists and on the style of research conducted. Three broad research approaches are distinguished (Table 1): scientist-led, farmer-led and interactive. Rather than a rigid classification system, the typology is intended as a conceptual tool for analysing the relationships among different approaches, recognising that they often have overlapping boundaries.

Scientist-led research

In this approach, scientists determine the research agenda and conduct formal research, employing hypothesis testing, controls and replication, and drawing upon the full range of tools associated with the scientific method. Scientists may consult with farmers and may involve them as collaborators in experiments. When consultation with farmers is practised, it may be with groups or individuals, and it may employ Participatory Rural Appraisal/Assessment (PRA) tools[3] (e.g. focus-group discussions; semi-structured interviews; seasonal and historical diagramming; mapping and modelling; preference and wealth ranking; transect walks; institutional mapping) to gather information and to improve communication with rural people (World Bank 1994).

[1]In this paper, an *approach* refers to a body of experiences or *platforms* that share key principles and processes, but that may differ in organisational form and deploy different tools. The concept of *platform* was originally introduced to the literature of sustainable agriculture R&D by Röling and Wagemakers (1998). A *platform* is an implemented, coherent set of principles and processes, organisational forms and tools.

[2]Consultative Group for International Agricultural Research.

[3]We define a tool as a conceptual or physical aid or device that facilitates the accomplishment of a specific participatory research objective.

Farmer-led research

Farmers – Individually or collectively – determine the research agenda and conduct the research. Farmers, scientists or other professionals may be involved as facilitators in one or more steps of the research process and often introduce and apply PRA tools to structure communication with and among farmers. In general, farmer-led research is non-formal and does not apply concepts such as replication and control.

Interactive research

In this approach, both farmers and scientists are involved in determining research agendas, which are mutually integrated, complementary and synergistic. The interactivity arises because the scientists' research is demand driven and the farmers are evaluating the options under development by formal research centres alongside other alternatives. Scientists are involved as facilitators of the local research process with farmer groups or individuals, and this facilitation may include teaching farmers key elements of the scientific method, such as replication and control, offering ideas, information and access to technology, and helping to establish contacts.

Scientist-led research is the least participatory of the three approaches. Although farmers may be consulted or involved as collaborators, they are not directly involved in decision-making about research priorities or about the research process itself. This approach is complementary to farmer-led and interactive research, and continues to be the principal strategy for elucidation of fundamental biological and ecological principles and processes. Agricultural and NRM research methods, tools and approaches are other important products of scientist-led research.

It should be noted that the typology does not include participatory learning approaches such as the Farmer Field School (FFS) or CATIE's[4] INTA-IPM[5] project in Nicaragua[6] (CATIE, unpublished). Similarities, differences and complementarities between participatory learning and participatory research

[4]Centro Agronómico Tropical de Investigación y Enseñanza.

[5]Instituto Nicaragüense de Tecnología Agropecuaria-Integrated Pest Management.

[6]The CATIE INTA-IPM project has concluded that both participatory and conventional (scientist-led) research are needed to develop the agricultural technology and strategies for strengthened farm family management of ecological variability. The project has identified the need to increase farm families' capacity to select and modify efficient and appropriate pest management practices. Farm families and IPM professionals associated with the project have undertaken a broad array of participatory evaluations of IPM methods for coffee, tomatoes, cabbage and plantains.

Table 1. A typology of agricultural and natural resource management research approaches.

Research type	Decision-makers	Roles of farmers and scientists	Research style
Scientist-led	Scientists determine research agenda	• Scientists conduct research • Farmers may or may not be consulted; they may or may not collaborate	Formal
Farmer-led	Farmers determine research agenda	• Scientists or farmers may facilitate farmer research	Non-formal
Interactive	Farmers and scientists develop interactive and integrated research agendas. Decision-making about local research is done locally. Decision-making by formal research services is influenced by their clients' priorities	• Farmers and scientists conduct research interactively • Scientists facilitate farmer research • Two-way communication is organised to facilitate mutual feedback	Farmers may conduct formal or non-formal research Scientists conduct formal, demand-driven research

approaches are discussed in an analysis of FFS and CIALs (Braun et al. 2000).

The remainder of this paper is devoted to comparative analysis of several FPR experiences from Latin America. Our objective is to identify similarities and differences in the processes, principles, roles and relationships underlying these experiences and to summarise key lessons learned.

A review of formal and grey literature was undertaken; however, the scope was not exhaustive. The review was conducted in two stages. After compiling the available information about each experience and conducting an email survey to capture additional information wherever possible (including drafts and submitted versions of papers), each case was classified according to the typology, and its essential aspects were summarised (Table 2). Several of the cases had characteristics of both the farmer-led and interactive approaches. These are indicated in Table 2 as *mixed-mode* experiences.

Four cases were chosen for in-depth analysis because they offered:

- systematised analysis of principles, processes, roles, relationships and lessons learned;
- evidence of a proven track record;
- diversity and contrast.

The selected cases (Farmer-to-Farmer, DIP, PRIAG and CIALs) span the continuum of farmer-led and interactive approaches. The Farmer-to-Farmer approach clearly falls at the farmer-led end of the continuum. DIP and PRIAG are rooted in the Farmer-to-Farmer approach, but also share elements of the interactive approach and are considered as *mixed-mode* cases. The final case, Farmer Research Committees (CIALs)[7], represents the interactive end of the continuum.

The FPR Landscape in Latin America

A farmer-led experience

Farmer-to-Farmer[8]

The Farmer-to-Farmer program was founded in Nicaragua in 1987 by the National Farmers and Cattle Ranchers Union (UNAG)[9]. It started with exchange visits between farmers from Nicaragua and Mexico with the aim of promoting and diffusing appropriate technologies among poor farmers. The program was a reaction to the top-down transfer-of-technology model that prevailed in Nicaragua during the 1980s, which promoted expensive technology packages involving improved varieties, irrigation, imported chemical fertilisers, pesticides and agricultural machinery. The program sought to improve soil fertility, productivity and living standards, while reducing production costs and external dependency.

Soon after their inception, Farmer-to-Farmer exchanges rapidly began to resemble classical technology transfer, but with the role of the extension agent filled by farmers. It became clear that promoting externally developed technologies, even when they were of farmer origin, had its limits: hence there was a need for farmers to test candidate technologies in their own fields.

In this approach, volunteer farmers or promoters, who are willing to share their knowledge and experience with others, conduct experiments in their own

[7]CIAL is the Spanish acronym for Comité de Investigación Agrícola Local. Other names in English are Farmer Research Committees, Local Agricultural Research Committees and Committees for Local Agricultural Research.
[8]Farmer-to-Farmer is known as *Campesino-a-Campesino* in Spanish.
[9]Unión Nacional de Agricultores y Ganaderos.

Table 2. Selected Farmer Participatory Research experiences in Latin America.

FPR Experience	Institution/ Area of Influence	Highlights
Farmer-led		
Farmer-to-Farmer	1. UNAG/Nicaragua 2. COSECHA/Honduras	1. See Programa Campesino a Campesino 1999, Hocdé in press; Website: http://www.copacgva.org/ifapidc97.htm#UNAG 2. Founded by R. Bunch, Regional Representative of World Neighbours and author of *Two Ears of Corn* (Bunch 1982). The primary objective of COSECHA is to disseminate the effective use of ecologically sound Agri-Cultural Development. It has training and rural development programs that serve as models in areas such as agroforestry and soil restoration (Bunch 1990; Bunch and Lopez 1994). Website: http://www.desarrollo-rural.hn/docs/curriculum/cosecha.html
Farmer inventors	Panamerican School of Agriculture (EAP), Zamorano, Honduras	See Bentley 2000.
Participatory Technology Development (PTD)	1. Ideas/Bolivia & Peru	1. The PTD* concept was originally developed by ETC (Waters-Bayer 1989; Haverkort et al. 1991); Website: {HYPERLINK http://www.etcint.org/)}. Ideas works with Andean peoples, who conduct experiments by themselves. Indigenous knowledge is considered to be of great value and is the starting point for PTD. Emphasis is on low external inputs. Seeks to institutionalise PTD in communities. Role of institutions is to provide support in accessing information and in networking.
Mixed mode		
Farmer Experimenters	1. PRIAG (CORECA/EU, IICA, KIT, CIRAD)/ Central America 2. World Neighbours/ Bolivia 3. UNICAM/Nicaragua 4. As-PTA/Brazil	1. See text, Hocdé in press, and Jaén & Silva (1995) 2. See Ruddell (1994) (Website: http://www.wn.org) 3. This NGO has supported the farmer-led experimentation process for 7 years. Emphasis on women, family and Farmer Experimenter groups. Collaborates with municipalities in some cases. Current emphasis is on introducing concept of Farmer Experimenters in producer organisations. 4. This NGO supports rural farmer associations in learning how to manage their own experiments to strengthen family farming within difficult agroecological systems. Emphasis on generation of local knowledge. Website: http://www.dataterra.org.br/aspta/faspta.htm
DIP	FMVZ-UADY/Yucatan, Mexico	See text, Gündel (1998) and Anderson (1998).
Interactive		
PPB	INIAP, Ecuador; EMBRAPA-CNPMF, Brazil; EAP-Zamorano, Honduras; CIAT; CGIAR SP-PRGA	See CGIAR (1999), Sperling et al. (in press); Website: http://www.prgaprogram.org/
CIALs	CIAT – 8 countries of Central & South America	See text and Braun et al. (2000), Ashby et al. in press; Humphries *et al*. (in press). Website: http://www.ciat.cgiar.org/cials

*PTD connotes the specific farmer-led approach developed by the consulting group, ETC International. It is also an umbrella term to describe an approach or activity that combines technology development with participatory methods (Sutherland et al. 1998) fields. Each takes responsibility for guiding a group of experimenting farmers from his/her community, visiting them regularly to help with planning, implementation and interpretation of their experiments. Promoters also organise and give training on topics determined by their own accumulated experience and concrete results, ranging from soil conservation, cover crops, husbandry, forestry and organic agriculture to cropping systems and diversification. They focus their experiments on low external-input agriculture[10]. Today in Nicaragua, there are 700 farmer promoters working throughout the country in a wide range of agroecological and socio-economic contexts. The approach has taken root throughout Central America and is applied by many NGOs and in some R&D projects.

The farmers themselves define the research agenda, manage the experiments and interpret the results. They may do this individually or in groups. Generally, they do not apply formal scientific methods such as the use of control plots or repetitions. Two key elements in the Farmer-to-Farmer process are the farmer promoter and the mechanisms of communication employed (Hocdé in press).

The promoter's basic function is to find technical solutions to problems in smallholder agriculture. A main task is therefore to communicate solutions to neighbouring farmers who are also searching for answers to their problems. In order to have credibility as a communicator, a promoter needs to have tested recommendations on his/her own land. The two functions and processes – experimentation and communication – are therefore interdependent. Promoters do not recommend technical recipes or packages, but rather suggestions or ideas to stimulate experimentation by others. A promoter's main tool for convincing others is through mentoring and setting an example, although workshops and training events are also employed. The goal of the Farmer-to-Farmer movement is to promote a culture of inquiry and experimentation among smallholder farmers.

Sharing and disseminating knowledge horizontally is a central responsibility of each promoter. Each communicates intensively with other farmers, as well as with other promoters, using traditional communication tools such as sociodrama, theatre, poetry and music. A diversity of mechanisms such as forums and exchange visits are used, employing a broad range of PRA tools.

Promoters organise exchange visits involving farmers and communities. They may involve small or large groups and be of short or long duration, 1–4 days. Experiments are exposed to the critical eye of a diversity of people, each with his or her own perspective. These are intensive training and learning opportunities and their pedagogical content can be considerable. During exchanges, participants explain and discuss results, methods and procedures, often amid criticism, argument and debate. Each participant analyses the strengths and weaknesses of his ideas and results before the group. The atmosphere of mutual reinforcement and encouragement permeating these events helps motivate farmers to continue experimenting. Learning from mistakes is encouraged, as is the idea that each person follows his own problem-solving path.

Promoters facilitating these situations must be able to create a constructive and productive atmosphere, and to bring out and synthesise the ideas of others to orient and guide the design of new experiments. This requires that promoters be highly skilled in facilitation techniques.

Lessons learned

The Farmer-to-Farmer process can result in radical changes in farmers' mental maps of their role in the process of technology generation and diffusion. Through involvement in the program, farmers realise that they are capable of experimenting, offering solutions, communicating and transmitting technological options to others (Merlet 1995).

The Farmer-to-Farmer process builds enthusiasm, self-confidence, pride and hope for the future (Programa de Campesino a Campesino 1999). Motivation grows as creative capacities are tapped, and the attitude of dependency on external actors diminishes as farmers begin to identify themselves as experimenters. The most radical of the farmers involved in the program view it as a way to break the monopolisation of the technology-development process by agricultural professionals.

A number of initiatives within and outside of Nicaragua are applying this approach. Although many of these conserve the horizontal communication between farmers, which is the key methodological element of the approach, they may omit the other key dimension, which is the creation of a social movement of innovators, making their own decisions and supported by their own organisational structures. This has led to some confusion as to what this approach really consists of. When looking at these experiences, care should be taken to see which dimensions are actually being applied.

[10]The rationale behind the focus on low external input agriculture is that the farmers targeted by the program have extremely limited access to purchased inputs, live in remote locations and/or have little purchasing power.

Technological lessons

- Farmers' research themes tend to concentrate on agronomic, animal husbandry and technical issues.
- In some cases, the advent of a solution generated by promoters leads to excessive promotion of the technology over an ongoing search for solutions to other limiting factors.
- The strong emphasis on low external-input technologies can be a barrier dissuading some farmers from participating in the Farmer-to-Farmer movement, thus impeding its growth.

Methodological lesson

- Farmers' concepts of the experimental process are different from those of formal researchers. For example, farmers may not limit what they conceive of as experimentation to plots specifically designated for that purpose.

The relationship between Farmer-to-Farmer initiatives and the formal research sector have traditionally been limited, with a few notable exceptions[11]. Advocates of the Farmer-to-Farmer approach contend that formal researchers tend to consider the experiments conducted by farmer promoters as an extension mechanism rather than as bonafide research. They also complain that promoters have tended to find few useful elements in the technological solutions offered by formal researchers. Holt-Jimenez (in Scarborough 1995), who participated in the creation of this program, argues that it is indeed possible for professionals to participate in the process, but that most of them need to be trained by *campesino* promoters in order to do so successfully. Overcoming the mutual reservations between promoters and professionals would undoubtedly constitute a leap forward, thereby improving and enriching the work conducted by both. Potential gains from the joint development of realistic solutions to concrete problems in farming lie not only in the better design and management of experiments, but also in the increased diversity of options that would become available.

Despite its limitations, the Farmer-to-Farmer experience constitutes an important reference point for both the farmers themselves and formal agricultural services, in terms of demonstrating the potential of smallholder farmers as researchers and communicators. This approach is of historical significance, because it made a significant break with the conventional models of knowledge and technology transfer.

[11]An example is the close articulation between the Farmer-to-Farmer program and the Soils Department of the Agronomy School of Nicaragua's National Agrarian University.

Mixed-mode experiences

Diagnosis, Investigation and Participation (DIP).

In 1991, participatory research and rural assessment methodology was introduced into the graduate curriculum of the School of Veterinary Medicine and Animal Science of the Autonomous University of the Yucatan (FMVZ-UADY), Mexico, as part of an ODA-sponsored project (DIP unpublished). The DIP group formed in 1994 as a multidisciplinary team of 10 members and decided to conduct participatory research on backyard animal production. Their objective is to improve the quality of life of indigenous communities at the forest-agriculture interface in the region through participatory innovation based on local resources.

DIP, which emerged in response to the need to fill the gap between conventional research and farmers' needs that were not being addressed by government research and extension systems, proposes to facilitate endogenous change among small farmer families to improve food security and family well-being through the sustainable use of natural resources. Equity is sought both in terms of benefits from agricultural innovation and in the development of gender-differentiated knowledge systems. The resulting process can be divided into four overlapping, interlocking phases (Figure 1), which can be repeated as often as necessary and be constantly readjusted by the participants on the basis of new information (Gündel 1998).

Appraisal

In this phase, researchers and farmers establish the common vocabulary essential for effective communication. This is accomplished by using PRA tools such as maps, calendars, ranking exercises and semi-structured interviews in order to identify the problems and potentials of the local agricultural system and to understand farmer strategies for its management. Changes that occurred within the system in the past and existing sources of information on innovations are identified. The outcome is shared information on existing local knowledge and concepts.

Convergence

In the convergence phase, the actors involved negotiate and agree upon shared objectives, activities to be undertaken together, and the division of tasks and responsibilities. Negotiation does not always result in an agreement. Where there is no convergence of interests among the actors, the process is generally discontinued. In some cases, however, a partial convergence can be reached, making it possible to

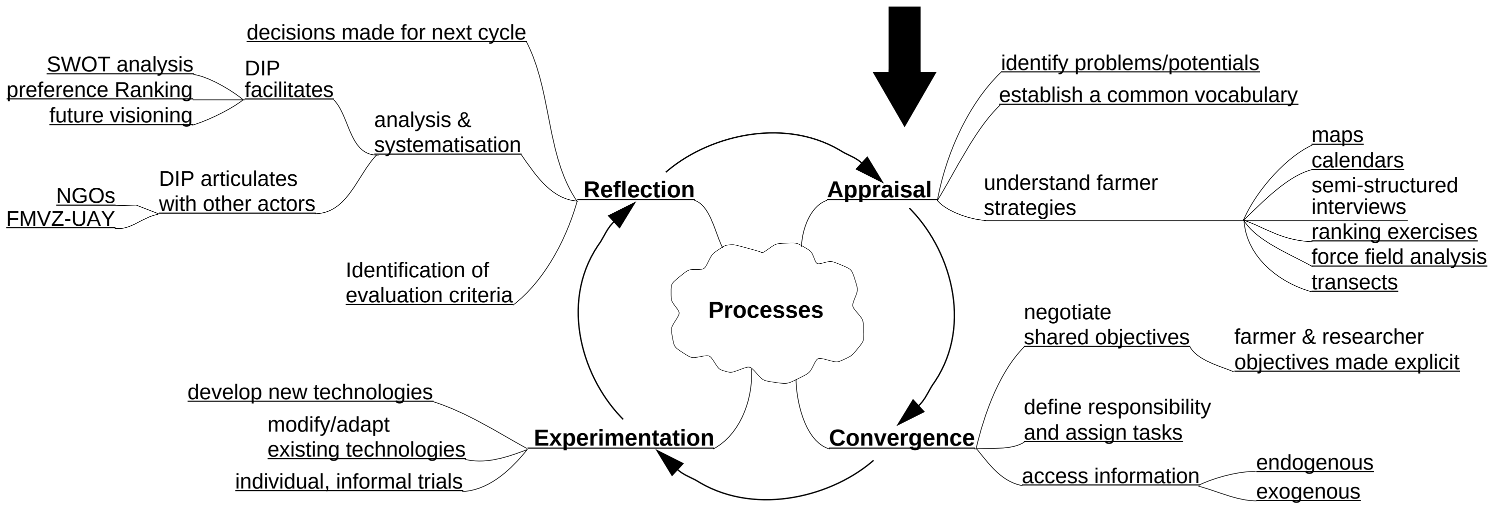

Figure 1. Processes associated with the DIP experience, Yucatan, Mexico. The thick arrow indicates the initiation point.

initiate the process. Having started the process, the participants can then re-negotiate specific objectives in subsequent cycles.

Innovation opportunities are explored and discussed among the participants. Different sources of information can be accessed, for example, from other farmer groups (as in the Farmer-to-Farmer approach), or information available from formal research. Any technology components introduced by researchers should have the potential to be modified. Group discussions and exchange visits are the principle methods used to facilitate the negotiation and decision-making. The outcome of this phase is the convergence of different objectives into a shared strategy.

Experimentation

Experimentation in DIP is rooted in the Farmer-to-Farmer approach, but stresses greater involvement of researchers and other actors. During this phase, participants either develop new technologies or modify and adapt existing ones (external or local) to local conditions and needs. The experimentation is carried out by the participating farmers and is often organised on an individual basis. Farmers determine the experimental designs. This leads to non-formal trials without formal requisites such as replication and control. The objective of the experimentation phase is to become familiar with the innovations being tested and adapt them to specific conditions. The researchers learn about qualitative issues such as farmers' strategies and objectives. The management strategies for individual experiments are shared among the participants during village exchange visits, group discussions and frequent visits to each other's plots.

The researchers' role in this phase is to facilitate the exchange among the participants of the different ways the experiments are conducted and to provide information where required. The mechanisms used include interviews, group discussions, field visits and participant observation, combined with PRA tools. During the establishment of farmers' experiments the researchers discuss their ideas and reasons for experiments with individual farmers and support their decisions with additional information.

Reflection

The information generated during the experimentation phase is documented, systematised and analysed by the participants. Evaluation criteria used by the farmers are identified and established and are made accessible to both farmers and researchers. Decisions on the next experimentation cycle are made based on the experiences of the previous cycle.

The role of the researchers in this phase is to facilitate the documentation, systematisation and analysis of the process. The researchers facilitate group meetings, both within the communities and between communities. Two-day workshops are often used to share experiences and to evaluate findings. Tools used during this phase include analysis of strengths, weaknesses, opportunities and threats (SWOT), preference ranking and 'future visioning'.

Linking the local and formal research

DIP facilitates the flow of information between the rural communities and the FMVZ-UADY. This began once research was initiated at the FMVZ-UADY on questions identified from PRA and farmer experimentation work (Anderson 1998). The sequencing of the farmer- and scientist-led research is very important: The starting point is the PRA work done within the communities. This sets the research agenda for the formal researchers and influences the way research questions are asked. The nature of the control treatments, the level of significant difference, which response variables are chosen and what level of response is sought, all depend greatly on information from the PRAs and farmer-led research process. The DIP group has made some headway in reorienting conventional research work performed at the FMVZ-UADY towards the researchable questions encountered in the community-based appraisal and experimentation phases (Anderson 1998).

The DIP Group has also developed a strategy of forging partnerships with local NGOs to involve other informed actors in the identification of researchable questions. These alliances enable the NGOs to facilitate the uptake of the outputs of the participatory research by other communities where they are involved.

Based on their experiences, DIP has identified a number of lessons with respect to methodology, technology options and scaling up:

Methodological lessons

- Food security is of top priority among the very poor; thus, initiatives focusing only on NRM issues will fail to achieve convergence.
- Farmers' innovative capacity, knowledge available resources and their priorities will be heterogeneous, resulting in different economic strategies
- When there are many individuals experimenting, the pooling of their information can fulfil the function of replication.

Technological lessons

- In smallholder systems, there is no one 'best' practice, because farmers are always making modifications to suit their specific needs.

- Specific technologies have a life span. New technologies substitute for former ones as conditions change. This implies that farmers are involved in an ongoing search for suitable options.
- New options should be presented as modifiable components rather than as fixed and final solutions.

Scaling up

- Sufficient resources for exploiting complementarity between formal and farmer research need to be committed from the onset in order to provide continuity and follow-through on R&D priorities.
- Scaling out (i.e. starting new initiatives) may be more advantageous than scaling up (i.e. replication of a pilot-scale initiative). Small grants may be a useful mechanism for stimulating scaling out.

PRIAG (Regional Program for Reinforcement of Agronomic Research on Basic Grains in Central America)

PRIAG is an example of various experiences known collectively as *Experimentación Campesina* in Spanish, hereafter referred to as Farmer Experimentation.

PRIAG emerged as a response to the erosion in public-sector capacity for research and extension. A primary objective is to increase the autonomy and self-reliance of small- and medium-scale producers in the generation and dissemination of technology, by strengthening farmer capacity to identify, obtain, modify, adapt, disseminate and use information, knowledge and technology (Jaén and Silva 1995). PRIAG's mandate is to increase the responsiveness of national research and extension systems to farmer's needs. It approaches this mandate indirectly through two main strategies (Hocdé 1997).

1. enhancing farmer's capacity to engage in dialogue with researchers and extension workers, so that they have their own specific space and role in the research-extension-farmer chain;
2. strengthening farmers' capacity to investigate and innovate.

PRIAG strives to complement existing agricultural technology generation and dissemination efforts through enabling more localised and independent innovation, while responding to the need for achieving agricultural improvement among larger populations in a cost-effective manner (S. Sherwood unpublished). Although it is firmly rooted in Farmer-to-Farmer methodologies, PRIAG has gone farther in articulating farmer and formal research.

PRIAG focuses on human resource development processes to develop linked cadres of Farmer Experimenters (FE) and Farmer Communicators (FC) (Jaén and Silva 1995). A number of organisations in various Central American countries take part in PRIAG (see Table 2), but discussion will focus on PRIAG-Panama and Guatemala[12 13].

Agricultural professionals (facilitators) from Panama's national agricultural research institute (IDIAP) and the Ministry of Agricultural Development (MIDA) identify Farmer Experimenters (small- and medium-scale producers of basic grains) based on the criteria in Figure 2. After training in basic presentation skills, Farmer Experimenter participate in a workshop facilitated by professionals from IDIAP or MIDA, where they present their experiences, identify the agricultural problems in each of their communities and brainstorm solutions. After the workshop, training in basic project formulation skills is provided, and the Farmer Experimenters meet with IDIAP and MIDA facilitators to prioritise the problems identified in their communities and to formulate research projects.

The objective of FE experiments is to evaluate potential technological alternatives. Each farmer experimenter develops and presents his/her annual research work plan at a local planning and evaluation workshop. At these workshops, which last 3–5 days, Farmer Experimenters, extension agents and researchers present the results of their previous season or cycle of research, so that it can be evaluated by all present. Then the three groups of actors present proposals for the upcoming cycle. The Farmer Experimenters can reject the proposals of formal researchers and vice versa (Hocdé 1997). The execution of the work plan developed by the Farmer Experimenters is their responsibility; however, 'collegial' support (Biggs 1989), oriented towards promoting the non-formal, indigenous experimentation systems in existence, is available from IDIAP and MIDA staff.

A number of training 'modules' were developed by IDIAP and MIDA to meet demands expressed by the Farmer Experimenters and in response to knowledge gaps identified by the Farmer Experimenters and the facilitators[14].

Once the Farmer Experimenters have compiled results from their experiments, training is provided in simple data analysis and interpretation methods. Each Farmer Experimenter presents results in a

[12]PRIAG teams are also found in Costa Rica, El Salvador and Nicaragua. Each team innovates in response to the local context.

[13]The agencies involved in Panama are the national agricultural research institute (IDIAP) and the Ministry of Agricultural Development (MIDA).

[14]The training modules are Farmer Research; Methods of knowledge transfer; Monitoring and Evaluation; Soil Conservation, Crop Agronomy and IPM.

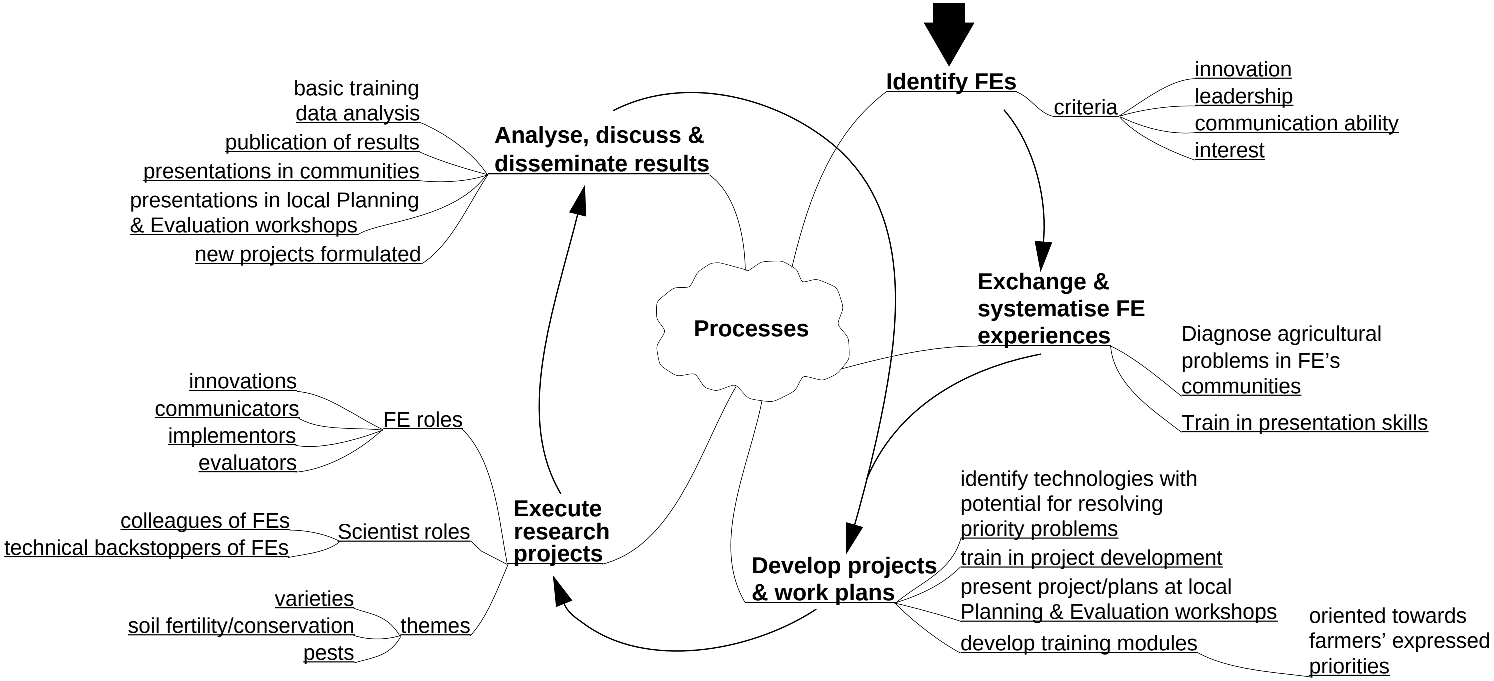

Figure 2. Processes associated with Farmer Experimenters in the PRIAG-Panama experience (Jaén and Silva 1995). The thick arrow indicates the initiation point.

workshop held in his/her community and in a local workshop. Both are attended by other farmers and by MIDA and IDIAP facilitators. New research projects are formulated at these workshops, thereby continuing the cycle and building upon previous experience. This process allows experimenting farmers and researchers to refine their research and provides mutual feedback on relevant topics as input to the agendas of Farmer Experimenters, scientists and other agricultural professionals.

In the PRIAG approach, the FE processes are linked to another set of processes that stimulate the flow of the research results though existing local information channels and networks. Farmer Experimenters with innate ability as communicators[15] are identified and trained in information diffusion methods, with development and delivery of radio programs by farmers, for farmers, as a central element in some cases. Other communication modalities include field days, exchange visits and community meetings, planned, organised and facilitated by Farmer Experimenters. Visiting other farmers' experiments requires Farmer Experimenters with different kinds of facilitation and communication skills than those required by Farmer Experimenters working as radio correspondents.

In Guatemala, Farmer Communicators have been trained as radio program developers and presenters in workshops, where they produced and broadcast radio shows. After the Farmer Communicators developed the themes to be presented, these were recorded and evaluated in plenary workshop sessions and recordings were finalised based on the resulting feedback. Farmer Communicators learned how to combine the agricultural content with music, drama, advertising humour and other elements. Programming was developed in local languages in some cases. To scale up the process, successful Farmer Communicators committed time to training new Farmer Communicators in regional workshops.

Evolution of PRIAG

The key steps in the PRIAG process are:

- helping farmers to organise and communicate;
- helping farmers to experiment;
- negotiating concerted annual work plans among interacting Farmer Experimenters, researchers and extension workers.

As these processes have unfolded, capacity building in areas critical to experimentation has taken on greater importance. New areas of capacity-building include the biology and dynamics of managed and natural ecosystems, experimental design and analysis of results. In addition, PRIAG is responding to higher levels of information demand by Farmer Experimenters by encouraging the participation of experts and the introduction of more formal scientific tools and methods of analysis (S. Sherwood unpublished).

PRIAG has not invested in the formal training of researchers and extension agents in participatory approaches to working with farmers because its primary strategies for influencing the agendas of national agricultural services were to strengthen the farmers' capacity to engage in dialogue with researchers and to improve their research capacity. Interaction with, and feedback from farmers, has influenced the setting of research priorities by scientists. Changes in attitudes have occurred in farmers and scientists alike, with sharp rises in farmer self-esteem, as they become advisors to fellow farmers and to scientists. As scientists have experimented with the additional role of facilitation, many have discovered the necessity to complement, update and improve their professional capacity. Nevertheless, many have become discouraged by the magnitude of the changes required in their modes of working. Continued strengthening of the whole PRIAG process requires that the technology supply be increased dramatically, and stronger participation of the formal research system is viewed as essential for the further development of the approach (H. Hocdé and B. Triomphe, unpublished). PRIAG now aims to enhance processes and mechanisms for more demand-driven research and to introduce new actors to agricultural knowledge and technology generation.

A key strategy used by PRIAG to foment FE process is the organisation of well-structured exchange visits between Farmer Experimenters, supported by teams of professionals from national agricultural research services, NGOs or other projects. Exchanges involving PRIAG teams composed of four Farmer Experimenters and one scientist or extension worker have proved an effective way to foment innovation and share experiences. The exchanges involve organisational as well as technological issues (Hocdé in press).

PRIAG's view to the future is that Farmer Experimenters need to be well organised in order to be able to pressure national agricultural services to respond to their needs effectively. Strong Farmer Experimenters are necessary, but not sufficient. PRIAG believes that producer organisations also need to become better organised if they are to respond more effectively to the problems of their members and to exert pressure on research services.

PRIAG has concluded that successful initiatives are those that strengthen critical thinking, organisational

[15]The other criteria for selecting FCs were high interest level and leadership capacity.

and operational abilities, and other life skills. PRIAG has identified the following lessons learned with respect to global strategy and methodological issues:

Global strategy

- The capacity to experiment and innovate, and to manage these processes (including the selection of Farmer Experimenters) should be in the hands of producer organisations that can defend the interests of smallholder families. This requires strengthening the negotiation skills of producer organisations. If producer organisations do not exist, mechanisms for stimulating their formation should be given priority.
- Relationships between producer organisations and agricultural research and extension services should be formalised in order to foment a culture of mutual accountability.

Methodological issues

- Farmer Experimenters should be considered not only as users but also as generators of knowledge and information.
- Farmer Experimenters should be selected by producer organisations based on their capacity for innovation and communication.
- Effective communications mechanisms among different actors (e.g. farmer to farmer, between farmer and scientist) are essential.
- A diversity of organisational and methodological approaches should be encouraged.
- Linkages with a diversity of actors and sectors should be encouraged in order to avoid the creation of self-limiting FE 'ghettos' and to diversify the scope of FE experience towards non-agricultural as well as agricultural problems.
- Entry points such as IPM, soil fertility and NRM, should be combined and integrated.
- Limited farmer research experience in animal husbandry has resulted in a paucity of methodological approaches for this area. This is a gap that requires attention.
- It is critical that the information generated via the experiments conducted by Farmer Experimenters should be sufficiently rigorous and reliable for it to be transmitted confidently to other farmers.

Complementary lessons from other farmer-led approaches (Table 1) summarised by Larrea and Sherwood (in press) include:

- Technology as the exclusive or primary focus of projects should be avoided. Technologies are tools, and tools alone are not enough to tackle the social issues underlying poverty and natural resource degradation.
- Motivation to participate should be inspired by recognisable successes, not by paternalism in the form of gifts or subsidies.
- Starting small is important. Projects should avoid unnecessary complexity and demands on time and resources. Starting with simple, manageable projects permits people to build up their confidence and abilities without having to assume substantial risk.
- As participants gain experience, the scale and complexity of research projects can be increased and new priorities can be taken on.

An interactive experience

Local agricultural research committees (CIALs)

A CIAL is a local research service belonging to and managed by a rural community. The research team is made up of volunteer farmers, chosen by the community for their interest in and aptitude for research. The main objectives (Figure 3) are to strengthen the capacity of rural communities as decision-makers and innovators of agricultural solutions, and to increase their capacity to influence and exert demand on the formal R&D system. CIALs link farmer-researchers with formal research services, thereby increasing the capacity of local communities not only to exert demand on the formal system but also to access new skills, information and research products that could be useful at the local level.

The first CIALs were established in the Colombian province of Cauca in 1990 by the CIAT participatory research project. Since then the approach has spread to other countries in South and Central America. Today 36 institutions, including governmental organisations, and universities in eight countries, have established nearly 250 CIALs (Ashby et al. in press).

Successful CIALs require that facilitating organisations adhere to the following basic principles:

- Knowledge is generated through learning by doing, and building upon experience.
- The foundations of the interactions among the CIAL, community and external actors are mutual respect, accountability and shared decision-making.
- Technologies are generated and/or modified through systematic comparisons of alternatives in a participatory process.
- The research products are public goods.
- Partners share risks inherent in research.

The staircase (Figure 4) is a metaphor for the iterative process followed by the CIALs.

Facilitating the process

Facilitation, like monitoring and evaluation, is depicted as a pillar that supports all the other CIAL processes. The farmers providing the research service have a formal link with a research institution mediated by a trained facilitator. He/she may be a farmer who has been a CIAL member or a professional from an NGO, research institution or extension service. The facilitator initiates the CIAL process by convening a motivational meeting in the community and supports the CIAL members until they are able to manage the entire process independently. The facilitator must respect local knowledge and accept risk as a normal characteristic of experimentation.

Training in CIAL processes is provided in the community through regular visits by the facilitator. It equips the local farmer research team to conduct experiments that compare alternatives with a control treatment and that employ replication in time and space. The training also familiarises the farmer researchers with terminology that will give their results credibility with the formal research system,

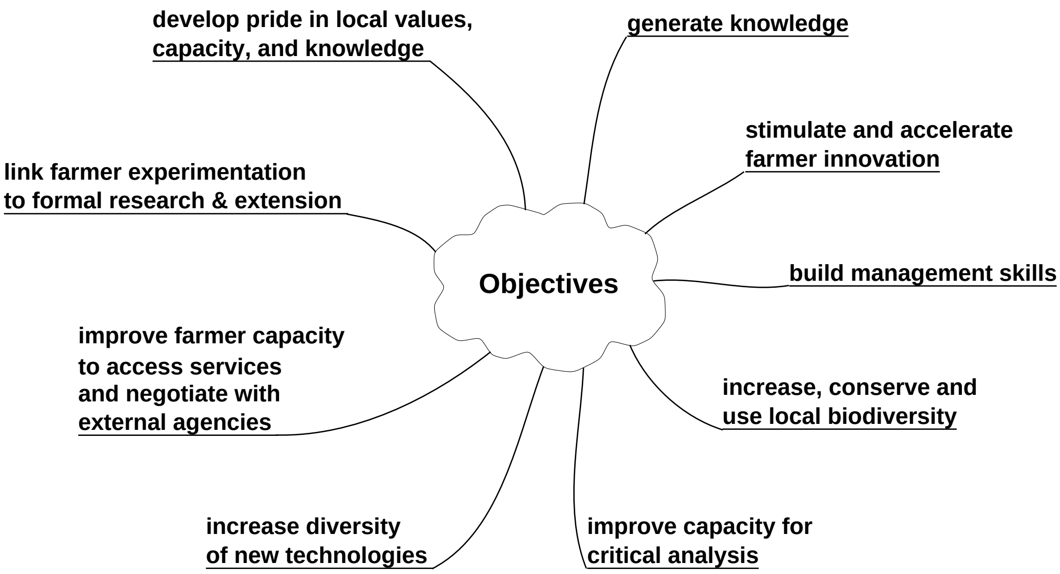

Figure 3. The CIAL objectives.

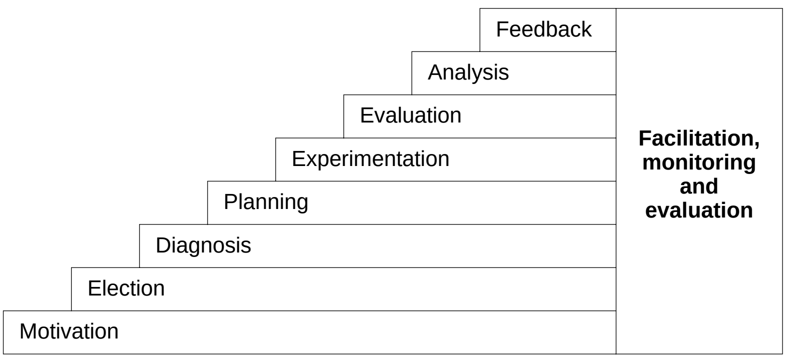

Figure 4. The research staircase, a metaphor for the iterative CIAL process.

but that is communicable to local people. The training also builds skills related to planning, management, meeting facilitation, monitoring and evaluation; record keeping and simple accounting. To reinforce the development of these skills, the facilitator encourages regular communal or collective reading aloud and group discussion of the CIAL handbooks by the farmer research team and as many others as are interested.

Facilitators are expected to respect the research priorities established by the community and the decisions made by the farmer research team in defining experimental treatments and evaluation criteria, generating recommendations and managing research funds.

Profound changes are needed in the relationships among farmers, rural communities and agricultural professionals if all the CIAL processes are to be executed successfully. A change of attitude is frequently required before a professional is capable of forming and facilitating a CIAL. The training of facilitators therefore begins with a sensitisation process and learning new communication skills. The first lesson is to avoid the leading questions that so often characterise a researcher's interactions with farmers. Instead, facilitators learn how to ask open questions that permit true two-way communication with their clients. Another change that facilitators must make—but one that is even more difficult to achieve – is to cease promoting their organisation's agenda.

A facilitator begins training with a 2-week course and continues throughout the formation of his or her first CIAL. During the first year of work with the CIAL, he/she has the support of a professional trainer with several years of experience as a facilitator. The trainer visits the CIAL at key moments (diagnosis, planning and evaluation; see below), monitors processes and provides feedback to the committee and to the facilitator, and points out strengths and weaknesses. After the first year, a yearly follow-up ensures that the facilitator and the CIAL have access to an expert with experience in subsequent phases of the process as the CIALs evolve.

Motivation

The facilitator invites everyone in the community to a meeting. Enough information about the nature and purpose of a CIAL is provided for the participants to evaluate whether they want to establish one. The facilitator asks farmers to analyse what it means to experiment with agricultural technologies or options for managing local resources. Local experience in experimentation and its results are discussed, together with the possibility of accessing technology from outside the community. If the community decides to form a CIAL, it elects a committee with a minimum of four members to conduct research on its behalf.

Managing risk

A CIAL fund is established to help absorb research risks. The fund is initiated from seed money, which may take the form of a one-off donation from the facilitating organisation. Alternatively, it may be provided from a rotating fund managed by an association of CIALs[16] (Ashby et al. in press; Humphries et al. in press), or it may be raised by the CIAL itself (N. Gamero, EAP, personal communication). The farmer research team uses the fund to procure inputs needed for their experiments that cannot easily be provided in kind locally, and to compensate members for losses incurred. The fund is owned by and is established in the name of the community. The CIAL and the community are jointly responsible for assuring that decapitalisation does not occur and are expected to contribute to building the fund through collective efforts.

Electing CIAL members

A key selection criterion for elected members is that they should be experimenting on their own, and are able and willing to provide a service to the rest of the community. CIAL members agree to serve for a minimum of one year. Each elected member agrees to take part in a regular training and capacity-building process over at least one year. Each has a specific role as leader, treasurer, secretary or communicator. The CIAL is often assisted by several additional volunteers.

Diagnosis

The research topic is determined through a group diagnosis in an open meeting of the community. The starting point for the diagnosis is the question: 'What do we want to know about?' or 'What do we want to investigate?' The objective is to identify researchable questions of priority to the community. The topics generated by the discussion are prioritised by asking questions about the likelihood of success, who and how many are likely to benefit, and the estimated cost of the research.

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[16]Thus far, CIAL associations have been established in Colombia (CORFOCIAL) and Honduras (ASOCIAL).

The research cycle

The iterative research process includes the following steps:

- *Planning*
  The experiments carried out by the farmer-researcher team generate information on technological options of local or external origin that are of interest to the community. The experiments do not demonstrate technologies or teach principles. Alternatives from outside the community need not be finished products. Offering access to technology while it is under development, and making adjustments based on the feedback obtained from the CIAL, is a powerful mechanism by which research organisations can respond to farmer needs and priorities.
  The facilitator helps the farmer-researcher team obtain the information required to plan the experiment. Other farmers and staff of formal research and extension services are often consulted. If the information gathered indicates that the selected topic should be modified, this is discussed at a community meeting.
  The facilitator helps the CIAL formulate a clear objective for each experiment. The objective should guide the CIAL in all the decisions it makes from design to evaluation. Based on the objective, the CIAL decides what, how and when to evaluate the trial. It also determines levels of experimental variables, criteria for evaluating results, comparisons to be made, data to be collected and measurement units to be used.
- *Establishment and management of the experiment*
  The CIAL carries out the experiment as planned. The costs of the inputs are covered by the CIAL fund.
- *Evaluation*
  The farmer-researcher team meets with the facilitator to evaluate the treatments, compare them with the control and record the data.
- *Analysis*
  The CIAL draws conclusions from the experiment. Their analysis includes the question: 'What have we learned?' Analysis of the process is especially important when an innovation is unsuccessful or when unexpected results are obtained.

Iteration of processes

The facilitator guides the CIAL through three successive experiments. In the first, known as the exploratory or preliminary experiment, the CIAL tests innovations on small plots. There may be several treatments, such as different crop varieties, fertiliser amounts or types, sowing dates or densities. The exploratory trial is a mechanism for eliminating options that are unlikely to succeed under local conditions. If the objective is to compare the performance of different crop varieties, eight to ten materials may be planted including at least one local control, and the area planted may be in the order of three to four replicates of eight to ten rows, each five metres long. The treatments selected as the most promising are then tested on larger plots in a second experiment. In a comparison of varieties, the second experiment might consist of five materials planted in ten rows ten metres long. Finally, two or three top-performing choices are planted over a still larger area in the third experiment, often called the production plot. A production plot for top choice varieties might consist of three or more replicates of 20 to 30 rows of 20 to 30 m. After this, the CIAL may continue with commercial production if it wishes, or switch to a new research topic.

To begin on a small scale is fundamental. Small plots provide the CIAL with the experience of applying new concepts such as replication and control and allow it to gain confidence before moving to larger and therefore riskier scales. Small-scale experiments allow the CIAL to screen out options that have little likelihood of success.

As the CIAL becomes proficient in managing the process, the facilitator reduces the frequency of visits. The number generally drops from two visits per month for new CIALs, to one every three or four months in mature CIALs (for a contrasting case see Humphries et al. in press). The main purpose of facilitator visits to mature CIALs is to acquire feedback on research priorities and results, and to provide the CIAL with access to technology under development by formal research services.

Providing feedback

Open meetings are held with the community on a regular basis. The CIAL presents its activities, reports on progress and makes recommendations based on its experiments. It also reports regularly on the state of its finances. This is essential in creating a climate of accountability to the community and ensuring that research products become public goods. In turn, the facilitator is responsible for ensuring that CIAL research priorities and results reach the formal research system.

Monitoring and evaluation

Monitoring and evaluation is a mechanism for building mutual accountability among partners in the CIAL process. The community evaluates the performance of the farmer-researcher team and may decide to replace any member. The CIAL keeps records of its experiments, which belong to the community and are available for consultation. The farmer-researcher team is also responsible for the appropriate use of the CIAL fund. It should inform the community of financial decisions, expenditures and cash inflow.

The CIAL formally evaluates the support received from the facilitator and shares these results with the community and with the facilitating organisation. Experienced trainer-facilitators visit CIALs formed by new facilitators to monitor the evolution of the CIAL process and provide timely feedback to both the facilitator and the CIAL members. They assess the CIAL's understanding of the research process and capacity for self-management.

Evolution of the CIAL process

Complexity of research issues.

The majority of CIALs initiate their work as community research services with experiments involving germplasm. These CIALs are generally trying to increase productivity of staples such as maize, beans, potatoes or cassava in order to improve food security. Women's CIALs are often concerned with improving family nutrition and may decide to investigate production of protein sources such as soybeans or small livestock. As food security improves, CIALs generally begin to search for ways to generate more income, often seeking to diversify production to include non-staple species. Many experiment with fruit or vegetables at this stage.

Beginning with research on varieties, or new crop species, creates a firm basis for maturation and evolution. CIALs researching germplasm-related issues can obtain useful results from small-scale experiments and thus build their confidence. Those that begin with a poorly defined or overly complex research objective often experience frustration; and, if the facilitator is not successful in helping them extract lessons from a 'failed' experiment, they may become demotivated and cease their activities. As CIALs become more experienced, they are better prepared for and more apt to tackle more complex issues, such as pest or disease management or soil fertility problems. Nevertheless, pest and soil problems generally require consideration of scale issues, more sophisticated problem-solving capacities and integration of strategies. They also require knowledge of biological and ecological processes. Finding ways to build this knowledge is a current challenge facing the CIAL approach. The solution may involve integrating participatory mechanisms for building upon and enriching local knowledge.

One of the most difficult changes to achieve in a facilitator is that she/he is able to resist promoting, consciously or subconsciously, her/his organisational agenda. Respect for farmer knowledge and priorities is therefore heavily stressed in facilitator training as part of the effort to avoid biasing CIALs with researchers' priorities and concepts. The intention of preventing the intrusion of organisational priorities and agendas into CIAL decision-making may also explain the lack of an explicit enrichment element in the CIAL process. Nevertheless, CIALs can and do make requests for training to their facilitators, and training on Integrated Pest Management (IPM) is one of the commonest. As enrichment processes are optional, CIALs have not yet fully capitalised on available participatory learning approaches, such as the Farmers Field School (FFS) (Braun et al. 2000) or the CATIE-IPM experience. The result is that CIALs confronting pest problems, for example, may not go beyond comparing pesticides because they may lack the biological and ecological knowledge required to formulate research objectives that reflect a search for ecological alternatives and strategies for the management of ecological problems.

Because of the emphasis on risk management, the CIAL process is initiated with small-scale experiments. However, many biological or ecological processes occur over larger scales, and some problems cannot be managed on a plot or field scale. Management of resources such as water, soil or natural enemies, for example, often requires coordination of action beyond the boundaries of a single landholding. Scale and related collective-action issues need to be addressed explicitly when research objectives are formulated and in the planning, execution and analysis of experiments. At present, these issues are not explicitly addressed in the training of CIAL facilitators; consequently, they are rarely addressed during the research process itself. Incorporating participatory learning mechanisms, either directly within the CIAL or indirectly through establishment of linkages to participatory learning initiatives, is an evolutionary direction that could enhance the capacity of the more mature CIALs to undertake more complex research challenges.

Maintaining motivation in poor communities

The organisations working with CIALs have generally focused their efforts in poor communities. Several interrelated management issues have emerged from this choice. Firstly, concrete improvements in wellbeing are often important for maintaining the motivation of the CIAL members and for retaining the support of the sponsoring community. CIAL participation in community development activities has been an effective way of increasing interest and participation in CIALs in very poor hillside communities of Honduras (Humphries et al. in press). Several types of community-development projects have been conducted by these CIALs in addition to their research. Examples include:

- training in food processing techniques;
- germplasm multiplication initiatives;
- formation and facilitation of new CIALs (often for women);
- vaccination campaigns;
- campaigns to protect and conserve water resources;
- education of schoolchildren in the research process;
- establishment of rotating credit schemes.

Such projects create social cohesion and permit the CIALs to undertake longer-term research while ensuring their sustainability as research services.

Secondly, where poverty is deep and social capital[17] is low, CIAL members may be motivated to privatise research products and other benefits resulting from the CIAL process. There may also be a tendency for the CIAL to be composed of the better off members of the community. These and other factors can feed upon each other, causing friction and resulting in violation of the CIAL principles by the CIAL itself. Monitoring by the facilitator and the skilful and timely introduction of corrective actions is critical. In Honduras violations of the CIAL principles related to public goods and accountability have been successfully managed by investing effort in obtaining the participation of marginalised individuals or groups and by opening up the CIAL process to more members (Humphries et al. in press).

CIAL associations

An analysis of failed CIALs (Ashby et al. in press) showed that discontinuation of activities is often related to lack of continuity in program goals, staffing and funding among supporting organisations and to paternalistic policies, resulting in violations of the principles of mutual accountability and risk-sharing by partners. In search of a more stable institutional framework for the CIALs, CIAT facilitated the establishment of CORFOCIAL, an association of the 46 Cauca CIALs as a means of stimulating a higher degree of self-management and autonomy. CORFOCIAL has absorbed many CIALs that were inadequately supported or abandoned by their original counterpart organisations. CORFOCIAL organises annual CIAL meetings in Cauca and has sponsored a large number of cross-training visits and other enrichment activities. It has also provided loans to launch a number of agro-enterprise development projects and helped obtain seed money for several more. The Association has obtained its legal status, is learning to manage administrative and technical responsibilities, and is developing a solid bridge between member CIALs and research organisations.

Taking the CORFOCIAL model as a starting point, Participatory Research in Central America (IPCA)[18] facilitated the formation of ASOCIAL in Honduras in 1999. One of ASOCIAL's priorities is to provide mechanisms for replenishing and incrementing the CIAL fund. A second related priority is the diversification of CIAL activities. Both strategies stimulate the flow of benefits to the communities and help sustain motivation and participation in the CIAL process.

Many CIALs submitted projects to ASOCIAL requesting loans for commercially oriented production of maize, beans, pigs or chickens. Upon sale of the produce raised via the project, each returns its loan plus a small amount of interest to ASOCIAL and deposits the remainder in its own fund. An additional benefit is the building of local capacity in the formulation and presentation of projects. Other benefits from ASOCIAL activities include:

- the establishment of community shops that reduce the cost of purchasing basic products, increase opportunities for commercialisation of local products and reduce the time and money spent on travel to commercial centres,
- the establishment of rotating savings and credit systems to increase savings capacity and provide a source of credit that does not require extensive paperwork or collateral.

These accomplishments testify to the capacity of a second-order organisation to contribute to sustainability by promoting broader community development objectives and overcoming the limitations of formal research organisations, the narrow mandates of which constrain their role in development.

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[17]The concept of social capital was introduced by James Coleman in 1988 and has been expanded upon by Bourdieu (1993), Putnam (1993) and Fukuyama (1995). In the 1950s economists hypothesized that the key difference between rich and poor countries lay in the amount of physical capital. After disappointing foreign assistance experiences in less-developed countries in the 1960s, the concept of capital was broadened to include human capital. More recently, the focus has broadened again to include institutional requirements for economic growth such as social networks, legal frameworks and relations of trust, summed up under the heading of social capital and reviewed by Harriss and de Renzio (1997) and by Wall et al. (1998). Putnam's definition (1993) of social capital is: *Features of social organisation, such as networks, norms and trust, that facilitate co-ordination and co-operation for mutual benefit.* Wilson (1997) defines social capital *as a propensity for individuals to join together to address mutual needs and to pursue common interests.*

[18]Investigación Participativa en Centro America.

Lessons learned

Institutional issues

- Institutional commitment to the CIAL approach translates into investment in training facilitators and committing sufficient time and resources so that facilitator responsibilities to the CIALs are fulfilled. Unless there is serious commitment on the part of a supporting institution, the principles of the CIAL process will be violated. When this occurs, CIALs often discontinue their activities unless there is a CIAL association that can fill the gap.

  The quality of facilitation is of paramount importance. Facilitators must be able to guide the CIAL process without dominating it and to cede responsibility to the CIAL as its capacity to manage the process independently develops. They must be flexible enough to deal with evolutionary changes as the CIAL matures. Additionally they must be able to monitor processes within the CIAL and relationships between the CIAL, the community and other external actors and be prepared to negotiate or facilitate solutions to the problems that will inevitably arise.
- The formation of regional and national associations of CIALs greatly enhances their sustainability and potential as community services. The benefits of CIAL organisations are many and include:
  1. Enhanced communication and exchange of research products among CIALs;
  2. development of local management, organisational and negotiation skills;
  3. building of financial capital that can be used to undertake community development projects, initiate new CIALs, build CIAL funds, decrease dependence on external actors and thus ensure their sustainability;
  4. increased credibility with governmental and other formal services and enhanced ability to influence and exert demand on them.

Methodological issues

- Establishing CIALs in very poor communities requires particularly good facilitation, monitoring and evaluation skills. Literacy and other skills are generally at lower levels in poorer communities, hence more time may be required to master the CIAL processes. If the capacity for association (social capital) is low, greater emphasis on planning, the establishment of norms and on negotiation of responsibilities will be required. Larger CIALs that increase representation of women and other marginalised groups have been found to reduce the risk of privatisation of benefits under such circumstances.
- The length of time required to realise benefits from the CIAL process is often important in poorer communities. Research themes that bring about concrete improvements in food security, such as evaluation of varieties of staple crops, can help build confidence and maintain the motivation level. Embedding CIAL research activities within a broader community development context is another way of securing the flow of short-term benefits. Credit/savings schemes, rural stores and project development support, are examples of types of community development activities that can be catalysed by CIALs. The establishment of CIAL associations increases local capacity for such undertakings.
- Second-order associations (ASOCIALs) can be created once there is a nucleus of CIALs functioning in a given area. These associations can consolidate efforts among member CIALs, provide information and networking services, feedback to institutions, training opportunities and facilitate horizontal diffusion of technology.

Ashby et al. (in press) provide information on the institutional costs of establishing CIALs and analyses of the impact CIALs have had on local experimentation and innovation, diffusion of technologies and on levels of well being in poor communities.

Cross-cutting Lessons from Farmer-to-Farmer, DIP, PRIAG and CIALs

- All four experiences draw upon the concepts of Freire and Fals Borda of rejection of passive knowledge banking in favour of active knowledge acquisition and generation. These experiences view farmers not only as users but also as developers and transmitters of knowledge and of technology. Other concepts which have also been mapped over to these FPR cases from earlier participatory research experiences include the interaction of processes, the cycling of action[19] and reflection[20], and the importance of feedback as keys to ensure learning from the experimentation process.
- Each experience has generated diverse tools and methods to support the practice of FPR. All four use PRA tools to facilitate communication with farmers and rural communities; however, the

[19]Action refers to processes such as planning, experimentation and evaluation

[20]Reflection refers to processes such as analysing results and also extracting what has has been learned from the process itself.

application of these tools is not synonymous with FPR, which has been defined as the involvement of farmers in decision-making at all stages of the research process.

- A common thread running through all four experiences is the importance of building confidence and reducing risk when innovations are being tried. Risk management usually involves starting on a small scale.
- The farmer-led and interactive experiences are convergent, both recognising that the development of knowledge and technology is synergised when it occurs in a process involving different types of actors. This convergence is also manifested in similarities in principles and processes. The coexistence of approaches at different points along the continuum from farmer-led to interactive invites a multi-tiered approach involving the integration of networks of rigorous farmer researcher 'experts', less rigorous community-based research networks, and large-scale individual, non-formal experimentation.
- A conclusion common to all the cases presented is that the essential factor in strengthening farmer innovation capacity is not technology per se but rather the construction of social processes that support experimentation and learning. This is an incentive towards moving beyond supporting individual innovators to support diverse forms of experimenter groups (e.g. isolated or inserted in communities, producer organisations). The experiences of DIP, PRIAG and CIALs suggest that these processes should involve the articulation of different actors. In the cases of PRIAG and CIALs, the focus on multiple stakeholder linkages has led to the formalisation of responsibilities (e.g. concerted annual work plans in PRIAG and definition of roles and responsibilities for CIAL members and facilitators).
- A number of concepts emerge from this analysis that were not common in the FPR literature some 5–10 years ago. These include mutual responsibility, accountability and the convergence of agendas or shared decision-making. This reflects an evolution towards a more actor- and process-oriented perspective (see also Cramb 2000) as evidenced by:
  1. New criteria for identifying and prioritising research themes such as likelihood of success, analysis of who benefits,
  2. The offering of technological options that are in early stages of development by formal research services.
  3. Evaluating the utility of experimentation not only in terms of results (e.g. resistance to pests or higher yields) but also in terms of what has been learned through the process.

The importance of 'outsiders' with high-quality facilitation and interaction skills is a common conclusion of the DIP, PRIAG and CIAL experiences. The outsiders may be individuals (as in the CIAL approach) or a team (DIP, PRIAG). Nevertheless, in those situations where outside expertise is unavailable and the small farmers cannot count on their valuable support, they themselves can foment the farmer research process, as occurred in the Farmer-to-Farmer approach in Nicaragua and in Central America.

- An interesting difference among the four experiences lies in the identity of the group that catalysed the process. In Farmer-to-Farmer, DIP, PRIAG and CIAL the original protagonists were, respectively, a farmer organisation, a university, an externally funded international cooperation project and an international research centre. Future analyses of impact might do well to consider this difference and examine in detail how each actor constructed strategies and mechanisms to promote sustainability.
- There is an interesting twist to the common conclusion that capacity to innovate is the key rather than the development of specific technologies. The term Farmer Participatory Research, which has been so useful during the 90s, now seems to fall short of describing or representing the full spectrum of the innovation processes that have been activated. Farmers involved in participatory research approaches are not restricting their interactions and activities to agricultural research. NRM, education, health, local government and even information and communication systems have become arenas of interaction, involving new actors.
- The experiences analysed have generated an atmosphere of critical analysis, and each contributes important elements to the debate surrounding the role of farmers and formal researchers in agricultural development and NRM.
- Each has incorporated internal mechanisms for monitoring and evaluation, and has made adjustments based upon these. This suggests that FPR approaches themselves must be capable of evolution if they are to respond to the rapidly changing circumstances in agriculture and NRM.
- None of the experiences presented has been able to accomplish fully the objectives for FPR suggested by Okali et al. (1994):
  1. changing the orientation of existing R&D structures;
  2. developing sustainable community-based research capability;
  3. creating new social and political institutions.

They have, however, demonstrated that it is possible to increase community research capacity, and they have made some progress towards changing the orientation of existing R&D structures. Achieving sustainable community-based research processes and organisations is still a major challenge. Placing the community research process in the hands of farmer organisations is an important first step in this direction.

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References

Anderson, S. 1998. Research centres and participatory research; issues and implications. In: Blauert, J. and Zadek, S. ed. Mediating Sustainability, Mexico, Kumarian Press, 304 p.

Ashby, J.A. 1996. What do we mean by participatory research in agriculture? In: New Frontiers in Participatory Research and Gender Analysis. Proceedings International Seminar on participatory research and gender analysis (PRGA), Cali, Colombia 9–14 September 1996. Cali. Centro Internacional de Agricultura Tropical (CIAT) Publication No. 294, 15–22.

Ashby, J.A., Braun, A., Gracia, T., Guerrero, M.P., Quirós, C.A. and Roa, J.I. in press. Investing in Farmer Researchers: Experience in Latin America. Centro Internacional de Agricultura Tropical, Cali, Colombia.

Bentley, J.W. 2000. The mothers, fathers and midwives of invention. Zamorano’s Natural Pest Control course. In: Stoll, G. ed. Natural Crop Protection in the Tropics: Letting Information Come to the Life. Tropical Agroecology Series, Weikersheim, Margraf Verlag.

Biggs, S.D. 1989. Resource-poor farmer participation in research: a synthesis of experiences from nine National Agricultural Research Systems. The Hague, OFCOR Comparative Study Paper 3, ISNAR, 37 p.

Bourdieu, P. 1993. Sociology in Question, London, SAGE Publications, 192 p.

Braun, A.R., Thiele, G. and Fernández, M. 2000. Farmer Field Schools and Local Agricultural Research Committees: Complementary platforms for integrated decision-making in sustainable agriculture. AgREN Network Paper No. 105, ODI, UK. 20 p.

Bunch, R. 1982. Two Ears of Corn. A Guide to People-Centered Development. Oklahoma, World Neighbours, 250 p.

Bunch, R. 1990. Low input soil restoration in Honduras. The Cantarranas Farmer-to-Farmer extension program, IIED, Gatekeeper Series No. 23.

Bunch, R. and López, G. 1994. Soil recuperation in Central America: Measuring impact 4 to 40 years after intervention. Honduras, COSECHA, 18 p.

CGIAR 1999. Program on Participatory Research and Gender Analysis, Crossing Perspectives: Farmers and Scientists in Participatory Plant Breeding. Cali, Colombia, CIAT, 46 p.

Chambers, R. and Ghildyal, B.P. 1985. Agricultural research for resource-poor farmers: the farmer-first-and-last model. Discussion Paper #203. Institute of Development Studies. Brighton, England, University of Sussex,. Also in Agricultural Administration, 20: 1–30.

Chambers, R., Pacey, A. and Thrupp, L.A. ed. 1989. Farmer First: Farmer Innovation and Agricultural Research. London, Intermediate Technology Publications, 218 p.

Coleman, J.S. 1988. Social capital in the creation of human capital. American Journal of Sociology, 94: 95–120.

Conway, G. 1997. The Doubly Green Revolution: Food For All in the 21st Century. Ithaca, NY, Cornell University Press, 334 p.

Cramb, R.A. 2000. Processes influencing the successful adoption of new technologies by smallholders. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings (See Contents).

Fals Borda, O. 1985. Knowledge and People’s Power. New Delhi, Indian Social Institute.

Fals Borda, O. 1987. The application of participatory action research in America. International Sociology, 2(4): 329–347.

Farrington, J. and Martin, A. 1987. Farmer Participatory Research: A review of concepts and practices. Agricultural Administration Network, Discussion Paper 19, 88 p.

Freire, P. 1970. Pedagogy of the Oppressed, New York, Continuum International Publishing Group. 164 p.

Freire, P. 1973. Education for Critical Consciousness, New York, Continuuy International Publishing Group, 180 p.

Fukuyama, F. 1995. Trust: The Social Virtues and the Creation of Prosperity, Toronto, Penguin. 457 p.

Gianotten, V. and Wit, T. de. 1985. Organización campesina: el objetivo politico de la educación popular y la investigación participativa. Amsterdam, The Netherlands. Latin America Studies Vol. 30. Centre for Latin American Research and Documentation. Dordrecht, ICG Printing, 531 p.

Gündel, S. 1998. Participatory Innovation Development and Diffusion: Adoption and Adaption [*sic*] of Introduced Legumes in the Traditional Slash-and-Burn Peasant Farming System in Yucatan, Mexico, Eschborn, GTZ, 79 p.

Haverkort, B., Hiemstra, W., Reijntjes, C. and Essers, S. 1988. Strengthening Farmers' Capacity for Technology Development, ILEIA Newsletter. Issue on Participative Technology Development, 4, 3, 3–7.

Haverkort, B, Kamp, J. van der and Waters-Bayer, A. ed. 1991. Joining Farmers' Experiments: Experiences in Participatory Technology Development, London, Intermediate Technology Publications, 269 p.

Harriss, J. and de Renzio, P. 1997. 'Missing link' or analytically missing? The concept of social capital. An introductory bibliography essay. Journal of International Development, 9: 919–937.

Hocdé, H. 1997. 'No quiero plata; quiero conocimientos'; no equivocarse de planteamiento. San José, Costa-Rica, PRIAG technical document, 65 p.

Hocdé, H. in press. Los intercambios campesinos: más alla de las fronteras …. Seamos futuristas! San Jose, Costa Rica, IICA- CIRAD technical document, 200 p.

Humphries, S, Gonzalez, J., Jimenez, J. and Sierra, F. in press. Searching for sustainable land use practices in Honduras: Lessons from a program of participatory research with hillside farmers, ODI, U.K., AgREN.

Jaén, B. and Silva, A. 1995. De facilitadores a protagonistas del proceso de generación y transferencia de tecnología. Segundo Simposio Latinoamericano sobre Investigación y Extensión en Sistemas Agropecuarios, Santa Fe de Bogotá, D.C., Colombia, 7–9 Nov. Reimpresión: Programa Regional de Reforzamiento a la Investigación Agronómico sobre los Granos en Centroamérica (PRIAG). San José, Documento técnico No. 18, 30 p.

Lambrou, Y. 2000. A Typology: Participatory Research and Gender Analysis in Natural Resource Management Research. In: Nina Lilja, N., Ashby, J.A. and Sperling, L. ed. Assessing the Impact of Participatory Research and Gender Analysis. Cali, CGIAR Program on Participatory Research and Gender Analysis, CIAT, 3–18.

Lammerink, M.P. and Wolfers, I. ed. 1994. ed. Selección de algunos ejemplos de investigación participativa. Programas de investigación para el desarrollo financiados por la DGIS, La Haya.

Larrea, S. and Sherwood, S. in press. Looking back to see ahead: Farmer lessons and recommendations after 15 years of innovation & leadership in Güinope, Honduras. Agriculture and Human Values.

Merlet, M. 1995. Consolidación y ampliación del programa de Campesino a Campesino Nicaragua. Paris, France, Comission des communautes europeennes, Institut de Recherches et d'amélioration des méthodes de développement, 56 p.

Mikkelsen, B. 1995. Methods for development work and research. A Guide for Practitioners, New Delhi, SAGE Publications, 296 p.

Okali, C., Sumberg, J. and Farrington, J. 1994. Farmer Participatory Research: Rhetoric and Reality, London, Intermediate Technology Publications, 159 p.

Pretty, J.N. 1994. Alternative systems of inquiry for sustainable agriculture. IDS Bulletin 25(2): 37–48.

Programa de Campesino a Campesino. 1999. La experimentacion campesina; algo más que una parcela de ensayo. Managua, Nicaragua, UNAG, 56 p.

Probst, K. 2000. Success Factors in Natural Resource Management Research: Dissection of a Complex Discourse. In: Nina Lilja, N., Ashby, J.A. and Sperling, L. eds. Assessing the Impact of Participatory Research and Gender Analysis. Cali, CGIAR Program on Participatory Research and Gender Analysis, CIAT, 19–48.

Putnam, R.D. 1993. The Prosperous Community: Social Capital and Public Life. The American Prospect, 13: 35–42.

Röling, N.G. and Wagemakers, M.A.E. ed. 1998. Facilitating Sustainable Agriculture, Cambridge, Cambridge University Press, 230 p.

Ruddell, E.D. 1994. Documentation of farmer experiments: A key strategy for achieving food security on a sustainable basis, Santiago de Chile, Vecinos Mundiales.

Scarborough, V. ed. 1995. Farmer-led approaches to extension: Papers presented at a workshop in the Philipppines, July 1995. AgRen Network Papers Abstracts for papers No. 59a, 59b and 59c. ODI. UK. (http://www.oneworld.org.od/agren/agabs59.htm)

Selener, D. 1997. Participatory action research and social change. The Cornell Participatory Action Research Network, Ithaca, New York, Cornell University, 358 p.

Sperling, L., Ashby, J.A., Smith, M.E., Weltzien, R.E. and McGuire, S. in press. A framework for analysing participatory plant breeding approaches and results. Euphytica.

Sutherland, A., Martin, A. and Salmon, J. 1998. Recent experiences with participatory technology development in Africa: Practitioner's review. Natural Resource Perspectives. No. 25. 15 pp. (http://www.oneworld.org/nrp/25.html)

Wall, E., Ferrazzi, G. and Schryer, F. 1998. Getting the goods on social capital. Rural Sociology, 63(2): 300–322.

Waters-Bayer, A. 1989. Participatory Technology Development in Ecologically-Orientated Agriculture: Some Approaches and Tools. AgREN Network Paper No. 7, 63 p.

Wilson, P.A. 1997. Building social capital: a learning agenda for the twenty-first century. Urban Studies, 34: 745–760.

World Bank 1994. Participatory Rural Assessment: Techniques to improve communication with the rural poor. Agriculture Technology Notes 6. (http://www-esd.worldbank.org/extension/key/agtech6.shtm).

Working with Farmers to Develop Forage Technologies – Field Experiences from the FSP

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Abstract

Participatory approaches to developing forage technologies present some major challenges to the researchers, extension workers and project field officers whose job it is to implement them in the field. New skills and methods are required as these development workers move from being 'implementers of government programs and promoters of technologies' to partners with farmers in the technology development process. There are many publications that describe the processes of participation but few that provide guidelines of how to implement participatory approaches in the field. This paper summarises the field experiences of development workers who implemented and adapted participatory approaches to forage technology development in Southeast Asia, and some lessons gained through the ongoing process of action-learning. The participatory approaches described in the paper were the catalyst for strong new linkages between farmers and development workers and for ongoing forage technology development on farmers' fields.

A PREVIOUS paper (Horne et al. 2000a) described the participatory approaches that were developed by the Forages for Smallholders Project (FSP) to try to improve adaptation and adoption of forage technologies on smallholder farms. One of the conclusions was that 'Many other researchers, extension workers and project personnel in Southeast Asia are familiar with the benefits of these approaches and the concepts of implementation, but are looking for practical guidelines on how to implement them in the field'.

The authors of this paper were faced with the same challenge when commencing participatory technology development in 1995. This paper highlights their subsequent experiences from the field and some lessons for future on-farm development.

Field activities of the FSP

The FSP had two main goals:

1. To identify robust, broadly-adapted forage varieties that had the potential to provide substantial impacts to smallholder farmers and
2. To develop and implement participatory approaches to demonstrate that the potential

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impacts described in Point 1 can be achieved on smallholder farms in Southeast Asia.

The processes that were followed to achieve these goals are illustrated in Figure 1.

Early activities focused on site selection (Horne et al. 2000a) and species evaluation (Stür et al. 2000; Gabunada Jr. et al. 2000). As robust, broadly-adapted forage varieties emerged from these evaluations and promising sites were selected, the emphasis of field activities shifted more towards participatory technology development. This naturally led into local expansion of forage technologies, as farmers expanded the areas of forage on their own land or new farmers in the same area started planting forages, often using vegetative planting material. As these developments started to occur, the project implemented a process of monitoring to understand the process of adaptation and adoption of forage varieties and technologies (Horne et al. 2000b).

Figure 2 shows where the on-farm technology development was implemented. At each of these locations, there was at least one development worker who implemented the process and monitored outcomes. Their on-going experiences were shared with partners both within and between countries. Despite different countries and different cultures, we found there were common livestock feeding problems with common opportunities for solving them.

These 19 sites represented six broad farming systems, most of them in the uplands (Table 1). Two sites were in the lowlands but these did not develop because of a lack of potential for impact. At all sites, we were working with resource-poor smallholder farmers. Although the farmers at some sites had access to much better resources than at others, all of them were primarily subsistence farmers producing their own food and some products for sale (e.g. cattle), but with little generation of cash.

Field Methods: Participatory Diagnosis

When commencing participatory development of forage technologies, the 'entry point' into a rural community was usually through the process of Participatory Diagnosis (Horne et al. 2000a). In this process, the people of the community were encouraged to:

- describe their resources;
- identify the main limitations in their farming systems and their livestock systems;
- prioritise the limitations in their livestock systems that they would like to resolve;
- describe how they have coped with these problems in the past; and
- discuss strategies for working on solving these problems in future.

Table 1. Number of farmers evaluating forages in each farming system[1].

Farming system	Number of sites	Farmers evaluating forages on farm
Short duration slash and burn	3	395
Grassland	3	240
Extensive Upland	3	268
Moderately Intensive upland	5	450
Intensive upland	3	385
Rainfed lowland	2	19[2]
TOTAL	**19**	**1757**

[1]Source: FSP Adoption Tree Database, 1999.
[2]Stopped after the first year.

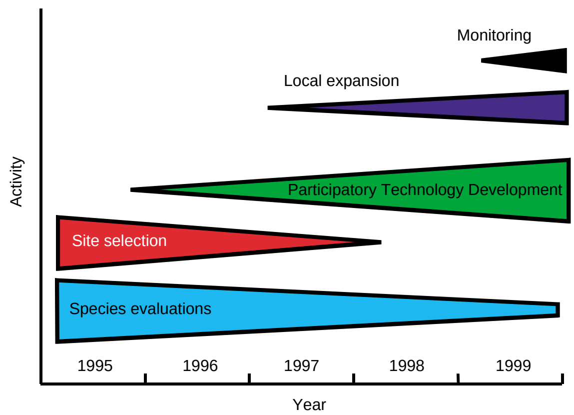

Figure 1. Field activities of the FSP.

A large range of 'tools' is available for participatory diagnosis, most of them having been developed for Participatory Rural Appraisal (PRA). We most frequently used village resource mapping, seasonal calendars and long-term calendars to understand resource availability and card&chart methods (sometimes linked with preference weighting) to analyse problems. Through this process, we were able to confirm whether there was real potential for forage technologies (as had been indicated in the site selection process).

From field experience with participatory diagnosis, we learned that:

- Participatory Diagnosis was an important first step in building trust with communities. It was the first time that we encouraged them to be partners in the process of solving their problems – a concept that often was met with initial surprise but was later readily adopted, especially after one or two follow-up visits.
- While being aware of the potential of biasing farmers' responses in the diagnosis, it was essential

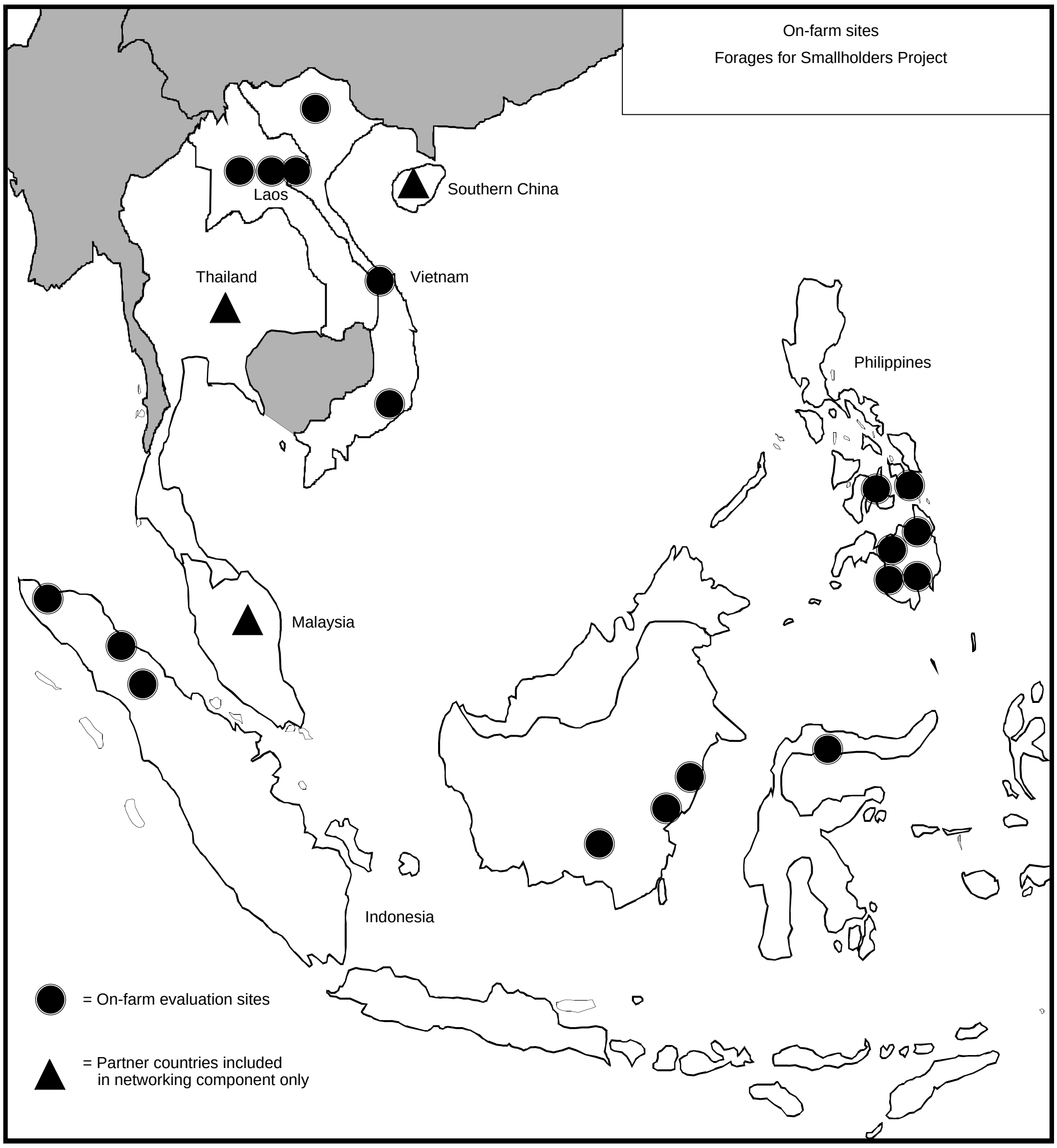

Figure 2. Location of field activities of the FSP.

to clarify from the beginning exactly what kinds of technology options we had to offer. Farmers often had unrealistic expectations of the project; expectations that were based on previous experiences with projects and programs that provided credit and other inputs in a process of 'technology injection' (which rarely worked) rather than 'technology development'.

- It was important for diagnosis to start with a 'broad scope' before focusing on livestock system problems. If we only analysed the livestock system problems, we would not understand how important these were in the overall farming system.
- Farmers were sometimes confused and surprised at the start, expecting that we had come to follow the usual procedure, where extension workers tell them what they should be doing. The very active processes of producing resource maps and calendars invariably and rapidly broke down these barriers. This was especially true for the women farmers, who frequently were shy at the beginning, preferring to observe from behind the men farmers. With encouragement and the active methods, however, they would quickly become lively participants in the process. These active methods also helped overcome the common problem of one or two farmers dominating village meetings.
- The diagnosis process was necessarily fast, frequently taking no more than one day. In most of the cultures and communities where we worked, farmers could describe their complex farming systems and analyse their problems in detail in a very short time. It is our experience that PRA, as it is often implemented in the region, is too slow and too oriented towards 'appraisal rather than action'. Farmers want quick action! They want technology options to test. We do not have to wait until we fully understand their problems and constraints before we initiate this action in the field. If so, we may wait for several years, and even then we have little hope of understanding the complexity (and, sometimes, volatility) that influences farmers' decisions in upland areas.
- For this reason, we found it useful to identify 'technology entry points' in the various farming systems. These entry points were, in our case, forage technologies that we could confidently predict would give some quick benefits for livestock feeding and contribute to building trust with the farmers. For example, an entry point in some of the upland villages of Laos and Vietnam was *Stylosanthes guianensis* 'Stylo 184' for feeding pigs. Often farmers in these areas kept pigs and were spending large amounts of time collecting, chopping and cooking pig feed. In one report, 'Forage gathered from the forest provided a very important source of protein and vitamins, making for a balanced diet of pigs. In most households in the study area, women were the main forage gatherers … [spending] … from thirty minutes to two hours to reach their gathering destinations' (Oparaocha 1997). Stylo 184 can provide large quantities of high-quality feed that can be fed directly to pigs without any processing. Another 'entry point' at several sites in Indonesia was fast growing grasses, providing cut feed for penned sheep and goats in areas where farmers were already spending a lot of time cutting native grasses each day.
- In some instances, it was necessary for the development worker to clarify the technological limits to development, so that farmers' expectations were not unrealistic. For example, in several areas farmers were hopeful that forages could help them convert communal grazing land into productive pasture. We had to explain that this was not possible without first solving the problem of uncontrolled grazing and land tenure.
- To be successful, Participatory Diagnosis requires excellent facilitation skills from the development worker, but not everyone has an aptitude for facilitation. The skills cannot be learned in a training course and cannot be learned overnight, but are developed and improved through an ongoing process of *action* (field experience) and *reflection* (evaluating what methods worked well, why and how they can be improved).
- We had initially imagined that a distinct process of action planning with the community would follow diagnosis. With farmers' desire for quick action and our identification of 'technology entry points' however, we found that action planning was a quick process that was either part of the diagnosis session or conducted with individual farmers or small farmers groups.
- The outcomes of Participatory Diagnosis are a reflection only of the views of the active participants. For this reason, it is essential to first give careful consideration as to which group of farmers you want to reach (and therefore who should participate in the diagnosis). The question to keep in mind is 'Are we talking to the right people?' If your main target group is, for example, women who keep sheep or the poorest farmers in the community, then they must be active participants in the diagnosis and subsequent technology development. One example that illustrates this well comes from a study of Hmong women farmers in northern Laos: 'The women not only own the livestock resources but control decisions made on the final outcome. All the women I met had broad and comprehensive knowledge about

the common illnesses of pigs ... [but] ... when an animal was treated with modern medicine, the medication was bought and administered by the men. With women nowhere in the extension picture, it is not surprising that the incidence of disease and epidemics in small livestock increased in the last 10 years' (Oparaocha 1997).

- The outcomes of Participatory Diagnosis need to be confirmed with the individual farmers and/or particular stakeholder interest groups, as their needs and opportunities vary greatly from individual to individual and from group to group. For example, if a diagnosis is conducted with a diverse group of farmers, including 'wealthy' cattle farmers and 'poor' farmers who only keep a few poultry, the problems identified from the group diagnosis may not accurately reflect the needs of either group.

Field Methods: Developing Forage Technologies

Two approaches to developing forages technologies on farms were used:

1. Researcher-designed and farmer/researcher-managed trials.

These were mostly regional trials which were designed to confirm the broad adaptation of promising forage varieties.

2. Farmer-designed and farmer managed trials.

Most of the on-farm technology development consisted of development workers offering farmers a range of forage varieties that were adapted to the area and had some potential to alleviate the problems identified during diagnosis. The main goal was to encourage farmers to innovate, adapt and integrate the forages on their farms, learning lessons and generating ideas throughout the process.

These are described in more detail in Gabunada Jr. et al. (2000). From field experiences with developing forage technologies, we learned that:

- Across all sites, farmers usually wanted to evaluate the new varieties in small monoculture plots, often close to their houses, before evaluating ways of integrating the preferred varieties into their farming systems. In doing so, they very often prepared clean seedbeds and planted the forages in well-managed rows. We had thought that we would have to offer labour-saving ways of establishing forages to interest farmers in evaluating them, but this proved not to be so.
- In most places, successful development occurred where individual farmers planted and developed forages on their own land rather than a group of farmers planting and managing a single plot on communal land.
- Regular visits by the development worker during the early stages of forage development, were very important to encourage farmers to persist with the evaluation and provide them with basic technical information about forages (Figure 3). Forage seeds are small and the plants grow more slowly than many of the crops that farmers already grow. The young seedlings are easily damaged by grazing or uncontrolled weed growth. Without early encouragement from development workers, farmers would sometimes abandon the evaluations without having ever reached a stage where the forages were well enough established to provide benefits.
- Development workers should always offer farmers a broad range of forage varieties/technologies to evaluate at the beginning. At many sites in the FSP, we discovered that, after seeing the different kinds of forage options available, farmers either identified other problems they could solve with forages or changed their farming practices to create new opportunities for using forages. One example was a site where farmers showed interest in growing grasses in small plots to be grazed by their cattle, but ended up expanding *Stylosanthes guianensis* 'Stylo 184' to feed their pigs. Offering a narrow range of choices at the start would have stifled this type of innovation.

Figure 3. Regular visits by the development worker build trust with smallholder farmers.

Field Methods: Evaluating Forage Varieties and Technologies

Once farmers had been evaluating forage options for at least one season, we used a process of participatory evaluation to understand:

- which varieties/technologies they liked and why;
- which varieties/technologies they did not like and why;
- what problems they had encountered; and
- what they planned to do in the following season (expand?, test new varieties?, test new ways of integrating varieties into their farming systems?).

During Participatory Evaluation in the field, individual farmers were asked to describe their preferences for the different varieties by either:

1. **Preference Ranking** of the varieties they had been evaluating (where '1' = the best variety, '2' = the next best and so on) OR
2. **Preference Rating** of the varieties they had been evaluating (on a scale of 0–10 where '0' = very poor and '10' = excellent) OR
3. **Preference Weighting** of the varieties they had been evaluating (allocating 50 'counters' between the varieties, where the more counters given to each variety, the more highly it was preferred)

'Preference Ranking' was not used very often because it did not give any indication as to the extent a farmer liked one variety relative to the others, and very often farmers preferred one or two varieties much more than the others. The advantage of 'Preference Rating' was that it told us how much farmers preferred each variety on both an absolute and a relative scale. Sometimes, however, farmers would give similar ratings to many or all of the varieties (maybe to please the development worker), as shown by Farmer 'C' in the example in Table 2. In these cases, 'Preference Weighting' was useful to help separate the farmers' preferences, but on its own, 'Preference Weighting' did not tell us how much farmers liked each variety on an absolute scale.

Care is needed when interpreting the results of participatory evaluations. In the example in Table 2:

- Not all farmers evaluated all varieties/technologies. As a result, you have to be careful when looking at average ranks and ratings for each variety. In the example, only two farmers evaluated variety/ technology 'T' but this resulted in the highest average rank.
- You also have to be careful in looking at average ranks and ratings if there are different groups of farmers in the group. For example, if some of the farmers keep only pigs and some keep only cattle, they are likely to prefer different varieties for logical reasons. In the example, Farmer 'D' has very different preferences to the other farmers, which may be because she has very different constraints and opportunities in her farming system. In cases like this, it may be necessary to 'disaggregate' the evaluation data (that is, analyse it separately for the different groups of farmers).
- Preference weighting helped to separate the similar ratings given by Farmer 'C'

Once farmers had rated (or weighted) each variety/ technology (which usually took no more than five minutes), we would ask them to explain the reasons for their choices by describing the positive and negative attributes of each of the varieties/technologies. This helped us to understand their criteria for accepting, rejecting or modifying different forage varieties/technologies.

From field experience with participatory evaluation we learned that:

- Not all evaluations had to be 'participatory'. In some cases, we were interested in technical aspects of the performance of the varieties/technologies in the field (for example, yield in relation to soil fertility). It was important, however, if we were to do a technical evaluation, that we did the participatory evaluations first, so as not to influence the farmers' responses.

Table 2. Example of 'preference rating' and 'preference weighting' with four farmers.

Variety/technology	Farmers' ratings				Average rating	Average rank
	A	B	C[1]	D		
P	8	9	7 (17)	4	7	3
Q	7	9	7 (11)	7	7.5	2
R	4	4	7 (9)	4	4.8	4
S	0	–	6 (3)	3	2.2	5
T	–	–	7 (10)	9	8	1
Total varieties tested	4	3	5	5		

[1] = Figures in brackets are this farmer's weightings using 50 counters

- The amount of data collection and the value of the data collected are dependent on the amount of experience the farmers have had with the forage varieties/technologies. Formal evaluations were not necessary during the first six months of technology development when farmers had not yet learnt much about the varieties/technologies

Field Methods: Local Expansion

Soon after commencing on-farm forage technology development, we were faced with issues of local expansion. This was where farmers started expanding forages on their own land and neighbouring farmers starting to plant forages. Local expansion raised questions for the FSP about local availability of planting material and the role of the development worker in the local expansion process.

From field experience with local expansion we learned that:

- Local expansion often occurs through the energetic efforts of a local 'champion', often an innovative farmer. We needed to engage closely with these farmers to help them in their efforts and also to ensure that new farmers continued to have access to a broad range of choices and not just one option favoured by the local 'champion'.
- Sometimes farmers launched into local expansion too early and development workers needed to encourage them to evaluate the broad range of varieties throughout a full year. In some of the distinctly wet/dry sites where we worked, for example, farmers started expanding varieties during the first wet season that subsequently died in the following dry season (e.g. *Brachiaria ruziziensis* 'Ruzi').
- Local expansion often occurs spontaneously, without the need for extra seed. We had thought we would need to foster local seed supply systems, but if farmers were sufficiently impressed by the varieties/technologies, they would either expand them using vegetative planting material or collect small amounts of seed locally. In some instances, local expansion was limited by the lack of planting material and the development worker had to either assist with small amounts of seed or simply facilitate farmer-to-farmer exchange of locally-available planting material.
- In some countries (especially the Philippines and Indonesia), we worked through farmers' groups which helped give momentum to the local expansion. Such farmers' groups will be especially important once local expansion of promising forage technologies gets to a scale that is beyond the capacity of the individual development workers to support (see Braun and Hocdé 2000).

Field Methods: Monitoring and Evaluation

As local expansion continued and became more complex, we realised that the different stakeholders (national partners, the project) needed information about the forage technology development, both to understand how the process was developing and to plan for future development. What was being adopted and why?

Late in the project, we implemented a monitoring process called the 'Adoption Tree'. Details of the process and field experiences are presented in Horne et al. (2000b).

The changing role of development workers

Perhaps the biggest challenge of the different approaches used by the FSP (Figure 1) was that they required a complete change in the roles of development workers and farmers. Previously, development workers were required to implement government programs, collect data and promote technologies, and the farmers also expected this. With the participatory approaches, the role of the development workers evolved as the activities in the field evolved (Figure 4) moving towards an increasing partnership between farmers and development workers. This was a significant change for both and a change that resulted in the rapid expansion of on-farm forage technology development at most sites. Although the FSP has not yet reached a stage of scaling-out (expanding to completely new areas), it is expected that the momentum will continue and that some of the more innovative and active farmers will themselves become extension workers in the process.

Some Lessons Learned …

The process of implementing the participatory approaches has been very challenging for all the development workers involved. Through this process we have learned some valuable lessons:

- In the early stages of the fieldwork, careful farmer selection can make a huge difference to the subsequent success or failure of the participatory process. With time, however, as local expansion starts to happen, this is not as important, as *farmers 'select themselves'* (by spontaneously planting forage or asking to join the FSP program).
- There are many documented methods or 'tools' of PRA, for example, village and resource mapping, seasonal calendars and matrices, that can be used in the field to facilitate diagnosis, evaluation and monitoring. Like a carpenter's tools, however, these methods are a waste of time without a skilled person to use them. While these methods

are generally well known (many development workers can faithfully describe 'matrix ranking'!), *the essential skills of facilitation and communication with farmers have been under-emphasised*. These skills take a lot of time and commitment to develop and consolidate.

- The participatory approaches usually made the development workers feel a lot more confident about visiting and working with resource-poor farmers. In their new role, they could admit to farmers that they did not have all the answers, but had some ideas and technology options to evaluate. In this role, development workers and farmers were able to learn new skills and ideas from each other. Although these approaches required a lot of time and commitment from development workers, the results were more sustainable and better directed towards farmers' needs.
- The 'tools' of participatory diagnosis can be a 'two-edged sword', lulling development workers into a false sense of achievement. We must not lose sight of the fact that *the goal of our work is to engage actively with farmers in working towards solution of their problems, not simply trying to better understand those problems.*
- The changing role of development workers (Figure 4) involves them encouraging farmers to become more actively involved in development processes that affect their livelihoods. *This process can be threatening to officers in centralised research and development institutions, who may feel they are losing control.* As technologies start to expand in the field, it is essential that the development workers' institutions become more actively partners in the process.
- There are often institutional pressures that push development workers to put most of their effort into helping a few farmers or to work in areas where there is little potential for forage or to come up with quick results by encouraging farmers to plant large areas in the first year. *It is our experience that success comes from first encouraging farmers to evaluate and innovate on a small scale*. It is better to have a small success than a big failure.

The participatory methods being developed, applied and adapted by the FSP are far from perfect. At some sites, it was not possible to conduct diagnosis before commencing the technology development process. On several occasions, poor site selection led to diagnosis being conducted in communities where it turned out there was little potential for impact from forage technologies.

Despite these problems, however, both farmers and development workers responded enthusiastically to their new roles and the result was on-farm forage development which had substantial momentum at many sites.

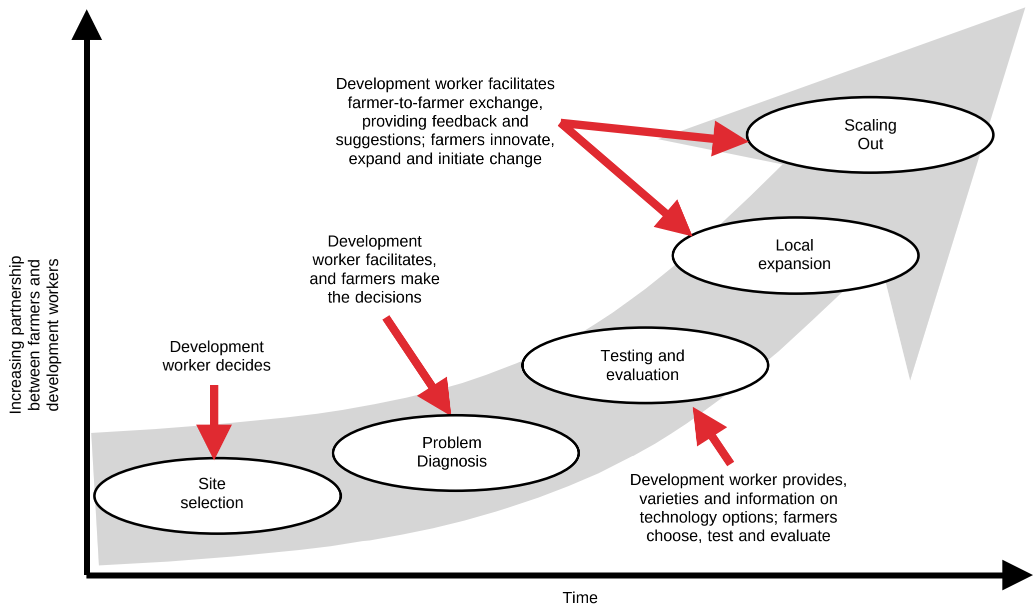

Figure 4. The changing role of development workers and farmers involved in participatory technology development.

Through these experiences, development workers collaborating with the FSP are moving away from dependence on a 'manual of methods' towards having a 'toolbox of skills and approaches' that they can use to respond to new situations and make the decisions required to nurture the participatory approach.

At present, there is only a limited number of development workers in each country who have this 'toolbox of skills and approaches' and a major challenge now is how to provide these skilled development workers with opportunities to mentor and help other development workers to learn about participatory approaches.

References

Braun, A.R. and Hocdé, H. 2000. Farmer Participatory Research in Latin America: Four Cases. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Gabunada, F. Jr., Heriyanto, Phengsavanh, P., Phimphachanhvongsod, V, Truong Thanh Khanh, Nacalaban, W., Asis, P., Vu Thi Hai Yen, Tugiman, Ibrahim and Stür, W. 2000. Integration of adapted forages on farms in Southeast Asia – experiences from the Forages for Smallholder Project. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Horne, P.M., Magboo, E.C., Kerridge, P.C., Tuhulele, M., Phimphachanhvongsod, V., Gabunada, F. Jr., Le Hoa Binh and Stür, W.W. 2000(a). Participatory approaches to forage technology development with smallholders in Southeast Asia. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Horne, P.M., Stür, W.W., Orencia, E.L., Gabunada F. Jr., Phengsavanh, P., Bui Xuan An and Tuhulele, M. 2000(b). Monitoring forage technology development – the adoption tree. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Oparaocha, S. 1997. Gender roles and relations in livestock management: the Hmong communities in Nong Het, Lao PDR. AIT, Bangkok, unpublished MA Thesis.

Selection and Targeting of Forages in Central America linking Participatory Approaches and Geographic Information Systems — Concept and Preliminary Results

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THE challenge is to match the potential of forages to improve sustainability of tropical agro-ecosystems with wide scale utilisation by smallholder clients. The potential of forages in improving the social, economic and environmental sustainability of smallholder production systems in the tropics is well recognised. Potential benefits of forages include the increase of livestock production through improved feed. Positive effects of forages on crop production include the reduced dependency on external inputs while maintaining or improving soil fertility; incorporation of forages in rotations have a positive effect on breaking pest and disease cycles. Forages also can reduce competition of weeds and lead to recuperation and reclamation of land. Synergistic effects between crop and livestock production can increase efficiency of land and labour inputs, in addition to utilisation of land not suitable for crop production.

However, adoption of forage-based technologies, in particular legumes, has so far been limited. Besides, an unfavourable policy environment giving preference to external inputs, the limited acceptance by smallholders can be attributed to lack of farmer participation in the development of forage germplasm and the lack of co-ordination of research on feed improvement, soil fertility and community participation. Moreover, methods for extrapolation and up scaling will need to be improved.

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The Approach

Based on the limitations to adoption described above we utilise an integrated approach for multipurpose forage germplasm development emphasising the following key components:

- Farmer participation.
- Integration of on-farm with on-station work.
- Synchronising demand and (artesenal) seed production (i.e. integrated community-based seed-supply systems).
- Increasing the capacity of stakeholders.
- Involvement of local, national, regional and international partners.
- Extrapolation of results using advanced technologies.

Developing Forage Germplasm with Farmers, NGO's and NARS

In 1998, we commenced in Honduras an initiative to select forage germplasm with farmers using participatory methods. We started evaluation with a reference site approach, with extension to satellite sites planned for the future. The collaboration with SERTEDESO (Servicios Técnicos para el Desarollo Sostenible), a NGO residing in the reference site, facilitates the communication with farmers, while the interaction with DICTA (Dirección de Ciencia y Tecnología Agropecuaria) working at the national level, is expected to enhance the up-scaling process. For using forages as feed we interact closely with the CIAT-led Consortium TROPILECHE.

In Tables 1 and 2 preliminary results from the selection of grass and legume germplasm are presented. Based on these evaluations all farmers involved in the initial evaluation have requested seed for planting larger plots. We are currently developing with the farmer's possibilities for artesenal seed production. DICTA has agreed, in collaboration with CIAT, to back-up this process by capacitation and basic seed production. We are also in the process of evaluating results from trials using shrub legumes and grass and legume species for soil reclamation purposes.

In 1999 the approach was extended to Nicaragua and in 2000 we intend to commence work in Costa Rica. Experiences gained from this initiative and other work with farmers is expected to focus future characterization and collection demand of forage germplasm.

Develop Expert Systems linking Biological and Socio-economic Data with Geographical Information

Developing a forage database

In an effort to make information gained from this and other work available to a wider community, we integrate experimental data into a forage database with a graphical interface. Figure 1 shows a screen-shot from an early version of the tool.

In contrast to many other forage databases, the tool in development is deriving information from

Table 1. Summary of evaluations for the participatory selection of grasses by farmers. Grasses were scored on a scale of 1 (least preferred) to 5 (most preferred). San Jerónimo, Honduras.

Accession	Evaluation																Points Total	Ranking
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
Brachiaria brizantha CIAT 26110	18	20	18	18	18	20	18	18	18	20	20	15	6	6	3	5	241	1
Brachiaria – hybrid FM 9201/1873	18	20	16	18	20	20	20	16	14	20	18	13	6	8	3	3	233	3
Brachiaria humidicola cv. Llanero CIAT 6133	12	14	16	14	16	16	14	10	10	8	14	7	6	6	5	5	173	5
Panicum maximum CIAT 16028	16	14	16	20	16	16	20	16	16	20	16	13	10	6	5	5	225	4
Panicum maximum CIAT 16051	16	12	12	12	8	10	12	12	16	14	14	9	4	4	5	3	163	6
Panicum maximum cv. Tanzania CIAT 16031	16	18	18	20	18	20	18	16	14	18	18	13	10	10	5	3	235	2

Table 2. Initial absolute evaluation for the participatory selection of herbaceous legumes by farmers. Legumes were scored on a scale of 1 (least preferred) to 5 (most preferred species), San Jerónimo, Honduras.

Accession	Evaluation											Points Total	Ranking
	1	2	3	4	5	6	7	8	9	10	11		
Arachis pintoi CIAT 17434 cv. Pico Bonito in Honduras	5	5	5	5	5	5	5	5	5	5	5	55	1
Arachis pintoi CIAT 22160	5	5	1	1	1	5	5	5	5	5	5	43	3
Centrosema brasilianum CIAT 15387	5	5	1	1	1	1	1	1	1	3	3	23	8
Centrosema macrocarpum CIAT 25522	3	3	1	1	1	3	3	3	3	3	1	25	7
Centrosema plumieri DICTA	5	5	1	1	1	5	5	5	5	5	3	41	4
Centrosema pubescens CIAT 434	5	5	3	3	3	1	1	3	3	1	1	29	5
Desmodium heterocarpon var. *ovalifolium* CIAT 23762	3	3	1	1	1	5	3	3	3	3	3	29	5
Stylosanthes guianensis cv. Pucallpa CIAT 184	5	5	5	1	3	3	3	5	5	5	5	34	2

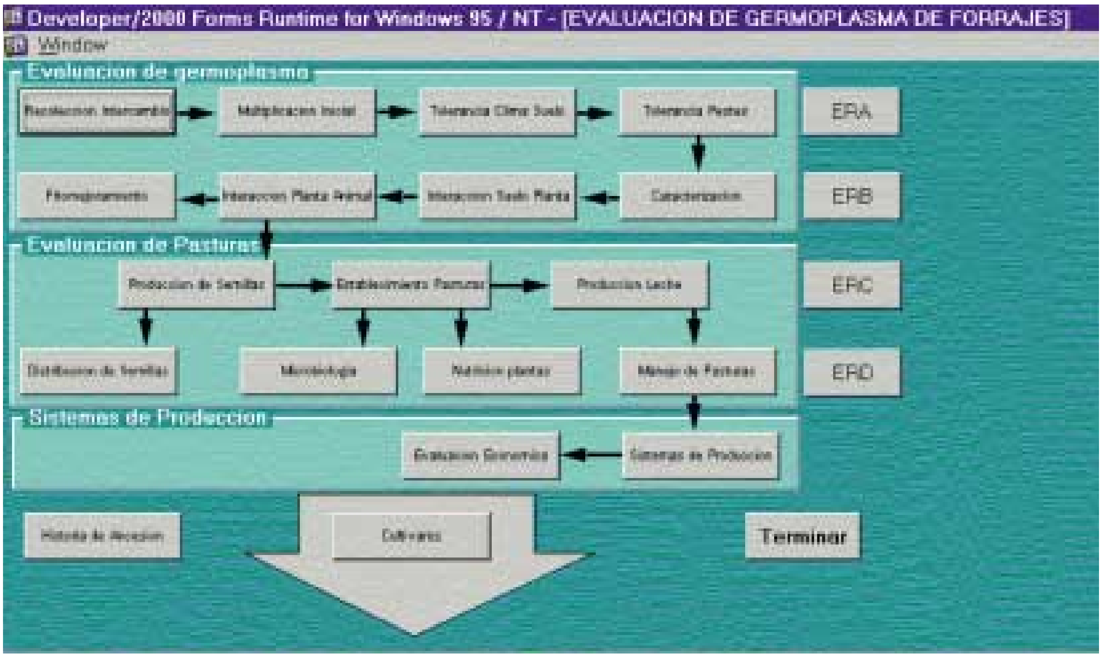

Figure 1. Screen Shot of CIAT Forage Database (under development).

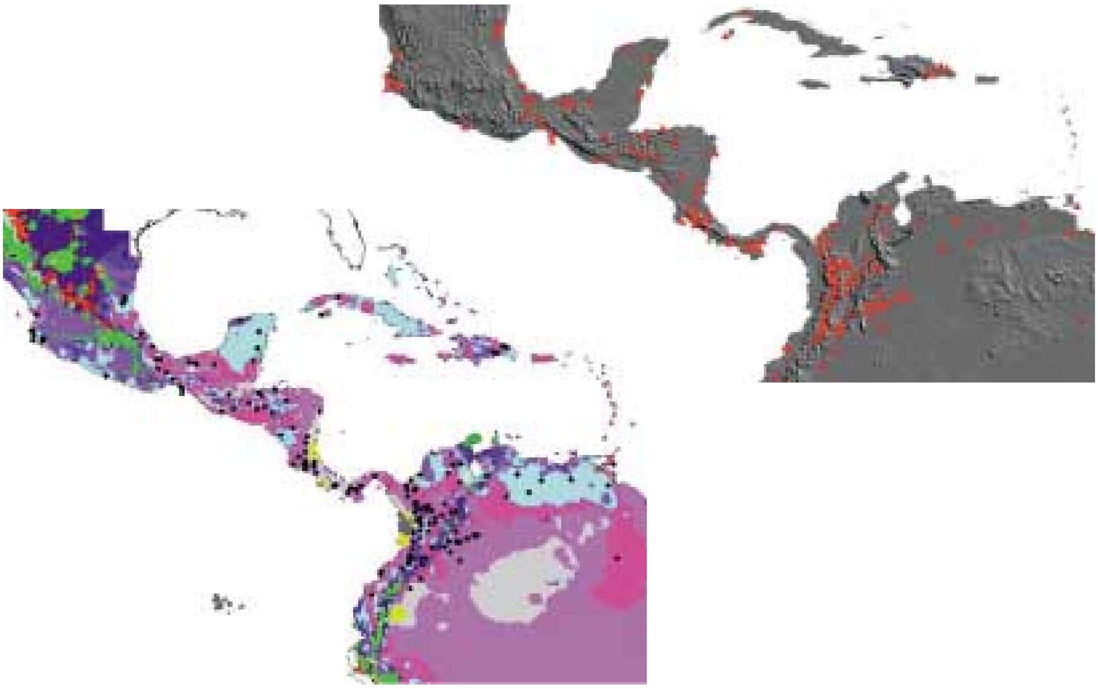

Figure 2. Initial maps showing the distribution of forage germplasm evaluation sites according to altitude level and life-zones, after Holdridge (1967).

actual experimental data — down to accession level — over a wide range of environments across Latin America and Africa. The incorporation of data from Asia is planned.

We expect to have a first version available for shipment to key collaborators in 2000. We intend continuous updating of information and extension to incorporate further information as it becomes available.

Developing GIS-based decision support tools

Based on the forage database, we are developing a GIS-based Decision Support Tool usable for mapping and extrapolating forage adaptation to different socio-economic and biophysical environments. A version to target forage germplasm to biophysical environments is scheduled for 2001. Initial maps developed are shown in Figure 2.

We are also developing models to incorporate socio-economic information such as different production systems, market access, social preferences etc. into the GIS-based tool.

Reference

Holdridge, L.R. 1967. Life Zone Ecology. Tropical Science Center, Costa Rica.

Scaling-Up: The Roles of Participatory Technology Development and Participatory Extension Approaches

J.G. Connell[1]

Abstract

While Farmer Participatory Research (FPR) and Participatory Technology Development (PTD) are becoming better recognised and accepted within mainstream research, similar acceptance of participatory approaches has not occurred within mainstream extension. Two cases are examined in which participatory extension approaches have been applied with success. The introduction of a new crop in Thailand, wheat, was achieved by initiating a PTD process within the extension, which resulted in a range of farmer developed technologies, that replaced the Officially Recommended Technology. The Pilot Extension Project in Laos attempted to initiate a broader based participatory extension approach, for the development of the National Extension System. The key to this was to have extension methodologies, and training programs which would be robust enough to be applied on a National basis. Apart from these approaches for participatory extension, the 'diversity of farmers' production environments' is proposed as a compelling pragmatic rational for the inclusion of participatory approaches in mainstream extension.

FARMER Participatory Research (FPR) and Participatory Technology Development (PTD) are becoming better recognised and accepted within mainstream research as effective in developing technologies appropriate to farmers' needs and conditions. The problem remains as to how to scale-up from the few farmers who have been engaged in the PTD, to other farmers in the village, and in other villages.

In areas with diverse production environments, as this scaling-up occurs, and a new technology moves to farmers who have different production conditions, it would seem that the PTD process should be maintained. If this is seen as a problem of 'technology development', it is natural for scientists to be concerned about scaling-up. But once one takes on the task of working across villages, districts and provinces, this is clearly beyond the resources of the research sector. If scaling-up is to be achieved at this level, it must begin to involve some sort of National Extension Service (NES).

Extension, however, will also need strategies to deal with diverse production environments, of which PTD is one. Attempts to develop Participatory Extension approaches do not date far back (Connell 1992). There has always been a grey area where research ends and where extension should take over. But in the past decade, as we have begun to see researchers concerned with scaling-up, and extensionists attempting to engage farmers in adapting technologies to their own conditions, this grey area and the overlap between research and extension seems to becoming even wider.

This paper aims to examine the need for participatory approaches, in particular PTD, in the context of extension, and then to look at the issues and strategies which would be needed to establish these approaches within NESs. It will do this by looking at two cases which illustrate these issues and provide some concrete guidelines as to how they could be addressed.

The Role of PTD in 'Extension'

When extension was dominated by the 'transfer of technology' paradigm, extensionists felt their role was to introduce and train small groups of farmers in the use of a new improved technology, which would then spread to other farmers in the area. The scaling-up, or spread of technology from the small group of

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farmers, was variously called 'diffusion of technology' or the 'adoption process' (Van den Ban and Hawkins 1988). This approach to extension has had mixed success, yet the role of Extension Workers (EWs) as 'technology messengers' and the use of the 'transfer of technology' approach to extension, is still very much alive today.

While the process of 'diffusion of technology' can still be used to describe the spread of technology among farmers, the diversity of farmers' production areas greatly inhibits and complicates this process. Particularly in upland and highland environments, the physical characteristics of the farmers' fields; soil fertility, texture, weed population, incident light and rain, etc., can vary significantly within a few hundred metres. In addition the socio-economic conditions of the farm-families, such as availability of labour, funds, equipment, technical knowledge etc. can vary from one family to another. All of this means that while one technology may suite one farmer in a particular plot, it may not suit another farmer, or another plot of land.

In this situation, no matter how effective a PTD activity has been to develop a new technology appropriate to one group of farmers, this technology might not be appropriate on the other side of the village, much less in the next village. Clearly EWs working in an area with this sort of diversity will need an extension approach which engages farmers in a PTD-type process, so that the farmers will adapt the starting technologies to their production conditions themselves. The case of the introduction of wheat to rice farmers in Northern Thailand serves to demonstrate the crucial role that PTD had in the context of extension.

CASE 1: Introduction of Wheat to Northern Thailand

During the 1970s, SE Asia had the world's highest rate of increase in wheat consumption (Byerlee 1984). CIMMYT's SE Asian Wheat Program (1981–93)[1] aimed to support the NARS of a number of countries in the region in the development of wheat production for import substitution. With wheat's excellent tolerance of drought, the two production domains identified for wheat were: as a rainfed crop in upland areas, established at the end of the wet-season; and, as a second crop, in irrigated paddy, following the main rice harvest.

While there were many initial concerns about wheat's ability to stand up to increased disease and pest pressure in the warmer climate of the region, no problems were expected with the planting technology for such an extensively grown crop. As a result, when the Department of Agricultural Extension (DOAE) began extension activities in 1983, the 'officially recommended technology' (Of-Rec-Tech) was straight off the experiment stations, without any modification for farmers' conditions. This consisted of:

- Full soil preparation (with formation of seedbeds in paddy areas);
- Seeding in rows;
- Rates for seed and fertiliser application, and planting dates.

Immediately, there were problems across the board with this technology. Thai farmers were unfamiliar with seeding in rows, and so tended to over-seed, resulting in inter-plant competition and poor plant development. In the paddy areas, farmers over-irrigated to the point of soil-saturation, causing damping-off and root-rot diseases. Extension efforts from 1983 to 1986 resulted in consistently poor stands with frequent complete crop failures. A few sites did produce well, lending some hope that wheat production was feasible. But the overwhelming conclusion was that while the crop could be grown in warmer environments, it was just too sensitive to be viable as a crop in farmers' fields in Thailand.

In the 1986 planting season, somewhat by chance, the Program suggested to a group of farmers at one lowland site that they try two alternative planting methods which were less intensive than the Of-Rec-Tech.

Alternative Tech. 1 – minimum tillage, with row seeding, and

Alternative Tech. 2 – full soil preparation, broadcast seeding + harrowing.

While these technologies gave a slightly lower yield than where the Of-Rec-Tech was applied correctly, the 'alternative technologies' appeared to help farmers avoid the common errors they had been making. Farmers who broadcast seeded were able to judge their seed-rates; and minimum tillage (which lacked raised seed-beds and irrigation channels) lead farmers to irrigate by flash-flooding, thus eliminating the incidence of over-irrigation.

What was more interesting, was the range of adapted and innovated technologies which appeared in farmers' fields. Of the 26 farmers at the site, 11 used the alternative technologies, with six of the farmers using more than one technology in their field. What was more, two entirely new technologies emerged!

This sort of innovation by the farmers was an exciting development. It appeared that it could offer the Thai Wheat Program a shortcut to identifying appropriate and robust technologies, by stimulating

[1] Thailand, Philippines, Indonesia and Sri Lanka. Of these, Thailand developed the most vigorous program.

farmer experimentation. In the following season, this extension approach was tried in a variety of conditions; in rainfed and irrigated production areas, with lowland and ethnic minority farmers, and implemented by District EWs and NGO development workers. In all cases it had the result of stimulating farmer experimentation.

On-Farm Research and Joint Monitoring Tours, in which scientists and extension staff together surveyed results in farmers' fields, ensured a constant cross-fertilisation of ideas between researchers, extensionists and farmers. While the Of-Rec-Tech still stood, an informal extension strategy developed, with many extension workers offering farmers a number of alternative technologies. By the 1988 planting season, a survey conducted by the DOAE revealed that only 60% of the 400+ farmers surveyed were using 'alternative technologies' (Connell 1999).

Farmers' informal 'trials' often appeared as small plots alongside their main field. On other occasions, they committed larger areas to compare different technologies. Some of the variations in the production technologies were made in response to problems or issues felt by the farmers, whereas in other cases farmers seemed to be just trying something different. A dozen farmers in a village, all trying various technologies (not all sensible!), did not always give the impression of being constructive. However a longitudinal study conducted at one site showed that there was indeed an evolutionary path in the direction these informal trials took over a number of seasons.

This sort of evolution of farmers' production technologies was seen in Pai District, where farmers began growing irrigated wheat using the Of-Rec-Tech in small plots (<0.1 ha). In the following season, they began to increase their area of wheat and changed to minimum tillage + row seeding to eliminate the cost of soil-preparation. As they increased their area of wheat further, the time for digging furrows for row-seeding became a limiting factor. So they switched back to broadcast-seeding, being willing to pay the cost of full soil preparation to save the time and labour for seeding. Finally a few farmers tried to reduce both the cost for soil preparation and the time for seeding together by experimenting with zero-tillage and broadcast-seeding. At this point the technology development seemed to reach a steady state, with this becoming the main enduring technology applied in Pai (Table 1).

This sort of trial and evolution of technologies by farmers was not structured or guided in any way. The key factor which helped to stimulate it on such a wide scale, appeared to be the extension strategy of simply offering farmers a selection of technologies and inviting them to identify which suited them best.

Table 1. Farmers' adjustment of production technologies in response to new constraints as they expand production area. (Pai District, Mae Hongson Province, North Thailand).

Season/Farmers' objective	Soil preparation +	Seedling method
1988 season *Of-Rec-Tech.*	full tillage +	row seeding
1989, 1990 seasons *reduce soil-prep. costs*	↓ minimum + tillage	row seeding
1991 season *reduce time/labour*	↓ full tillage +	↓ broadcast seeding
1992 season *reduce costs + time/labour*	↓ zero tillage +	↓ broadcast seeding with straw mulch

This role of offering farmers a choice was confirmed statistically during the IDRC Participatory Extension Project (1992–1994). The project aimed to examine whether participatory extension approaches could be introduced and applied by EWs of a large NES, such as Thailand's DOAE. Training in extension methodologies, which included offering farmers a choice of technologies, was provided to EWs from eight Districts. At the sites where EWs had provided farmers with a choice of technologies, farmers adapted some component of the technologies provided (Department of Agricultural Extension 1995). The level of farmer adaptation was much less at sites where farmers had been provided only the Of-Rec-Tech

To those committed to the ideals of participation, simply offering farmers *a choice of technologies*, might seem a poor brand of participation. And they may be right; that without other changes in attitude and behaviour of EWs towards farmers, this will not be sufficient to realise farmers' full potential, or empower them. However there are some important implicit changes which take place when EWs begin to offer farmers a choice of technologies. When they do this, the EWs are admitting that:

(a) They are no longer the bearers of the 'best' technology, or the 'right way'; and that
(b) Farmers do have the role and capacity to evaluate and select technologies themselves. If such an approach could be applied as a general extension strategy, it would be a significant and worthwhile step in the institutionalisation of participatory extension approaches within mainstream extension.

Implications and role for PTD within extension

PTD and national extension services.

The provision of a choice of technologies to the Thai wheat farmers was pivotal in the development of more robust technologies. Without this, wheat would not have gained a foothold as a new dry-season crop in Northern Thailand[2]. Thus it represents a significant demonstration of the role and impact of PTD, not as part of a FPR Program, but within the context of a broadly based extension program.

While the development of new technologies is exciting, this aspect should not be overemphasised, as genuinely new technologies are going to be an occasional event only. The full range of functions of providing farmers a 'choice of technologies', for extension in diverse production environments, can be summarised as the following:

- Farmers have alternatives as 'starting-points', from which to identify the technology most suitable for their particular plot of land;
- From time to time, it can stimulate a PTD process which may result in worthwhile 'spin-off' technologies;
- Ensures a relationship of mutual respect between EW and farmers, where the needs of farmers are recognised, and farmers are engaged in decision making.

Any attempt to alter the procedures of a large organisation such as an NES can be a daunting task that many senior staff will shy away from. However, simply offering farmers a choice, or menu of technologies, is not a difficult adjustment for an EW and would not require massive amounts of re-training. In areas with 'diverse production environments', this is simply a pragmatic response to the need for farmers to have alternatives to choose from. Put in this context, it should receive ready support from administrators to place into mainstream extension.

Interface between FPR and Participatory Extension

Given the opportunity for PTD to be stimulated within the context of extension, the implications this has for research need to be examined.

Results of 'adaptive research' will always be site-specific where farmers have diverse production environments. If the research paradigm were followed for 'scaling-up', additional adaptive research would be needed at each new site/village. In terms of researcher time and funds, this is simply not possible. Yet the reality is that such technology adaptation is, in fact, needed for diverse production environments. Instead of scientist-managed adaptive research, some level of technology adaptation could be achieved through farmer-lead 'adaptive research', by initiating a PTD process through Participatory Extension (Figure 1).

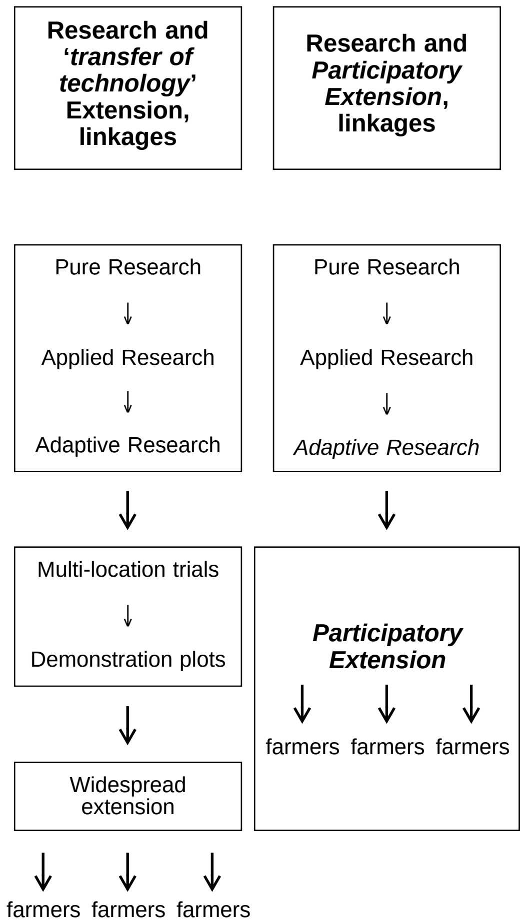

Figure 1. Potential adjustment of the demarcation between research and extension effected by general application of Participatory Exensions.

If widespread technology adaptation by farmers can be initiated, then it should be possible to re-direct scarce research resources to issues which farmers are not able to address. This then poses two new questions:

(a) What are the types of issues which farmers are well able to deal with, and which researchers need not focus on, and visa versa?

[2]By 1993, there were over 2000 farmers growing about 1000 ha of wheat in the 7 Provinces of Northern Thailand. Farmers' yields in villages where farmers had developed a few years experience were averaging 1.6 t/ha, with maximum yields in farmers fields in excess of 3 t/ha (Connell 1999).

(b) How far does research need to go in refining new technology before it is handed over to extension, if the researcher knows that it will go through a process of adaptation under Participatory Extension?

Participatory Extension approaches are just beginning to find a foothold in mainstream extension. Thus the opportunity to examine these questions is just emerging.

Participatory Extension Approaches

NESs must work with not just one village, but with many villages. An extension office at a District level typically might be responsible for working in 60–100 villages. While considerable diversity can be expected of farmers' production environments over a whole District, this can still be managed at the farm-level by EWs providing farmers with choices of technologies to stimulate PTD. However PTD focuses only on the technology aspect of extension, and should not be confused with the broader objectives of Participatory Extension approaches.

The real-life issues that farmers face are broader than just applying a new technology. Each season farmers need to decide how best to use their resources of labour, land, cash, etc. In the past, farmers had a relatively fixed set of framework conditions, and could rely on their Indigenous Technical Knowledge to guide them in making these decisions. As farmers have become irrevocably involved in market systems and require outside inputs, they must now take into account new factors in their decision making, such as: which cash-crop to grow, market prices, whether to purchase new equipment such as a sprayer or a pump; and so on. The introduction and transfer of new production technologies to farmers is an important aspect of improving productivity, but only one aspect of the every-day challenges they must face.

Extension therefore needs to have objectives beyond simply improving productivity. It should have Human Resource Development (HRD) objectives also, which would include enabling farmers to identify issues affecting their production; and to evaluate and to decide on the potential benefits of improved practices.

Participatory approaches applied by projects and national organisations usually include these HRD objectives. While they may be effective in enabling and empowering farmers, such projects also have special attributes, such as selected staff with a high degree of commitment and special training, and excellent resources and back-up. These conditions cannot be replicated within most NESs with their existing rank and file EWs and limited funds[3].

For NESs to apply participatory extension approaches on a broad basis, they will need to face operational challenges in several areas:

Extension Methodology: to identify extension methodologies which will be participatory, yet have simple enough procedures, and be sufficiently robust that rank and file EWs can accept and apply them on a regular basis.

Training EWs: the training strategies will need to address not just knowledge and skills development, but also changes in behaviour and attitude. This needs to be achieved not just with a small selected group, but across the board with rank and file EWs.

Administration of Participatory Extension: administrative systems for participatory extension approaches must include planning at the local level, and will need to accept that progress is indeterminate. This may conflict with the traditional expectations of administration to exert direction over staff and extension activities, achieve set goals and ensure funds are used effectively and accounted for.

There will always have to be some play off between quality and quantity when mobilising a national program. NESs also need to balance national goals, budgets and policy. Apart from these issues, the practical issues of operationalising Participatory Extension approaches remain. One attempt to do this has been the Pilot Extension Project (PEP) recently conducted in Laos.

CASE 2: Participatory Extension Project, Laos

Background

Lao PDR has a network of Provincial Agriculture and Forestry Offices and District Agriculture and Forestry Offices (DAFO) spread throughout the 17 provinces and 132 districts of the country. Within the DAFO, staff are allocated as specialist staff to Sections for Crop Production, Livestock, Irrigation and Forestry.

The DAFO is the key institution interacting with farmers, but most of its work has been focused on either administrative type activities (collecting data on production, crop losses etc.), or improving the infrastructure to expand irrigated paddy area. Very

[3]Two notable exceptions to this are the FAO's Integrated Pest Management (IPM) Program and Agritex's Participatory Extension Approaches in Zimbabwe. While IPM might not be considered by all as mainstream extension, it certainly has been applied by large numbers of rank and file extension staff. The process of Agritex's Participatory Extension bears great similarity to PEP's four 'Steps of Implementation', but elaborates these in far greater detail (Hagmann et al. 1999).

little of the work would be considered 'extension', such as working with farmers to introduce new production technologies etc. The technical expertise of the DAFO staff, even in their own subject areas, is quite limited, and their communication skills are poor. The official extension approach (introduced in 1993) is that of the establishment of Model Farmers. DAFO staff would rarely have been able to work consistently over a number of seasons on any issue, so their experience and concept of extension is non-existent.

The objective of the Pilot Extension Project (PEP)[4] was to develop strategies which could be used to establish a NES.[5] With effective extension in Laos being more or less a blank slate, this appeared to be an opportunity to build a participatory extension system from the ground up. While this was true, there were still many pre- and mis-conceptions that still needed addressing and clarification.

The project was based in the Agriculture Extension Agency of the Department of Agriculture with a small group of technical staff comprising an Extension Training Unit (ETU). The ETU then worked at the local level with staff of the PAFO and DAFO. The strategy was to implement extension on a pilot scale in four DAFOs in two Provinces. In each of the DAFOs, six staff (approximately 30% of technical staff) were trained and supported to work as generalist EWs in a number of pilot villages (10–12 villages per DAFO, making a total of 46 pilot villages).

With the understanding of extension at such a low level, PEP had to make a number of Working Assumptions:

- The initial focus of a young NES should be directed at farmers' 'basic-needs' (e.g. smallholder production of rice, livestock raising etc.) rather than introducing new cash-crops, or attempting dramatic changes in the existing farming system. This level of work is applicable to the majority of villages nation-wide, and the skills needed for this level of work can be developed fairly quickly with DAFO staff.
- DAFO staff should become generalist EWs assigned to a number of villages where they would assist farmers in whatever basic production activities were required, including rice, livestock, horticulture, etc.

[4]The Pilot Extension Project was funded by the Novartis Foundation for Sustainable Development.

[5]PEP was implemented by the Agriculture Extension Agency, under the Dept. of Crop Production. While there were other projects, in other Departments of the Ministry, aimed at improving extension in other sectors such as forestry, livestock, irrigation, PEP was the only project which took the DAFO as the target unit, and dealt with the implementation and management of all activities by the DAFO.

Over the three years of the project (1996–1999), the Project developed three Working Models for the implementation of extension:

- A Community-Based Extension Methodology;
- A functional model for the DAFO structure (with emphasis on extension over administrative duties);
- An Extension Management System (EMS).

The Project also developed two HRD Programs, necessary to provide staff with the capacity to apply the Working Models, in case they would be accepted by the Ministry to be applied nation-wide:

- Capacity-building of the DAFO technical staff;
- Leadership development for administrators of extension.

For the purposes of this paper it is worth focusing on three of these: (A) the Community-Based Extension Methodology; (B) capacity building for DAFO technical staff; and (C) the Extension Management System (EMS).

A) Community-based extension methodology

Various 'tools', such as PRA, have allowed a familiarity with participatory approaches to become widespread. However a PRA can only help to initiate work in a village and there is a danger that, once the PRA has been conducted, extensionists or development workers will be at a loss as to how to continue to maintain a participatory operating approach. The other extreme of participatory approaches is that they can become so complex that only staff with a high degree of experience and commitment can apply them.

When working with rank and file EWs, the participatory approach needs to be readily described, and easy to follow. This will lose the detail that some practitioners might want to see. But this is inevitable when processes are to be applied by large numbers of individuals. If the process developed is more complex than this, the bulk of staff will become frustrated in their attempts to apply them and begin to take short-cuts. At the same time, it is worth remembering that, while the bulk of staff may be operating at a medium level of 'participation', there will always be those few staff who will operate to a much higher degree of participation, due to their own skill and commitment.

Four 'Steps of Implementation'

The Extension Methodology introduced by PEP had four steps, which could be used to structure activities each season.

The function of each step[6], as it would be applied when starting to work in a new village which has not previously had regular extension, is as follows (see Figure 2):

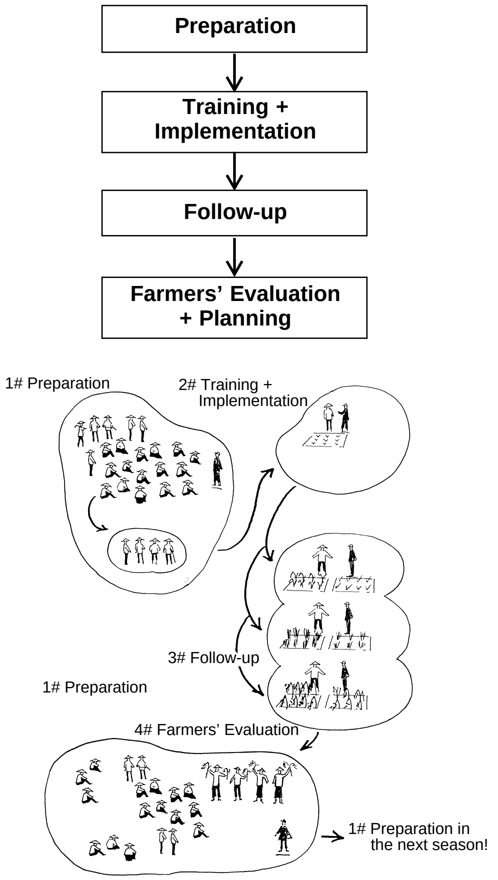

Figure 2. Four 'Steps of Implementation' for PEP's Community-based Extension Methodology.

Step 1: 'Preparation'

Farmers need to identify their problems and needs. DAFO staff then respond with a selection of technical options, from which the village can decide what they would like to try. (In this way the technical options are not presented as recommendations, but as answers to the farmers' expressed needs). The village should then choose a few 'selected farmers' to try it first.

This initial step is carried out with the whole village involved, so that the issues have become village-issues. All villagers are then engaged and waiting for the results of the 'selected farmers' trial.

Step 2: 'Training and Implementation'

Support is then focused on the 'selected' farmers to provide them with the technical information they need to try the new technology. (In the first year this can often take the form of working directly with farmers on a small trial plot, rather than formal training).

Step 3: 'Follow-up'

Farmers implementing a new technology the first time usually need to be shown where mistakes have arisen and to be provided with additional technical advice. DAFO staff should also encourage farmers at this point to compare their new activity with their old way of doing things, to begin the process of 'evaluation'.

Step 4: 'Farmers' Evaluation Planning'

Towards the end of the season the 'selected farmers' should evaluate the results of their trials, and then report their results and experiences back to the village. Other farmers can then 'evaluate' these in terms of their own conditions, and the village as a whole can begin to make provisional plans for the following season.

The Community-Based Extension methodology is participatory in that each of the steps engages the farmers in some degree of analysis and decision making (this will be true if the training approach in Step 2 uses adult education principles!). The participatory nature of this process is further supported by:

- Staff providing farmers with a choice of technologies so that it is clear farmers will make a decision based on an evaluation of their experiences.
- Inputs provided only in sufficient quantities for a trial to be conducted. This ensures farmers interests are focused on the trial and not on obtaining free inputs.
- The selection of farmer representatives should always be carried out by the villagers. EWs provide guidelines for the type of person, type of area suitable for the trial, etc., but leave the selection itself to the village.
- Extension activities planned to target 'village clusters', with Farmer Exchange Meetings held between villages. This allows farmers to see fellow farmers as sources of information and stimulation, as well as the EW. If conducted on a regular basis, a network can develop within the cluster.

[6] These four steps were derived from what is commonly called the 'project cycle' which has the steps of a) data collection; b) assessment; c) planning; d) implementation; e) evaluation. For the four steps in PEPs Community Based Extension, the first three steps of the project cycle have been lumped into a single step called 'preparation'.

The process just described for the four Steps of Implementation applies to the first year of initiating a particular activity, when issues are still being identified and new technologies are introduced and tried for the first time by farmers.

But this is only the first stage in scaling-up. As a new technology is introduced and then adopted within a village, two factors will be changing. Firstly, the number of farmers using the new technology will gradually increase, from a few farmers using it on a trial basis, to larger numbers using it extensively. Secondly, farmers' interest, and skills in the new technology, will also increase, from initially a healthy skepticism, to a commitment to applying it rigorously, as well as greater competence in its implementation. Thus, while working directly with a few farmers on small trial plots is an appropriate extension activity in the first year, this would not be a constructive extension activity in later years.

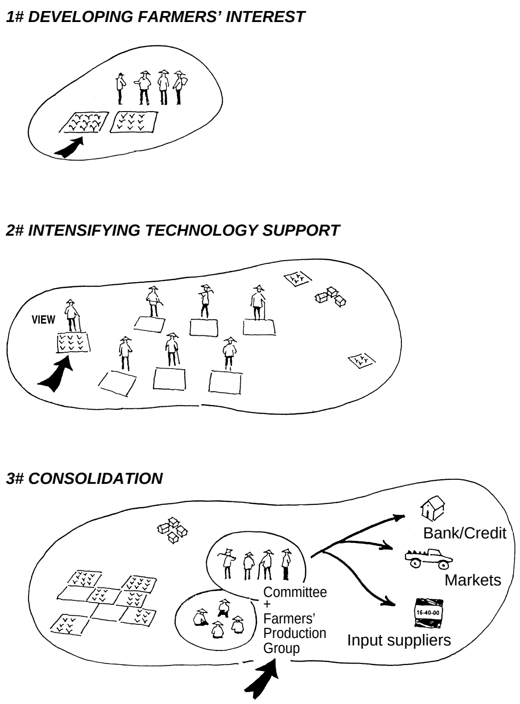

Figure 3. Three 'Stages of Development' for typical villages in adoption of a new technology.

To provide a framework for DAFO staff to identify the 'extension objectives' for each season and plan the 'extension activities' accordingly, the Project described three Stages of Development (Figure 3). These are:

1. *Engaging farmers' interest*

In the initial stage of working with a new village, the extension objectives should be to:

- identify farmers' problems; and
- to work with a few farmers, to demonstrate technologies that farmers are interested in.

(The description of the four Steps of Implementation, applied to this Stage of Development).

2. *Intensifying Technology Support*

As the interest and numbers of farmers increases, DAFO staff need to find ways to meet the greater demand for technical assistance. The extension objectives should be to:

- support the expansion of the use of the new technology (i.e. assist in the supply of inputs); and,
- establish and provide formal training to Village Extension Workers (VEW) who can provide on the spot advice to new farmers.

3. *Consolidation*

As the number of farmers continues to grow, there will be a need for farmers to organise themselves without relying on DAFO staff for supply of inputs etc. Technical support is still needed for those farmers just beginning to take up the new technology, with an additional need to stimulate further adaptation of the original technology (i.e. the PTD process) in an on-going manner. DAFO staff should aim, where appropriate, to:

- form Farmer Production Groups to: (a) manage supply of inputs and the sale of excess; and (b) continue technology development within the village;
- develop the Farmers Exchange Meetings into a 'network' within the village cluster to continue to stimulate technology development and adaptation.

The four Steps of Implementation still provide a framework for EWs to structure extension activities for each Stage. For instance, as the numbers of farmers begin to increase in the second stage (Intensifying Technology Support), the step of 'Preparation' should focus on (a) planning of inputs needed to scale up, and (b) the role and selection of VEW. And so on.

The time each village spends moving through each of these 'stages of development' depends on the capacity of the villagers themselves, and the complexity of the issues they address. Many villages may not see the third Stage fully established.

What started out sounding fairly simple with the four Steps of Implementation, now begins to sound overly structured. While three Stages of Development do reflect processes commonly encountered in the establishment and scaling-up of a new technology, they are not intended as a blue-print for the DAFO to follow. Their main function is to alert DAFO staff to the fact that conditions do change from year to year. As a result, they will need to assess the status of development each season to be able to set appropriate extension objectives and to plan suitable activities to meet these.

B) Program of capacity-building for DAFO technical staff

For the application of participatory approaches to become a reality within an NES, it will depend to a large degree on how these staff can be trained. The aim was that the capacity-building program developed by PEP be applied nationally for all DAFO staff. To do this, the program was designed to be conducted in-service, with the staff carrying out extension in pilot or training villages, so that real impact would be achieved in the course of the training.

The capacity-building program had four main components:

On-the-Job Training:
– to instill the processes of extension.

Formal training:
– to provide concepts and technical skills.

Workshops:
– for review and reflection.

Short Technical Inputs:
– for specific technical knowledge.

Many aspects of the program are particular to Laos, but the On-the-Job Training component of the program is of general relevance to training EWs in participatory extension approaches. The full Training Program is provided in Annex 1.

On-the-job training

Formal training can provide staff with knowledge, but skills, and to some degree the necessary attitudes, will come more effectively from experience. Staff were initially provided with concepts and a general outline of the Community-Based Extension methodology in a formal workshop. From then on work was at the DAFO level.

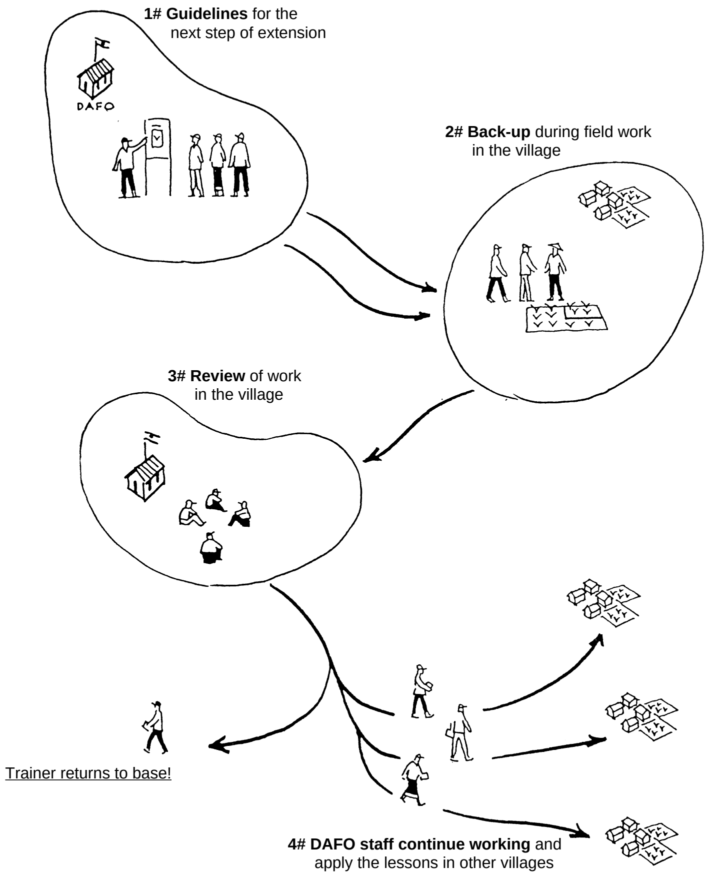

Figure 4. On-the-job training process.

For each step of the extension process throughout the season, trainers travelled to the DAFO and worked directly with the staff there. The On-the-Job Training process used was as follows (Figure 4):

Provide objectives + guidelines for implementation

Trainers met with DAFO staff prior to each extension activity in the villages, to discuss DAFO objectives and to provide guidelines for their implementation.

Back-up during field work

Trainers accompanied DAFO to the village, where they provided back-up to the staff in implementing the activities.

Review experiences and summarise lessons

Following this, the experiences were reviewed and suggestions made for improvement.

Independent implementation

Trainers returned to base leaving the DAFO staff to continue to work independently in the remaining pilot villages.

Leaving the DAFO staff to work independently was an important part of this process. It ensured that the ETU staff were clear that their job was training only, and not to implement extension. It also ensured the DAFO staff knew that it was they who had to carry the load and to make the real achievements. The first step of On-the-Job Training on the next visit of the trainers included the DAFO staff reporting on the work they had continued independently. This mentoring process was consolidated with strategic workshops where the DAFO staff could reflect on the overall process and their growing skills.

In the first year, the main emphasis of training was on On-the-Job Training. It was only after having worked through one cycle, and observed farmers' responses, that DAFO staff could appreciate the function of extension and how it could be carried out. They could then recognise their own weaknesses and became receptive to formal training. Thus, in the following two years, the formal training component was increased. The On-the-Job Training component is gradually reduced to provide back-up for new types of extension activities, as staff meet as they work through the three Stages of Development (Figure 5).

The whole capacity-building program covered three years. This period was necessary for the training to guide staff through key extension activities they would require for the three Stages of Development. This is a relatively long period for training to cover, but as the training was in-service, staff were active in the field and actually achieving greater impact under training, than they had ever achieved previously.

C) Extension Management System

This is an easily forgotten area of extension as most efforts are focused on the technical aspects of developing extension methodologies and training strategies. But unless the administrative and management's systems support Participatory Extension approaches, staff will not be able to work in this way. The Project identified three main issues which would need adjustment:

- Planning for extension is centrally driven with set targets. If DAFO staff are to work according to farmers' needs and to respond as the situation changes, then the planning of extension activities will need to be locally based.
- Monitoring of extension activities in the past has not been difficult as there was little activity to monitor and any reporting was simply made against set targets. However, if funding is raised to adequate levels and DAFO staff can work effectively, the level of activity in larger numbers of villages will increase, with the results achieved being quite variable according to the situation of each village and the stage of development it has reached. Reporting will need to provide information on the progress and impact of widespread extension activity. Furthermore, administrative staff at higher levels need to learn how to use such reports in a functional and constructive manner.
- Funding of extension in the past has been extremely limited. The funds that were available were 'handed-over' piece-meal with no accounting of actual use. For extension to be functional, an adequate level of funding will be needed. For this level of funding, a transparent system of accounting against actual use will be needed.

These three issues are deeply embedded in the existing policy and administrative environment, and are not likely to change in any fundamental manner. However, PEP tried to reduce them to a technical level by encapsulating them in what was dubbed 'Extension Management Systems' (EMS). These included:

- Planning procedure for staff on an annual, monthly and personal basis.
- Reporting of activities to both inform and to engage the DAFO Heads
- Accounting procedures which provided quarterly funds managed and acquitted by PAFO and DAFO staff.

All of the EMS implied a decentralisation of the administration of extension to the level of the PAFO and DAFO.

Implementation and impact of PEP's models and programs

These models and programs were implemented during the course of the Project with a fair degree of consistency. Where there were lapses, the reduced impact that resulted only served to confirm the models further. The main impact of the three models and program described in this paper were as follows:

Extension methodology

DAFO staff were able to engage the majority of farmers in all the pilot villages in a consistent manner. The main extension activity had focused on improvement of rice production. By the end of three years 42% of all farmers had begun to use improved technologies over 20% of the total paddy area in the 46 pilot villages (Figure 6). The typical yield increase was over 50%. This is not difficult to achieve with a few new seed varieties and use of chemical fertiliser. But the fact that this was achieved in such a consistent manner by the DAFO staff, across four DAFO in 46 villages, did indicate that the Community-Based Extension methodology was effective and robust enough to be applied by the DAFO staff.

This improvement in productivity could simply have resulted from the fact that some form of extension had begun to reach farmers. But there were aspects of farmers' behaviour which indicated the

TRAINING PROGRAM

YEAR 1		YEAR 2		YEAR 3	
On-the-Job Training		**On-the-Job Training**		**On-the-Job Training**	
→ (back-up in the field)		→ → → → → → → → → → → → → → → → → → (back-up in the field)		→ → → → → → → → → (back-up in the field)	
Formal Training		**Formal Training**		**Formal Training**	
Extension: Concepts + Methodology	5 days	Extension Planning 1#	3 days	Extension Planning 2# + Reporting	5 days
Facilitation Skills + Development (inc. PRA)	5 days	Communication Skills	5 days	Group Development*	5 days
		Basic Technical Skills – Rice*	10 days	Basic Technical Skills – Irrigation Management	5 days
				Basic Technical Skills – Livestock/Fish*	5 days
Workshops		**Workshops**		**Workshops**	
Review of PRA and Role of Village Extension Worker	5 days	End of Year Review	3 days	Evaluation of Extension Methodology + Vision	5 days
End of Year Review	3 days				
Short-technical Input		**Short-technical Input**		**Short-technical Input**	
Rice Production	8 days	Dry season crops	1 day	Compost making	1 day
		Seed selection (rice)	1 day	Fruit trees	2 days
Total	26 days	Total	23 days	Total	28 days

* training is preceded by data collection by DAFO staff in the field
** elective training input
*** late in Training Year 2#, or, early Training Year 3#
→ On-the-Job Training: guidelines/back-up in the field/review

Figure 5. The 3-year training program.

'participatory' element of the Community-Based Extension Methodology had had some effect on farmers' capabilities:

- Farmers who had begun to use the improved technologies were articulate in what effect the inputs had had, and were adjusting their own practices according to their conditions.
- In the Farmer Exchange meetings, representatives from different villages were making coherent statements of the status and issues affecting rice production in their villages, and discussing these among themselves.
- Farmers who had been trained as Village Extension Workers, were beginning to assist other farmers.

But perhaps one farmer expressed the changes to their approach to change, when he said: '*In the past we had just tried new things. If they worked we continued, and if they didn't we stopped. Since DAFO staff have been working with us, we now think about why something new works, and if it didn't, why it didn't*'. If this sort of thinking can be stimulated across the Districts and Provinces, this would be a significant step to enabling and empowering large numbers of farmers.

Staff training and capacity-building program

This had improved the knowledge and skills of the DAFO staff in a real and obvious way. Staff already strong gained additional skills, particularly in areas of facilitation and communication. Staff who initially had been considered 'weak' began to function effectively. This was evident in their ability to conduct village meetings, advise farmers in the use of improved technologies and to conduct short training courses for Village Extension Workers.

In addition to the technical skills, staff who had worked through the full three years of the Capacity-Building Program were then able to identify issues and develop their own programs. As such they are now able to continue to implement extension on a professional basis within the District. And, finally, a real commitment and self-pride in their work had developed.

Extension management systems

During the course of the project, the annual and monthly planning procedures became a regular feature of the staff operation, not just for themselves, but within their respective DAFO. Operating funds were provided at a minimal level, but on a regular basis. In the final year of the project, these were provided to the PAFO and DAFO on a quarterly basis and then managed and accounted for by them with a high degree of efficiency. Only reporting could not be instilled. It was not possible for this to be project driven, in the absence of any demand for this type of indicative reporting from the top.

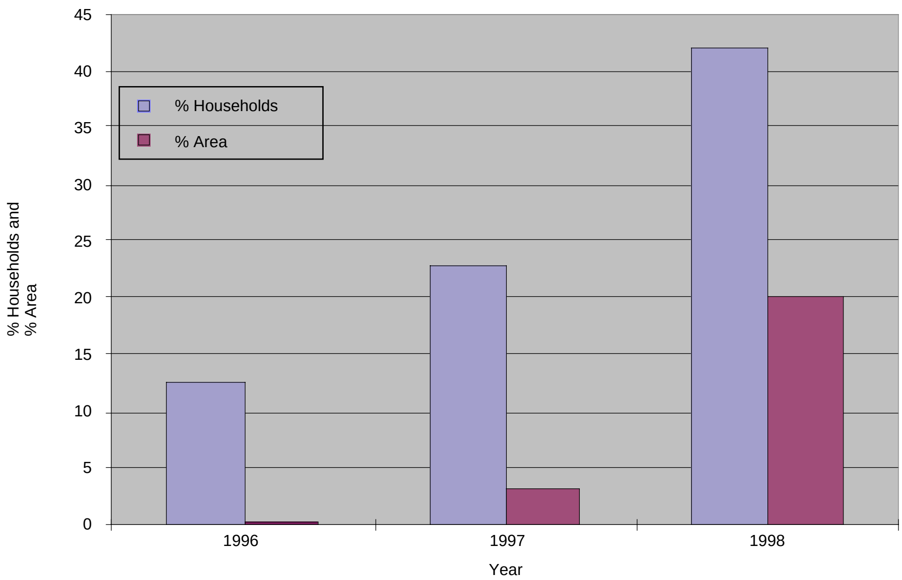

Figure 6. Impact of extension: rate of adoption of improved rice technologies (46 pilot villages).

Nonetheless, the EMS was able to give a profile to the difficult area of management, and to demonstrate sufficiently that it is an area which needs to be addressed.

PEP was implemented from within the existing system, and was subjected to the various day to day difficulties that affect the system as a whole. Thus the impact described above should not be seen as results achieved within a special situation, but in fact represents what could be achieved on a regular basis. Indeed, even better results should be expected if the models and programs were refined further and the trainers more experienced.

Despite this optimism, there are two serious constraints to the application of these on a national level. These are: (a) the need for adequate operational funds to provided to DAFO on a regular basis and (b) the need for a team or task force of trainers to be established who would be committed to the very considerable but necessary task of training and mentoring DAFO staff on a national scale.

While these two factors are not going to fall into place quickly, already two of the working assumptions and models applied by PEP have appeared in the recently promulgated 'Vision for the Agriculture Sector' published in October 1999. These were: (a) DAFO staff should work as generalist extension workers; and, (b) that the operational administration and management of extension should be devolved to the PAFO and DAFO levels. Meanwhile the application of PEP's Working Models and HRD Programs remains under review. Nonetheless PEP has already contributed to discussion on the establishment of extension in Laos which is likely to continue to evolve over the next months.

Integrating Participatory Extension Approaches into Mainstream Extension

From the two cases discussed here, it should be clear that there are opportunities for the institutionalisation of participatory approaches in mainstream extension.

Firstly, PTD processes can be applied by EWs through a fairly simple mechanism of 'offering farmers a choice of technologies'. Being a relatively small shift in the behaviour of EWs, this can be achieved without expensive and time-consuming retraining programs. As was the case with the introduction of wheat in Thailand, this can stimulate a general process of experimentation by farmers, which can then be harnessed by conducting Joint Monitoring Tours by the researchers and EWs. In this way the issue of 'linkage' between research and extension is achieved directly in farmers' fields, rather than across conference or meeting tables.

The case of PTD for the introduction of wheat in Thailand was concerned just with the 'transfer of technology' aspect of extension of a single commodity. Participatory Extension needs to include far more than this and should include HRD objectives of strengthening farmers' ability to analyse and make decisions. To achieve this will require substantial changes in the extension approach. For the case of PEP in Laos, this was achieved through the application of a process (Community-Based Extension Methodology), rather than introduction of a few tools or techniques (such as PRA).

To achieve such changes in extension procedures and EW behaviour, considerable training inputs are required. In the case of PEP, the key element of the training strategy was a mentoring process called On-the-Job Training. It is difficult to see how changes in an extension process and EW behaviour can be achieved without this sort of mentoring over one or more seasons. For this to become effective, a group of trainers would need to be established as an Extension Training Unit. This sort of input can only be achieved if there is going to be significant political commitment at the top to the development of an effective NES.

Often the call for increasing the 'participatory' nature of extension (and research) has been lead by idealism to ensure greater equity for farmers. To many administrators, this does not automatically equate with improved production. If Participatory Extension approaches are to be accepted by NESs, they will have to be able to demonstrate concrete achievements (not just for administrators, but for the farmers too!). This was possible for both of the cases described above. Such results, however, take time to demonstrate and in the complex environment of extension, can easily be attributed to many other factors. Thus new rationale is needed to justify farmers' involvement in decision making. One of the most compelling arguments for this is the 'diversity of farmers' production environments'. Once this is emphasised, it makes good sense that farmers be 'offered a choice of technologies, so that they can identify the best one for their own conditions, or that they be consulted on their needs and opportunities. 'Diversity of farmers' production environment' could therefore provide a simple pragmatic justification for higher degrees of participation in mainstream extension.

References

Byerlee, B. 1984. Wheat in the tropics: Economics and policy issues. In: Villareal, R.L. and Klatt, A.R. ed. Wheats for More Tropical Enviroments. Proceedings of the International Symposium Sept. 24–28 1984, Mexico, D.F., 303 – 315. Sponsored by UNDP and CIMMYT.

Connell, J.G. 1992. A minimalist approach to participatory extension. Journal of the Asian Farming Systems Association, 1 (3): 361–369.

Connell, J.G. 1999. Developing production of a non-traditional crop in S.E. Asia: Wheat in Thailand. Wheat Program Special Report, No. 44, Mexico, CIMMYT.

Department of Agricultural Extension 1995. Participatory Extension Project: An action-research project to examine potential for the development of participatory extension procedures for a national extension institution. Final Technical Report for IDRC Project file: 91–0231, Bangkok, Thailand, DOAE.

Hagmann, J., Chuma, E., Murwira, K. and Connolly, M. 1999. Putting process into practice: Operationalising Participatory Extension. Network Paper No. 94, London, UK, The Agricultural Research and Extension Network of the Overseas Development Institute.

Van den Ban, A.W. and Hawkins, H.S. 1988. Agricultural Extension, London, Longman Scientific and Technical, 100–123.

Participatory Approaches and Scaling-up

E. van de Fliert[1], R. Asmunati[1] and W. Tantowijoyo[2]

Abstract

Participatory research and extension approaches have been accredited as being effective in achieving impact, although success has seldom been demonstrated on a larger scale. Participatory activities are often characterised by intensive guidance processes, which would not always allow for scaling-up. However, to achieve sustainable impact, particularly when dealing with complex environmental issues where farmers have to work collectively, appropriate mechanisms for scaling-up need to be sought. This paper presents a framework for integrative research and development as a tool for planning and evaluation of participatory projects aimed at impact. It is argued that the objectives of an activity, i.e. research versus extension, should be clearly defined, and methods planned accordingly. Basic and applied research carries risk, and should therefore not necessarily be scaled up. Adaptive research, however, can be incorporated in participatory extension programs, in which farmers test and adapt innovation collectively and enhance their experimental skills for further application on their own farms. Appropriate mechanisms for scaling-up as well as key factors in the institutional and/or community setting will have to be identified on a case-by-case basis to enhance the chances of success. Anticipating scaling-up at an early stage of project implementation through the establishment of linkages with potential mechanisms is likely to facilitate accomplishment later.

THE IMPORTANT role farmers can play in agricultural research, development and extension, if only given a chance, has become widely accepted (e.g. Chambers et al. 1990; Haverkort et al. 1991; Jiggins and de Zeeuw 1992). Participatory research and development advocates the involvement of farmers as collaborators at all stages of the process, particularly at the early stages of problem definition and setting of research objectives. Benefits of such an approach include early definition of concepts of what technology users are likely to adopt, and adaptation of prototype technology to meet implementers' needs and preferences, hence, the likelihood of greater adoption (System-wide Program on Participatory Research and Gender Analysis 1997).

Despite the growing recognition for participatory approaches, several criticisms are often fanned, among others relating to replicability and, hence, the potential for scaling-up. So far, there is little documentation of large scale replication of pilot successes. Participatory research networks do not relate effectively to established, conventional extension mechanisms, which are in many countries primarily designed to transfer standard technology packages in a linear mode from formal research centres to a select group of contact farmers. These extension systems have no way of dealing with location-specific technologies and the 'transfer of processes' (experiential learning, experimentation), as required for sustainable agriculture (Van de Fliert 1993).

This paper presents a methodological framework for participatory research and development aimed at achieving impact on a larger scale, and some hands-on experiences of participatory research and extension approaches, and of anticipating scaling-up. The framework has been developed and implemented within the context of sweet potato Integrated Crop Management (ICM) and ICM training development in Indonesia by the International Potato Center and its local partners, as described in the following section, but should be applicable to the development of sustainable agricultural systems in general.

The sweet potato ICM project in Indonesia was designed according to an initial version of the framework, and the framework developed as the project

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advanced and expanded to other countries and to potato Integrated Pest Management (IPM) research.

Our experiences in these projects are specific to the context of sweet potato and potato IPM/ICM systems in Southeast Asia, where we are dealing with highly diverse smallholder farming systems. IPM and ICM are complex concepts requiring location-specific, informed decision-making and, under smallholder conditions, collective action. A predisposition of this framework is that, for achieving the overall objectives of enhanced problem-solving and decision-making capacity, and next, impact at a larger scale, intensive farmer training is needed.

It is emphasised here that this framework is provided, not as a cookbook containing recipes to be followed rigidly, but rather as a systematic map for navigating farmer participatory research. This paper will specifically focus on how the use of a framework like this can help anticipate scaling-up of participatory research and extension approaches.

The Context of the Sweet Potato ICM FFS Project

During 1995–1997, the International Potato Center (CIP) in collaboration with Mitra Tani (a local NGO), the national Research Institute for Legume and Tuber Crops (RILET) and the Duta Wacana Christian University (UKDW), implemented a project to develop a protocol for a sweet potato Integrated Crop Management (ICM) Farmer Field School in Indonesia. The project strategy consisted of participatory approaches and methods at all stages:

- planning, implementation and analysis of a needs assessment;
- development of ICM components and integrated approach;
- development of a Farmer Field School protocol for extension purposes;
- training-of-trainers; and
- pilot program planning, implementation and evaluation.

Project activities were implemented in major sweet potato growing areas in East and Central Java, where crops are grown intensively throughout the year with fairly reliable water supply.

The Farmer Field School (FFS) model applied in this project is a training approach that, over the past decade, has been developed and applied as the predominant methodology for Integrated Pest Management (IPM) training in the majority of Asia's rice-growing countries. Having its foundation in non-formal education principles and initially being designed for rice IPM training, it emphasises learning by doing, and empowering farmers actively to identify and solve their own problems (Van de Fliert 1998). Participation, self-confidence, and collective action and decision-making are fostered during the experiential learning process. This approach seems highly consistent with the requirements of active ecosystem management by farmers implied by IPM and ICM. An IPM farmer field school lasts for a whole growing season, involving a group of at most 25 farmers in weekly sessions of, on average, four hours. The trainer is a facilitator of the experiential learning process, not an instructor. Each training session contains a set of activities that foster farmers' analysis, decision-making and problem-solving, including:

- Field monitoring of observation plots in small groups, considering environmental factors, crop development, pest and natural enemy occurrence and interaction, and damage symptoms on the plants.
- Agroecosystem analysis, in which drawings of observations are made, and conclusions about crop status and possible measures are drawn together.
- Presentation of the agroecosystem analyses, and discussion aiming at a collective agreement on what crop management measures should be taken during the coming week.
- Special topics dealing with locally occurring field problems, or providing opportunities to discover processes, causes and effects of phenomena occurring in the field; the 'insect zoo' (an enclosure) is a tool often used by farmers in the field school to study plant-herbivore-predator relations.
- Group dynamics exercises to enliven the school, strengthen the coherence of the group, and make the members better aware of the importance and dynamics of group processes.

The field school model is designed to allow farmers to learn to take informed pest management decisions based on their own observations and analyses. This ability often gives them more confidence in their own farm management skills, which, in turn, is reflected in improved, overall farm management. A second important purpose of the field school is that farmer groups are stimulated to take collective action, which in certain cases may be indispensable for effective IPM implementation, particularly for pests such as rodents.

A successful IPM field school often results in follow-up activities, spontaneously organised, and funded, by the field school graduates, such as IPM clubs in Vietnam (Eveleens et al. 1996). During these follow-up activities, the farmers may study newly occurring cultivation problems, organise collective control measures, and even get into wider aspects of community development, such as rice-fish culture and collective marketing of produce (Van de Fliert and Wiyanto 1996).

In order to institutionalise the sweet potato ICM FFS model and scale-up training and implementation, 82 farmer trainers and staff of the National IPM Program and 30 local NGOs were trained as trainers. Work plans were prepared for follow-up activities to be conducted on a self-supporting base. Mitra Tani initiated a second phase of the sweet potato ICM project to monitor and evaluate these follow-up activities during a two-year period (1998–1999). Documentation of the monitoring and evaluation outcomes is expected to provide an interesting case from which other projects may learn, and to contribute to the general appreciation of participatory research and development.

A Framework for Participatory Research and Development: Cycling from Problem to Impact

The framework in Figure 1 presents a possible route from problem definition to impact within the context of sustainable agriculture development (E. Van de Fliert and A.R. Braun, unpublished). Anticipating the various stages of this framework is considered important when aiming at large-scale impact. The framework emphasises iterative phasing or cycling of activities and a division of major responsibilities among the various stakeholders, distinguishing three main realms of activity: (1) research and development; (2) extension and implementation; and (3) monitoring and evaluation.

These three realms are strongly interconnected, and their respective activities will partly overlap in time and space. Additionally, the process is not limited to a linear set of sequential activities, but allows for cycling within and between the activity realms.

Research and development

The research and development realm comprises co-creative processes to identify the problems, generate new information and innovations, consolidate them with adequate existing farming practice, and then translate them into learning objectives and activities for enhanced farmer performance. These processes are likely to be highly iterative and synergistic. Participatory research targeting the needs of poor farmers should begin with collaborative identification and analysis of problems, needs and opportunities, in an attempt to gain an understanding of the broad agroecological and socioeconomic context.

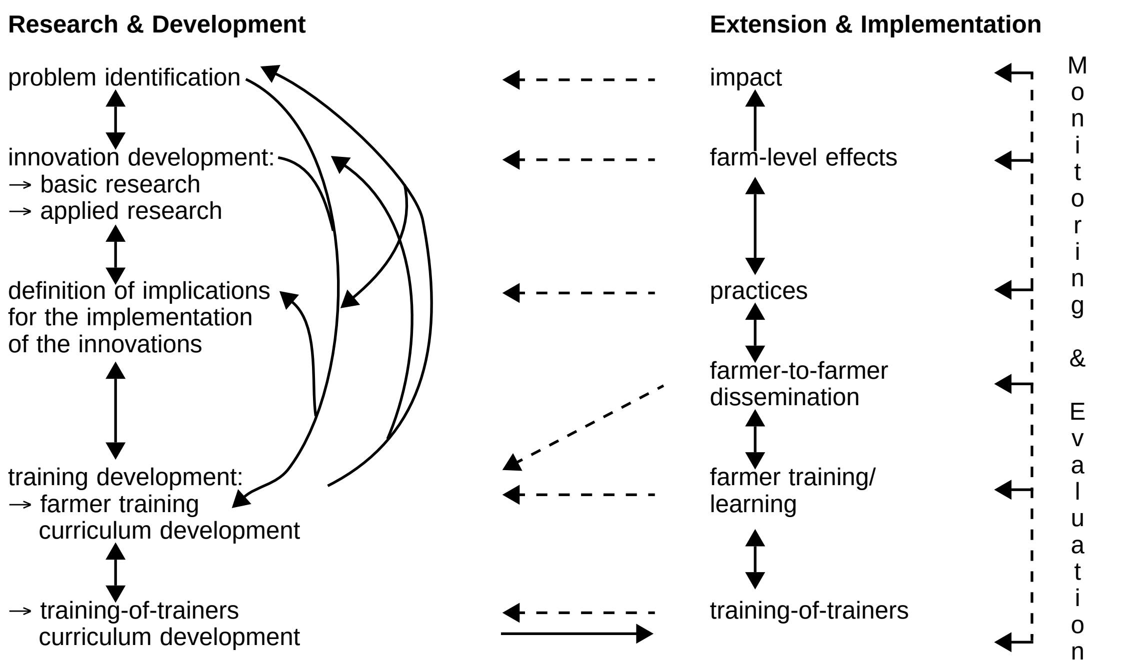

Figure 1. Framework for integrative, farmer participatory research aimed at impact.

This includes the identification of already existing alternatives to solve the problem(s), which may need to be tested under different conditions, and should eventually be consolidated with innovations. The problem identification phase should lead to the (participatory) priority setting and formulation of the overall project goals and specific research objectives. The final output is a prioritised research agenda.

Once the research agenda is set, innovation development follows. This phase is likely to include both a basic and an applied research component. Farmers' involvement in innovation development is particularly desirable at the level of applied research. Their role may vary from 'analysts and evaluators' (Fano et al. 1996) validating existing technologies to 'research collaborators' determining and testing treatments in their own fields (Ashby et al. 1995; Braun and Van de Fliert 1997).

It is emphasised here that participatory technology development serves an essentially different purpose from extension. Research carries risk that we do not want to extend to larger groups of farmers attending extension activities with the expectation that they will learn something. Therefore, we involve only small groups of farmers in participatory research activities and clearly define the objectives and expected outputs of the exercise together with the farmers. On the other hand, experimentation can be used as a learning method in extension, but mostly serving learning and/or adaptation rather than technology generation purposes.

The development component in the research and development realm emphasises the translation and validation of innovation development outputs in relation to the agroecological, socioeconomic and cultural conditions in target areas. The development process should not end with applied research, which is often considered the final step of research mandates. Applied research should be followed up by deliberate attention to training development.

Experience has shown that linear, top-down research and extension, as practiced in conventional technology transfer models, often failed because of inappropriate technology and/or inadequate 'packaging' of the messages (Röling 1988). Moreover, consistency is needed between the nature of the innovation and that of the extension approach and methods applied to convey the innovation to farmers (Röling and Van de Fliert 1997). Therefore, to ensure consistency, we should not only look at the innovations *per se*, but also define the capacities that practitioners need to implement them as well as the requirements for the support system (input supply, markets, etc.).

This leads to an analysis and definitions of what a change in agricultural practice effected by the developed innovations implies for the farmers. What knowledge, attitudes and skills do they need to implement the new practices and ideas? Answering this question is central to the development of the applied technology, and a prerequisite to the development of training strategy. The process of defining the implications of the implementation of the innovations may provide new insights for problem identification and/or raise issues that need to be fed back to the phases of applied or basic research, or even problem identification.

Training curriculum development is the next component of research and development and therefore within the responsibility of scientists. Preferably, technical and social or extension scientists would share responsibility, and farmers and extension officers would be involved in field-testing and validation. Training development implies designing activities, modules, and media for farmer training, carrying out pilot studies, and revising them accordingly. Once the curriculum for farmer training is set, a curriculum development for training the trainers can begin, preferably applying the same methods as those used for farmer training.

Extension and implementation

Extension and implementation encompass the phases when efforts are made – either in formal or a nonformal settings – to share the innovation with larger groups of farmers who then test, evaluate and incorporate (or reject) them in their farming practices. Changing farming practices should ultimately lead to substantive impact.

Extension—defined here as a function of disseminating an innovation to a wider audience—is not usually considered part of the mandate of research institutions (Fano et al. 1996). Therefore, suitable mechanisms and partners must be found to perform this function. To ensure that potential partners can carry out extension work efficiently, scientists can play an important role, contributing both technical and methodological skills. These skills may be complemented by those of GO or NGO extension workers, who have a comparative advantage as communicators at the village level. However, potential trainers must be trained themselves before they can be expected to run a curriculum according to the training model specifications. The participation of accomplished trainers is critical to success in the field.

In many developing countries, extension services lack the human resource capacity, in terms of both quantity and quality of staff, to reach a critical mass of their target audience effectively (e.g. Röling 1988). Much of the information obtained by farmers is disseminated by other farmers, either directly by sharing experiences, or indirectly through demonstrations of sample field practices and the resulting effects. Recent experience with IPM training in several Asian countries has shown the positive impact of involving farmers as trainers, and of enhancing farmer networks in order to support farmer-to-farmer dissemination deliberately (Eveleens et al. 1996; Braun 1997). Farmer facilitators must be selected with care and given additional training on facilitation methods. Training programs must also address farmer interaction and horizontal communication requirements from the start. i.e. during the planning stage.

The major actors in the implementation realm are, of course, the farmers. Farmers decide whether or not to implement, adapt or reject an innovation. Enhanced knowledge and skills, obtained through training, contact with fellow farmers or any other form of learning, are catalysts for change in farming practices. While much research has been devoted to studying the process of adopting innovation (Rogers 1995), in terms of sustainable agriculture, *adapting* innovation, to farm-specific conditions, is considered a more valuable output, particularly under the marginal conditions of poor farmers. The ability to adapt *guidelines* rather than follow a standard recommendation is evidence of farmers' enhanced capacity to experiment, analyse, evaluate and, finally, solve many of their own problems without having to depend upon external advice.

Response mechanisms, however, are critical in this realm, because farmers often receive contradictory messages from other sources (e.g. promotional campaigns by commercial companies aiming to sell alternative inputs) that could lead to confusion. Questions arising during implementation need to be addressed by trainers, whose role includes supporting the adjustment process and helping bridge communications between farmers and researchers.

When farmers' capacities and practices change, tangible effects at the farm level can be expected. These may include yield increase, reduction of expenditures, or a more balanced ratio of pests to natural enemies in the field. When such changes occur on a larger scale, an even broader impact can be expected, such as the improvement of rural people's livelihoods and/or a healthier environment. If initial outputs prove beneficial to farm families, they will most likely be disseminated further, contributing to a general increase in the knowledge base of the farming community.

Monitoring and evaluation

The monitoring and evaluation realm forms a maze, overlapping with and collating the other two realms. Researchers must observe and measure what happens during training and implementation, and must relate and/or recycle the information back to the research and development realm for further adjustment or impact assessment. Systematic monitoring and evaluation of projects assures the capacity to make adjustments before it is too late, to learn from experiences and to justify the research investment. Rapid feedback is critical when farmers are presented with new variables (for example, a new variety, a new technology, or a more complex, integrated innovative approach). In participatory projects, monitoring and evaluation should be planned and implemented in conjunction with the farmers. Farmers should particularly be involved in defining indicators for evaluation, and in analysing evaluation results. In the case of sustainable agriculture, evaluation indicators should always relate to the objectives and expected outputs of each phase. Within this context, well-defined indicators usually focus as much or more on people and the environment as on technology and economics (Van de Fliert 1998). Monitoring and evaluation of clearly defined indicators should generate valuable feedback for adjusting current project methodology, improving future research and development, and providing examples for other projects.

In order to be able to justify the research and development investment, the monitoring and evaluation system should be designed to analyse the outputs in relation to the objectives set for each specific phase. This is depicted by the horizontal links in Figure 1, where the expected outputs of the activities and elements in the extension and implementation realm relate directly to the objectives of the activities in the research and extension realm at the same horizontal level. After the evaluation exercise, we should be able to answer the following questions:

- Is the impact of the activities consistent with the overall goal?
- Do the farm-level effects concur with the intended objective of the innovation? (for instance, was there a reduction of pesticide load on the farm ecosystem as a result of IPM practices?)
- After training, have farmers' capacities and practices reached the levels required for implementation of the innovation?
- Do dissemination mechanisms result in effective farmer-to-farmer communication?
- Are the processes of farmer education and training-of-trainers compatible with the curriculum design?

These horizontal links clarify the idea that, in order to achieve positive impact, research and development teams should seek mechanisms for incorporating extension and implementation requirements when setting their objectives for research and development.

Scaling-up for impact

Impact as depicted in the framework in Figure 1 is the desired change relating directly back to the initial problem definition and, hence, overall goals of a project. Impact occurs as a result of effects at the farm level, which in turn are induced by a change in farmers' management practices. Our understanding of actual impact of a project implies that the process of change occurs at a fairly large scale with regard to numbers of farmers, as opposed to potential impact as may have been demonstrated only on a pilot scale. This means that targeting for impact requires scaling-up. Particularly with sustainable agricultural approaches such as IPM, where a more natural balance of the larger agroecosystems needs to be established for optimal effectuation of technology components, collective action of farmers within that agroecosystem and hence large-scale implementation, is required.

Change leading to impact consists of two important components. One is the internalisation of (adapted) technology components in the farm management system – which is more than adoption of a technology only – and the other, often neglected, component is the change in knowledge and skills leading to enhanced problem-solving and decision-making capacity of farmers. As predisposed in the framework above, achieving impact for sustainable agricultural approaches requiring enhanced problem-solving capacities calls for extensive farmer learning, which is mostly achieved through intensive training and effectuation of farmer-to-farmer dissemination. As experienced in IPM training in Asia, training using participatory, experiential learning methods, such as the FFS described above, have proven to be the most effective.

In order to provide quality training to reasonably large groups of farmers, a mechanism responding to the needs of a certain project needs to be installed. The 'hardware' of such a mechanism consists of the channels or institutions to be identified and mobilised, taking into consideration the desired coverage of training activities, expertise available with regard to approaches applied, and funds available. The 'software' includes the training modules and curriculum that should contain elements guaranteeing replicability, and inducing motivation and capacity building of trainers for self-supported expansion, including farmer-to-farmer dissemination. Our experience is that deliberate attention should be given in training of trainers and training of farmers to importance and possible means and content of farmer-to-farmer dissemination to ensure it to happen in a satisfactory way. IPM training, for instance, is field-based and cannot be disseminated with the same level of effectiveness by talk only. As a result, farmers participating in IPM training should be provided with methods and ideas to effectively inform and teach their fellow farmers about IPM.

Scaling-up Participatory Processes

Farmer participatory research activities often result in good output with regard both to technologies developed, since they are more adapted to farmers needs and opportunities, and to enhanced problem-solving capacities of the farmers who have been involved in the process. The latter is a very valuable trait for farmers, allowing for adapted technology implementation and internalisation within the farm management system. However, extending this trait among more farmers should in most cases not be done by involving more farmers in participatory research activities, but rather by designing training/learning activities that enhance farmers' experimental and analytic skills. As the two-pier structure of the above framework suggests (research-development versus extension-implementation), participatory activities can occur in either realm but serve a different purpose.

Concretely, participatory technology development does not serve the same purpose as training to enhance farmers' problem solving capacities for farm-level adjustment of technological guidelines. Any participatory activity should have clearly defined objectives – research versus extension – to begin with, not to raise false expectation among the partners in the process.

Our experience is that research activities, especially those carrying risk, should be limited to a small group of highly committed partners. Only when proven technology components have been developed can we think of scaling-up by sharing both guidelines and methodologies with larger groups of farmers through some sort of learning mechanism. Nevertheless, socialising participatory technology development activities and processes, for instance through community-level analysis workshops or field days, is considered important for inducing wider interest among communities for both participatory research and extension.

A main characteristic of the Farmer Field School (FFS) model is experiential learning about ecological processes by providing opportunities to farmers to discover and experiment. Experimentation, however, serves primarily as a learning purpose in the initial model, although the FFS setting also allows for experiments to test and adapt technology components. In the Sweet potato ICM FFS developed by CIP and its partners in Indonesia, the FFS model was extended by incorporating activities to familiarise experimental methodologies to the farmers and encouraging them to design, conduct and analyse their own experiments on the FFS plot. This has proven very effective and several alumni groups continued to do collective and individual experiments further to adjust the ICM guidelines to their farm conditions, and convince themselves of compatibility of the ICM components in their farming systems. Again, the purpose here is (large scale) adaptation for final implementation, and not (participatory) technology development which had long before been preceded by the FFS implementation in order to provide its technical content.

Anticipating Participatory Scaling-up

Aiming at wider scale impact calls for anticipation at a very early stage of project management. In addition to thorough project planning, an important factor in this is the early establishment of linkages with organisations or individuals that can provide mechanisms for future scaling-up. Identifying such mechanisms should preferably be part of the needs and opportunity assessment. Linkages can be established and strengthened by involving key persons in critical events during the various stages of project implementation, for instance by inviting representatives of certain organisations to needs assessment analysis meetings, or an end-of-season evaluation and planning workshop of a participatory technology development team. When project development reaches the stage of institutionalisation, roles, responsibilities and mandates of the various institutions involved should be made very clear. An analysis of expertise and capacities may help to determine whether there is a need for additional input, such as training or provision of materials.

In the case of the sweet potato ICM FFS program, we originally intended to 'scale-up' through the eight farmer researchers who had been involved throughout all stages of the project. The effort to train them as master trainers, however, failed, because they lacked the experience of having learned themselves through FFS methodologies, and therefore did not pick up the facilitation skills needed.

As a result, the National IPM Program was selected as the major mechanism for scaling-up, since this program had an impressive, nation-wide cadre of very capable and well-trained FFS facilitators (Asmunati et al. 1999). The selected trainers from major sweet potato growing areas only needed upgrading with respect to (1) sweet potato cultivation aspects, since they only had experience in rice and soybeans, and (2) the particulars of ICM as opposed to IPM, including a range of crop management and methodological activities.

It was also realised that the National IPM Program only operated in irrigated areas, indeed covering several major sweet potato growing areas. However, in order also to reach farmers in rainfed areas who probably needed the ICM technology more, NGO networks working in the field of sustainable agriculture were involved as a second mechanism for scaling-up. Since NGO programs generally have a community rather than a commodity focus, the training-of-trainers for NGOs had to be adapted accordingly, by emphasising the principles of ICM and FFS approaches instead of focusing on ICM and FFS for sweet potato, as was the case for the National IPM Program training-of-trainers.

Due to the wider scope of ICM, the project had involved the Directorate of Food Crops Production, in addition to the National IPM Program which falls under the Directorate of Plant Protection. Although the role of this Directorate was very minor throughout the project, the presence of the head of the Subdirectorate for Rootcrops during an evaluation workshop resulted in the preparation of a proposal for submission to the Directorate's Planning Bureau for a three-year Sweet potato ICM FFS Program. This targetted 490 FFSs, potentially involving 12 250 farmers.

At the time this paper was written, the decision for program approval was still pending. The experience, however, shows that through long-time acquaintance and involvement, possibilities, albeit minor ones, for scaling-up opened up that would not have emerged without long-lasting, and initially seemingly fruitless, efforts.

Conclusions

When planning for scaling-up (participatory) project efforts, it should first be clearly defined what we want to scale up and what our objectives are, which globally could be categorised as either research or extension objectives. Do we need participatory technology development aimed at generating and adapting technological guidelines to be replicated in more, diverse places for a more widely adapted research output? Or do we want to extend research output, which may include both technological guidelines and experimental methodologies for location-specific adaptation of such guidelines, to larger groups of farmers? These two objectives call for a different scale of scaling-up, the second being much larger than the first, and requiring a different mechanism to be installed for scaling-up.

In terms of the framework presented above, activities with research objectives take place in the research and development realm, whereas scaling-up for extension purposes comes under the extension and implementation realm. The latter implies the development of learning protocols, training of trainers and organising wide-scale implementation of farmer learning activities.

Attention to experimental methodology in farmer training to enhance farmers' experimental skills, allowing them to verify and adapt technological guidelines under their specific farm conditions, is perceived to contribute greatly to the successful implementation of sustainable agricultural practices.

The farmer field school model provides a good environment for teaching such skills, although modules adapted to the agroecological and social-cultural setting of a FFS program need to be developed. Teaching such skills to farmers requires strong trainer capacities, hence solid training of trainers, especially in countries with top-down extension systems primarily delivering preset recommendations to farmers.

Selecting and preparing the right mechanism to achieve both quantity and quality in scaling-up is therefore of utmost importance. Setting clear objectives and anticipating implications for achieving these, in a participatory way, are necessary to build strong programs at the desired scale.

References

Ashby, J.A., Gracia, A.T., del Pilar Guerrero, M., Quiros, C.A., Roa, J.I. and Beltran, J.A. 1995. Institutionalising farmer participation in adaptive technology testing with the 'CIAL.' Network Paper 57, ODI Agricultural Research and Extension Network, 43 p.

Asmunati, R., Wiyanto and Van de Fliert, E. 1999. Integrating Sweet potato ICM and FFS Approaches in Government and NGO Initiatives in Indonesia. Paper presented at UPWARD Planning Meeting, 1999–2003 Program Cycle, 'Enhancing Sustainable Livelihood with Rootcrops: Potentials of Local R&D', Bogor, Indonesia, 29–30 April 1999.

Braun, A.R. 1997. An Analysis of Quality in the Indonesian Integrated Pest Management Training Project. Report of a Technical Audit Conducted for the World Bank of the Indonesia Integrated Pest Management Training Project, Jakarta, National IPM Program, 71 p.

Braun, A.R. and Van de Fliert, E. 1997. The Farmer Field School Approach to IPM and ICM in Indonesia: User participation. In: Local R&D: Institutionalising Innovations in Rootcrop Agriculture, 44–64 (UPWARD), Los Baños, Laguna, Philippines, UPWARD.

Chambers, R., Pacey, A. and Thrupp, L.A. Ed. 1990. Farmer First: Farmer Innovation and Agricultural Research, London, IT Publications.

Eveleens, K.G., Chisholm, R., Van de Fliert, E., Kato, M., Nhat, P.T. and Schmidt, P. 1996. Mid-term Review of Phase III Report. FAO Inter-country Programme for the Development and Application of Integrated Pest Control in Rice in South and Southeast Asia, P.O. Box 3700 MCPO, 1277 Makati, Metro Manila, Philippines.

Fano, H., Ortiz, O. and Walker, T. 1996. Peru: Inter-Institutional Cooperation for IPM. In: L.A. Thrupp, ed. New Partnerships for Sustainable Agriculture, Washington: World Resources Institute, 64–68.

Haverkort, B., Van der Kamp, J. and Waters-Bayer, A. Ed. 1991. Joining farmers' experiments. Experiences in Participatory Technology Development, London, IT Publications, 269 p.

Jiggins, J. and de Zeeuw, H. 1992. Participatory Technology Development in practice: process and methods. In: Reijntjes, C., Haverkort, B. and Waters-Bayer, A. ed. Farming for the future: An introduction to Low-External-Input and Sustainable Agriculture, London, MacMillan, 135–162.

Rogers, E.M. 1995. Diffusion of Innovations. 2nd edn., New York, Free Press.

Röling, N. 1988. Extension Science: Information Systems in Agricultural Development. Cambridge, Cambridge University Press.

Röling, N. and Van de Fliert, E. 1998. Introducing Integrated Pest Management In: Röling, N.G. and Wagemakers, M.A.E. ed. Rice in Indonesia: A Pioneering Attempt to Facilitate Large Scale Change. Sustainable Agriculture: Participatory Learning and Action, Cambridge, Cambridge University Press, 153–171.

System-wide Program on Participatory Research and Gender Analysis 1997. A Global Programme on Participatory Research and Gender Analysis for Technology Development and Organisational Innovation. Agren Network Paper No. 72, London, ODI Agricultural Research and Extension Network.

Van de Fliert, E. 1993. Integrated Pest Management: Farmer Field Schools Generate Sustainable Practices. A Case Study in Central Java Evaluating IPM Training. Doctoral Dissertation. Wageningen Agric. Univ. Papers 93/3, Wageningen, PUDOC.

Van de Fliert, E. 1998. Integrated Pest Management: Springboard to Sustainable Agriculture. In: Dhaliwal, G.S. and Heinrichs, E.A. ed. Critical Issues in Insect Pest Management, New Delhi, India, Commonwealth Publishers, 250–256.

Van de Fliert, E. and Wiyanto. 1996. A road to sustainability. ILEIA Newsletter, 12(2): 6–8.

Farmer-Based Extension in the Philippines: The World Neighbours – Mag-uugmad Foundation Experience

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Abstract

Some experiences of the World Neighbours Mag-uumad Foundation, in the uplands of Cebu, the Philippines, are discussed. The Foundation works on the premise that the sustainable development of the region is in the hands of the local farmers themselves and that extension of appropriate technologies is best led by the farmers. A Soil and Water Conservation Package was demonstrated on a model farm and was readily adopted by the farmers. Farmers conducted their own experiments and technology adoption was promoted through the 'alayon' (traditional co-operation groups) system. The farmers soon came to realise the importance of livestock on their farms. In collaboration with the Forages for Smallholders Project, forages have been promoted for use as hedgerows and for feeding livestock. It is concluded that 'alayons' are the best venue for learning, but that there is a need for more training to keep up with the rapid rate of adoption of new technologies.

THIS paper contains stories and lessons drawn from the experiences of Mag-uugmad Foundation, Inc. (MFI), or Mag-uugmad as it is popularly known. Mag-uugmad is an NGO formed in June 1988 by the implementing staff and farmer leaders to carry out the soil and water conservation program initiated by World Neighbours (WN) in some watershed areas of Cebu in 1981.

The Province of Cebu, the case study setting, is a mountainous island situated in the central part of the Philippine archipelago. The upland areas of Cebu, including its critical watersheds, are severely denuded. This situation was precipitated by the expansion of farming communities within the watershed areas, the encroachment of inappropriate lowland farming practices into ecologically fragile sites and the excessive extraction of resources from the remaining forest.

Mag-uugmad is working towards a farmer-centered and process-oriented development pathway. This direction is anchored on the belief that the rehabilitation and sustainable development of the uplands are the moral obligations of the very people who depend on its resources for a living, the farmers themselves. The promotion of forages integrated with soil and water conservation through farmer-led extension is the main thrust of this paper.

Participatory rural appraisal (PRA) was used to examine the impact of forages integrated with soil and water conservation (SWC) in villages within the watershed area. Field surveys and farmers' workshops were conducted to evaluate the processes of Farmer-Led Extension.

MFI's Approach to a Farmer-Based Extension System

A farmer-based extension system (FBES) is a development approach wherein farmer extensionists share with other farmers lessons in farming systems drawn from extensionists' own experiences. Farmer extensionists also assist fellow farmers in identifying key farm problems, implementing appropriate technologies and facilitating the formation of 'alayon' or farmers' workshop.

The farmer-based extension system evolved from the early successes of the soil and water conservation program. The SWC package was readily adopted by

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farmers because their need for a steady supply of fodder and woodfuel was immediately addressed by such components as hedgerows and forages. The momentum of technology transfer was triggered by the remarkable success of the early adoptors. World Neighbours, the project initiator, saw the need to develop farmer extensionists to assist in the implementation of a rapidly expanding program. Those farmer extensionists, then called farmer instructors (FI), were selected by WN from among the outstanding farmer adoptors in the community.

Farmer-based extension strategies

The farmer-based extension strategies proven to be effective are model farm development, alayon formation, participatory farm planning, small-scale experimentation, and training/cross-visits. The interplay of these strategies is the key to the success of the farmer-led extension.

Model farm development

The model farm displays the various SWC technologies, cropping systems and land-use patterns appropriate to the locality. It differs from a demonstration plot in the sense that it is not just a showcase but a product of a long process of technology adaptation by the farmer. The model farm serves as a living example of the technologies promoted by the extensionists, without which trainings and cross-visits would not be successful.

Alayon formation

The 'Alayon' is a traditional form of cooperation in the village, wherein farmers group themselves and work on each others' farms on a rotation basis. This mutual sharing of labour hastens the pace of the technology adoption, especially the ones that are labour intensive. The alayon also serves as venue for group learning, problem solving and the promotion of equitability among farmers.

On-farm experimentation

Farmer extensionists conduct their own experiments to ascertain the appropriateness of new technologies before these are disseminated to other farmers. Farmers learn of new technologies mostly from cross-visits to successful farmers and technology resource centres but seldom do they adopt the technologies on a wide scale without testing them first.

Experimental plots aid the farmer in extension work. Neighbours may take an interest in the experiment, keep track of its progress and readily adopt the technology if it turns out to be successful. The role of women in the conduct of the trials is very important as they are more keen on monitoring.

Trainings and cross-visits

Trainings and cross-visits are especially helpful to farmers from distant villages, where SWC model farms do not exist and the alayon is not practiced yet. The training methodologies proven to be effective are farm tours, farm practicals, sharing of experiences and other participatory techniques.

FBES management

The Farmer-based Extension System is managed by the farmers themselves. Mag-uugmad deliberately limited its role to the facilitation of complementary support and the upgrading of farmers' skills in extension. In this way, the leadership and management capabilities of farmers are enhanced and their sense of ownership of the program is gradually reinforced.

The Creation of Sustainable Upland Agriculture Resource Centre (SUARC): The Convergence of Farmer-led Extension Strategies

The soil and water conservation program was eventually turned over to peoples organisations (POs) by Mag-uugmad in the mid-1990s. A formal management structure was created by the POs in partnership with Mag-uugmad to consolidate the gains of the extension and the direct pace of the program expansion. This structure was called the Sustainable Upland Agriculture Resource Centre.

The Sustainable Upland Agriculture Resource Centre (SUARC) is now a learning institution which is co-managed by local farmers. It is the well spring of lessons in upland development and serves as the main vehicle of Mag-uugmad in reaching out to upland communities. SUARC offers technical assistance, consultancy research and development to upland communities in Cebu and in other provinces in the Philippines. It is also offers extension to member people's organisations.

MFI-FSP forage project

Mag-uugmad, in partnership with the Forages for Smallholders Project (FSP), collaborated in a project on 'On-Farm Testing and Production of Forages in four upland barangays of Cebu City'. The project intended to strengthen the technical capabilities and intensify forage production of farmers who are involved in the MFI-assisted Livestock Dispersal Project.

Methodology

In answering the above question, Mag-uugmad conducted a survey and a focus group discussion (FGD) in one of the *sitios* (sub-village or hamlet) where we worked with farmers on livestock production with forage production components. To address extension, during the FGD we asked farmers who they would approach if they needed technical advice related to forage production. We also used the Adoption Tree (introduced by FSP) to determine the extent of farmers planting forages within the sitio and in adjacent farming communities.

Mag-uugmad Learnings from Surveys and Interviews

Before soil and water conservation was introduced, farmers practiced tethering. After World Neighbours introduced SWC, farmers planted live erosion barriers which had multiple uses. Farmers also started integrating livestock in the farming system. An average family in a sitio owns a carabao, a cow or a goat. The farming system is integrated with hedgerow species being chosen for soil erosion control and its palatability to livestock. Among the species which have gained widespread acceptance are: *Setaria sphacelata* (setaria), *Pennisetum purpureum* (napier grass) and *Paspalum atratum*. Farmers are using these forages to feed all their livestock, propagating them through cuttings and tillers.

As for extension, farmers learned about forage production from their neighbours. They are getting technical advice from PO leaders who were trained by Mag-uugmad.

Analysis of MFI's Learnings

Farmers will always look at immediate economic gains, low cost of inputs, little labour requirement, compatibility with skills and farm resources before they decide to adopt a technology. In Mag-uugmad's farmers' experience, adoption of forage production is remarkably fast.

After the farms were relatively stabilised through soil and water conservation structures, farmers focused on soil fertility management technologies (use of animal manure, composting, etc.). It was during this stage that farmers realised the necessity of integrating as many livestock in the farming system as they could.

From the extension point of view, the project is readily accepted by farmers because of their need for a steady supply of forages.

Implications for Extension

Mag-uugmad's learning from PRA activities indicated that, in the sitio where the project has been adopted, there was at least one model farm that showcased the integration of forage production in the farming system that served as an eye-opener to other farmers before spontaneous adoption. An exposure trip from other villages to this sitio expedites the widespread expansion of the project.

Alayons have proven to be the best venue for learning. The alayon, being a community-based initiative, is highly replicable in other upland communities in the Philippines.

Since forage production has addressed the felt needs of farmers, the technology will spread by itself in the upland farming communities. But as adoption is advancing faster from farmer to farmer and from village to village, there is a need for more training and seminars on forage technologies. Farmer extensionists are also needed to sustain the momentum of extension and the pace of the project expansion.

Feed Resources for Ruminants in Smallholder Farming Systems in Southeast Asia

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Abstract

The demand for meat and milk in Southeast Asia has almost doubled in the past two decades, and this trend is expected to continue in following years. There is a need to enhance productivity in the prevalent smallholder crop-animal systems, in order to match these increases in demand without jeopardising the natural resource base. Some estimates suggest that available roughages may be enough to sustain the actual livestock population, but better quality and high yielding improved forages, and other nutritional options are needed to ensure more efficient use of available roughages. Current options for improving the efficiency of feeding systems in smallholder livestock farms include: a) appropriate budgeting of available feed resources; b) greater use of improved forages; c) supplementation of low quality feed resources; and d) treatment of crop residues. Research on genetic improvement of crop residues and the manipulation of rumen microbial populations should provide new options for the medium to longer term.

The Southeast Asian Setting

Trends in livestock production

THERE HAS been a significant increase in the per capita consumption of livestock products in Southeast Asia during the past two decades. This has been associated with increases in family incomes, urbanisation and modification to diet patterns, along with the higher elasticity of demand that characterise livestock products. Between 1961 and 1995, total meat consumption per capita increased from 9.4 to 21.0 kg/year, but pigs and poultry remain the main meat sources (FAO 1999). The changes in per capita consumption, and human population increase, suggest that there will need to be a 3.5 to 4.0-fold increase in livestock products by the year 2020 (Delgado et al. 1999).

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The increase in demand for livestock products as well as in population density will put more pressure on the natural resource base, as further expansion will be on more fragile lands. Also there is likely to be more competition between the use of resources for livestock and crop production.

Overview of Smallholder Farming Systems

Almost all farming systems have a livestock component which includes both ruminants and non-ruminants. Most livestock are raised in traditional systems, except for large-scale intensive systems of pig and poultry production practiced in some countries; however, the latter are not addressed in this review.

Most pigs and poultry are raised in traditional low-input systems. Local breeds are commonly used and animals are allowed to scavenge outdoors, and are fed some household residues and crop by-products as supplements (Edwards and Little 1995). In such systems, animal productivity is low (ca. 100 g/day LWG in pigs, and 50 eggs/bird/year for poultry), but also production costs are low (Vercoe et al. 1997). Where the main purpose of pigs and poultry is to generate income, farmers use improved breeds and concentrates, and under those circumstances productivity is much higher. For example, in Northern Vietnam, where cassava and other crops are grown for feeding pigs, productivity is 250–500 g/day (D. Peters, unpublished data; Nguyen 1994).

In lowland rice-growing systems and intensive upland systems, buffalo and cattle are used for land preparation and transport, with manure, meat and/or milk forming useful by-products (Vercoe et al. 1997).

In extensive upland systems, cattle and goats are largely kept for building wealth and generating cash when needed. The increased demand for meat has resulted in a steady increase in the cattle and goat population (Figure 1). This has allowed small farmers to increase their asset base. Buffalo numbers have remained constant or decreased slightly, due to increasing mechanisation in lowland rice areas (Paris and Sevilla 1995). However, in some cases buffalo numbers remain larger than expected. This is probably due to their ability to utilise crop residues and weeds or forage in waste areas and thus continue to have a role as an asset and in contributing manure for rice-based systems.

In both lowland and upland systems, livestock tend to occupy niches that do not compete with other forms of land use. This applies to both use of the land itself and the utilisation of farm labour. The systems in which they tend to be absent, and could be increased (Chee and Faiz 1991), are specialised perennial tree crop systems such as rubber, oil palm, fruit, tea and coffee. These are often relatively large enterprises where owners look on livestock as a source of damage or as a problem in management of such estates. Large waste areas available for free grazing of cattle, such as Imperata grasslands, are underutilised compared to equivalent areas in Africa.

The livestock population remains greatest in the densest cropping areas. Livestock are associated with intensive rather than extensive land use (which contrasts with the situation in South America). This is because livestock are closely integrated with cropping systems; the crop providing sustenance for the household and the livestock contributing draught power, manure for crops and cash for the family or to finance crop activities. In spite of these interactions, livestock compete with crops for land, labour and capital resources, and the competition is becoming greater as human population density and demand for land increases. However, where these resources are used for livestock production, it is because the products derived from livestock are equal to or more valuable than crop products.

The integration of crops and animals in smallholder upland systems is the main avenue for increasing animal production in Southeast Asia (Devendra et al. 1997).

Ruminant Production Systems

The ruminant production systems practiced in Southeast Asia can be grouped in three major categories:

(a) Systems integrating arable cropping and livestock;

(b) Extensive grazing systems;

(c) Systems integrating animals and perennial tree crops.

Combinations of cropping and livestock are the most common ruminant systems. In these systems, livestock are controlled in intensive cropping areas by stalling or tethering and shepherded grazing of roadsides, idle land and crop stubble (Devendra et al. 1997). It is common to 'cut and carry' grasses,

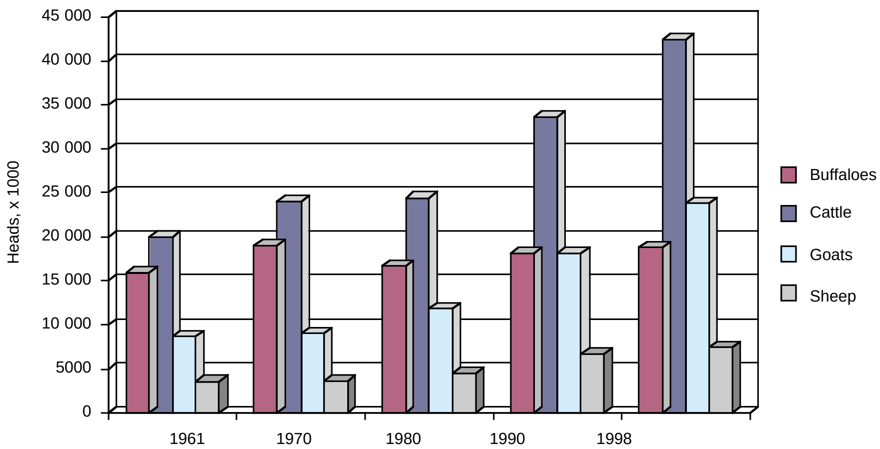

Figure 1. Changes in livestock population in East and Southeast Asia, between 1961 and 1998 (FAO, 1999).

weeds, and/or crop residues to animals maintained in pens or even to those tethered. Supplementation with concentrates is seldom practiced, and it occurs mainly during the dry season.

Extensive management of native or naturalised grassland systems is not as common in the region as it is in Africa and tropical America. Extensive systems tend to be low-output systems, in which animals graze native pastures or the understorey vegetation of upland primary or secondary forests. Poor control of cattle in extensive systems often causes problems to crop producers who have to use precious labour and capital resources to build fences. Livestock in extensive systems are more likely to be owned by absentee owners. In those intensive systems where animals are always stalled, tethered or shepherded by farmers, there is greater equity in ownership and more efficient livestock production (Piggin 1997).

Integrating ruminants is common in coconut plantations but has often been discouraged in other plantation crops such as palm oil, rubber and fruit trees. There is considerable opportunity for expansion. Considering that stocking rates of 3.0 sheep or 0.25 cattle/ha are achievable under tree crops, it has been estimated for Malaysia that if only 50% of the oil palm plantations are grazed, an extra 3.3 million sheep and 275 000 cattle could be reared. Also, a further 1.1 million sheep could be reared if only 20% of the rubber plantations were to be managed under grazing (Chin et al. 1998). However, the adoption of these systems by a large number of farmers will depend on resource endowment, supporting infrastructure, market potential and policies favouring intensification, diversification and specialisation (Devendra et al. 1997).

Feed Resources in Smallholder Farming Systems

Feeding systems for large ruminants in indigenous systems in Southeast Asia are characterised by the use of a wide diversity of feed resources. These are based largely on the use of crop residues, forages, and other resources not directly used for human consumption. Competition is more likely to occur in dairy systems because of the higher value for milk and milk products. However, the dairy cattle and milk buffalo population is relatively small in the region (FAO 1999). Rice straw and other crop residues, naturally occurring grasses and broadleaf weeds and shrubs are the dominant feedstuffs. Nitis et al. (1982) reported that a total of 56 different green feeds were fed to goats in Bali. These included tree leaves (35), grasses (15), legumes (3) and others (3). The distribution of the species of green feed fed varied according to climatic zone, topography, land utilisation and soil condition. Agro-industrial by-products and non-conventional feed resources may also be important under local situations (Devendra et al. 1997).

Rice straw is dried and stock-piled as hay for use when there are no other feed sources, in the dry season when other feedstuffs are in short supply or in the wet season when land is occupied by crops. In these cases, farmers either feed the animals with rice straw taken from the piles or let animals eat directly from the piles. In other cases, fields from which rice and other crops have been harvested are grazed, and cattle benefit by having a mixed diet of crop residues and green weeds. Farmers fully utilise these ‘waste’ resources before using other options such as purchased feedstuffs and committing labour to produce improved forages.

With a greater demand for meat products, farmers are modifying their feeding systems. In a few cases, there has been stratification of the industry where cattle are bred on extensive systems and then moved to other areas for fattening. As an example, cattle bred on Masbate in the Philippines are moved to Batangas for use as draught and for fattening. In other cases, improved grasses and legume trees and shrubs may be planted for cutting and feeding to stalled cattle.

Feeding systems for pigs, small ruminants, and fish make greater use of concentrates. These may be derived from alternative food crops such as cassava and from food crop by-products such as rice bran. Nevertheless, high quality roughages such as leaf of cassava and sweet potato, grasses and legumes are also fed to small ruminants, pigs and fish.

Permanent pastures represent only 3.9% of the total land in Southeast Asia (Table 1). However, native and naturalised forages, as well as ‘weeds’ are normally found in crop fields, roadsides, river banks, rice bunds and areas under fallow, and even as understorey vegetation in the forest, as well as under plantation crops (coconut, oil palm, rubber), although the latter are often underutilised. The estimated availability of these native forages from non-arable land is 110.4 million tons DM/year (Table 3), which would allow the maintenance of almost 30 million ruminant livestock units (RLU[1]).

Crops provide a range of residues, agro-industrial by-products and non-conventional feedstuffs, which can be utilised by ruminants and non-ruminants, either in crop-animal or specialised systems. Most are produced at the farm level (e.g. rice straw, sugarcane tops, sweet potato vines, cassava leaves, grain legume

[1]RLU Equivalencies: buffalo = 1.0, cattle = 0.8, goats = 0.1 and sheep = 0.1

Table 1. Land use (× 106 ha) in Southeast Asia, 1994.

Land use type	Brunei	Indonesia	Cambodia	Laos	Malaysia	Myanmar	Philippines	Thailand	Vietnam	**Total**
Arable land	3	17 126	3 700	800	1 822	9 534	4 970	17 085	5 511	**60 551**
Permanent crops	4	13 045	105	50	5 782	542	4 400	3 360	1 247	**28 535**
Permanent pastures	6	11 800	1 500	800	281	345	1 280	800	328	**17 140**
Forest and Woodland	450	111 774	12 200	12 550	22 248	32 400	13 600	14 800	9 650	**229 672**
Other land uses	64	27 412	133	8 880	2 722	22 934	5 567	15 044	15 813	**98 569**
Total	**527**	**181 157**	**17 638**	**23 080**	**32 855**	**65 755**	**29 817**	**51 089**	**32 549**	**434 467**

Source: FAO (1999).

Table 2. Availability of crop residues and agro-industrial by-products (1000 tons), from the most common crops in Southeast Asia.[a]

Crop residues/by-products	Brunei	Indonesia	Cambodia	Laos	Malaysia	Myanmar	Philippines	Thailand	Vietnam	**Total**	**Carrying capacity (1000 R.L.U.)[1]**
Rice straw[b]	1	50 632	1 414	1 970	18 900	11 269	11 269	21 280	26 397	**135 253**	**36 554.86**
Corn stover & cobs[c]	–	11 190	72	94	58	300	5 198	5 460	1 844	**24 261**	**6 544.86**
Wheat straw[4]	–	–	–	–	–	333	–	3	–	**336**	**90.81**
Sorghum stover[d]	–	–	–	–	–	–	–	690	18	**708**	**191.35**
Camote vines[e]	–	496	16	28	8	10	274	18	606	**1 456**	**393.51**
Cassava leaves[f]	1	650	7	2	20	4	108	600	138	**1 530**	**413.51**
Peanut hay[g]	–	645	9	9	1	512	46	100	263	**1 585**	**428.28**
Sugarcane tops[h]	–	2 015	40	15	120	365	1 835	5 275	1 200	**10 865**	**2 936.48**
Sugarcane bagasse[i]	–	4 291	31	13	240	576	3 900	8 846	1 350	**19 247**	**5 201.89**
Pineapple pulp[i]	.4	215	6	14	65	–	581	800	74	**1 755**	**474.32**
Total	**2.4**	**70 134**	**3 571**	**1 589**	**2 482**	**21 000**	**23 211**	**43 072**	**31 890**	**196 951**	
Carrying capacity	**.6**	**18 955.1**	**965.1**	**429.5**	**670.8**	**5 675.7**	**6 273.2**	**11 641.1**	**8 618.9**		**53 230.0**
Ruminants population (1000 RLU)	**6.1**	**14 999.0**	**3 010.0**	**2 176.0**	**783.5**	**10 702.6**	**5 433.8**	**10 221.0**	**6 045.3**		**53 368.3**

[a]Based on 1997 crop area and production (FAO 1998); [b]At 1:1 grain-straw ratio; [c]At 1:1.2 grain-straw and cob ratio; [d]At 1:3 grain-straw ratio; [e]At 2 t DM/ha; [f]At 0.5 t DM/ha; [j]At 1 t DM/ha; [h]At 5 t DM/ha; [i]At 15% of cane produced; [j]At 40% of fruit produced; [1]At 3.7 t DM per Ruminant Livestock Unit (RLU)/year.

haulms and straw), whereas others are by-products of crop processing activities, frequently performed off-farm (e.g. rice bran, lower grades of rice grain, copra meal, oil-palm cake, sugarcane molasses, pineapple and citrus pulps, fruit rinds and peelings).

The fibrous crop residues represent by far the majority of the total volume of feeds produced in Southeast Asia, and constitute the basic feed resources for most crop-animal systems. The availability of cereal straws in Southeast Asia is 158 million tons, 86% from rice. Considering the ruminant population, the average availability per RLU is 2.9 tons/year, this being in excess of the potential intake of this resource, which is 1.28 and 0.73 tons/year, for buffalo and cattle, respectively (Devendra 1997). However, there is a wide variation among countries, for example, in Vietnam and Indonesia, there are large excesses (4.7 and 4.1 tons/RLU/year), whereas the availability in Cambodia and Laos (0.5 and 0.9 tons/RLU/year) is below the potential intake of a RLU. The available crop residues and the agro-industrial by-products theoretically could provide all the roughage demanded by the present ruminant population (Table 2); however, these estimates are based on the assumption that all residues are exclusively used for feeding, are readily accessible to animals, and all the above-ground biomass is consumed. There is a need to quantify how much of these crop residues are actually used, and to study what proportion could be consumed under stubble grazing, considering different crop and animal management conditions.

There is a wide variation in the nutritive value of crop residues and agro-industrial by-products (Table 4). There is also variability within a given feed due to factors such as genotype, temperature, rainfall, soil fertility, fertiliser management, harvesting method, post-harvest handling and storage. In general, fibrous crop residues are poor sources of fermentable nitrogen, as their crude protein (CP) content is below the level required by rumen micro-organisms (6–7% CP). Most are low in easily degradable carbohydrates, and in mineral nutrients, as well as in nutrients required to balance the products of digestion to requirements. All these result in limited intake, poor rumen function, increased methane emissions, and low animal productivity (Leng 1993), unless strategies are applied to overcome the nutritional constraints of these fibrous crop residues.

Options for Improving the Efficiency of Current Feeding Systems

Appropriate budgeting of available feed resources

There is a strong relationship between feeding practices and cropping calendar in the crop-animal systems commonly practiced in Southeast Asia (Figure 2). Seasonal changes in the availability of crop residues and other forages determine important variations in diet composition (Figure 3), resulting in cyclical periods of feed scarcity and under-nutrition, alternating with periods of nutritional adequacy, and even feed surplus, with consequences on nutrient intake and animal performance (Figure 4). The impacts on rumen function and nutritional efficiency due to these changes through the year, as well as of the diversity of feeds used, is not fully understood.

Any attempt at balancing the offer and demand of nutrients year-round should be built on a clear understanding of the seasonal changes in the animal/herd nutritional requirements, as well as the availability and access to different feeds at the farm level, and in the local markets. For example, in the case of rice-based farming systems, the most critical feeding periods for ruminants are the dry season and the time when rice is harvested. In the former, lack of moisture limits forage availability and quality, while in the latter, competition for labour between rice harvesting and forage gathering, as well as the reduced area available for tethering or growing cut and carry forages, limits the amount of feeds on offer (Sevilla and Carangal 1995). In some areas, for example, the rainfed lowlands of Laos and Northeast Thailand, the deficit extends to the entire rice-growing season, as animals cannot access the rice fields. These problems are becoming more critical with the intensification of crop cultivation (Roxas et al. 1997).

Table 3. Availability of forages for ruminants from potentially grazing areas in Southeast Asia.

Land use type	Area (million ha)	Yield[1] (ton DM/ha/year)	Availability (million tons DM)
Permanent pastures	17.1	0.8	13.68
Forest and woodland	229.6	0.2	45.93
Permanent crops	28.5	0.4	11.40
Other land uses	98.6	0.4	39.43
Total	**373.8**		**110.44**

[1]Average yields proposed by Roxas et al. (1997).

Table 4. Proximate analysis, calcium and phosphorus values of crop residues, agro-industrial by-products, non-conventional feedstuffs and food waste materials.[1]

Feed resource	Dry matter (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Ash (%)	N-Free extract (%)	Ca (%)	P (%)	IVDMD (%)
Atis (*Anona squamosa*)									
peelings	96.2	6.3	2.6	35.0	4.0	48.3	1.72	0.17	27.0
seeds, roasted	96.7	14.7	22.4	44.1	1.9	13.6	1.14	0.21	9.0
Banana (*Musa* spp.)									
peelings	89.4	5.1	9.1	13.5	10.4	51.4	1.58	0.14	
rejects (pulp + peelings)	89.3	3.7	3.0	3.0	4.0	75.5	–	–	
Brewer's bagasse/Brewer's spent grains	91.8	20.6	13.1	13.1	2.6	42.3	0.36	0.39	
Cacao (*Theobroma cacao*)									
pods, boiled	85.8	7.6	2.6	36.0	7.4	32.3	0.60	0.17	
pods, raw	90.7	9.5	2.3	31.3	10.1	37.5	0.90	0.24	
Caimito (*Chrysophylum caimito*)									
rejects	93.4	4.5	20.3	19.5	4.0	45.2	1.06	0.11	34.0
Cashew (*Anacardium occidentale*)									
pseudocarp	87.8	7.3	6.1	8.9	3.7	61.9	0.67	0.18	–
Cassava (*Manihot esculenta*)									
leaves, sun-cured	90.0	20.1	4.6	16.1	7.5	41.4	1.43	–	
petiole – leaf meal	88.4	18.6	6.4	13.1	7.2	43.2	0.28	0.39	
Castor (*Ricinus cummunis*)									
oil meal	98.9	36.8	6.2	28.2	6.7	21.0	1.88	0.70	
Chico (*Manilkara zapota*)									
meal	97.8	2.4	4.2	16.9	2.7	71.6	1.02	0.12	46.0
Coconut (*Cocos nucifera*)									
cocopress cake	96.8	7.6	11.2	17.87	2.9	57.4	–	–	
Coffee (*Coffea* spp.)									
pulp	80.5	5.8	2.7	21.5	6.7	43.8	0.57	0.23	
hulls from roasted beans	88.3	5.12	1.0	51.9	2.6	27.8	0.33	0.07	
Corn (*Zea mays*)									
cobs	89.7	3.5	0.8	29.7	4.5	51.2	–	–	
cobs, fresh	27.0	0.8	0.3	10.2	0.6	14.9	0.06	0.02	
cob meal	92.2	3.0	0.9	34.6	2.4	51.3	0.19	0.04	
husks, dried	88.4	7.1	–	27.1	16.9	–	0.16	0.13	
leaves, fresh, wilted	45.0	2.8	1.0	14.14	4.1	22.5	–	–	
leaves, sun-cured	90.0	5.5	1.6	29.5	8.7	45.0	0.35	0.13	
stems, fresh, wilted, milk stage	24.0	1.7	0.8	8.6	2.3	10.5	–	–	
stems, sun-cured	89.0	4.00	1.3	34.8	5.6	43.6	0.25	0.11	
stover	89.0	5.7	0.4	28.3	8.9	45.7	0.41	0.16	48.3
Cowpea (*Vigna unguiculata*)									
empty pods	87.4	12.2	1.3	25.6	6.0	42.4	0.74	0.25	
seed	92.1	20.4	1.5	4.5	3.3	62.4	0.06	0.35	
vegetable pod meal	94.6	20.1	2.5	16.0	4.6	51.4	0.60	0.48	
Durian (*Durio zibethnus*)									
rind	92.0	4.9	1.5	18.0	7.8	59.8	0.62	0.15	
Guayabano (*Anona muricata*)									
peelings	94.8	6.4	3.7	32.2	3.0	49.6	1.18	0.16	32.0
seeds, roasted	98.7	13.4	24.7	54.6	1.8	4.3	0.94	0.20	
Jackbean (*Canavalia ensiformis*)									
fresh, full bloom	19.0	4.4	0.6	4.8	2.5	7.3	0.56	0.07	
leaves, sun-cured	89.0	19.9	2.8	21.9	11.3	33.1	2.55	0.33	
seeds	94.9	21.2	2.7	10.7	3.1	57.1	0.94	0.72	
seeds, roasted	92.0	25.8	1.8	9.8	3.7	50.9	0.31	0.34	
Jackfruit (*Artocarpus heterophyllus*)									
leaves, fresh	34.0	4.7	2.2	7.0	5.1	15.0	–	–	
leaves, sun-cured	89.0	10.9	3.9	17.7	22.6	34.1	–	–	
peelings with seeds, sun-cured	89.0	9.5	3.30	11.5	10.3	54.2	–	–	72.0
seeds	97.0	12.3	1.1	5.1	4.6	73.8	–	–	
seeds, boiled	92.7	13.5	2.2	9.5	2.9	64.7	1.12	0.20	72.0
Lanzones (*Lansium domesticum*)									
peelings	93.0	9.9	8.7	17.2	5.6	51.4	1.28	0.16	42.0
Mango (*Mangifera indica*)									
peelings	94.2	4.6	4.8	15.6	5.8	63.5	1.20	0.15	49.0

Table 4. Proximate analysis, calcium and phosphorus values of crop residues, agro-industrial by-products, non-conventional feedstuffs and food waste materials.[1]

Feed resource	Dry matter (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	Ash (%)	N-Free extract (%)	Ca (%)	P (%)	IVDMD (%)
Mungbean (*Vigna radiata*)									
empty pods	89.5	7.6	0.7	33.7	3.2	44.2	1.42	0.13	46.0
sprout coat	95.2	11.4	0.4	35.5	5.8	42.0	0.94	0.14	35.0
Peanut (*Arachis hypogaea*)									
germ meal	96.7	26.9	42.7	17.4	3.0	6.6	0.20	0.61	
hay	54.4	8.7	0.8	16.6	8.3	20.1	2.72	0.21	56.6
seed coat	94.9	14.5	11.6	21.9	2.4	44.4	0.50	0.13	
shells	92.5	4.8	0.6	66.5	6.6	13.6	1.38	0.07	20.0
straw	–	12.4	–	–	–	–	1.10	0.15	
tops	90.5	15.8	2.8	21.4	7.4	43.1	1.63	0.22	52.0
Pigeon pea (*Cajanus cajan*)									
leaves	88.8	19.6	1.7	7.0	4.0	56.5	0.84	0.56	
Pili (*Canarium hypogaea*)									
nut coat	93.4	9.9	15.6	27.6	3.2	37.0	0.78	0.33	
Pineapple (*Ananas comosus*)									
bran or pulp	88.0	3.2	0.9	16.3	3.9	63.8	–	–	
wastes (skin, pith)	11.7	0.4	0.1	1.4	0.6	9.1	0.05	0.01	
Rambutan (*Nephelium lappaceum*)									
peelings	98.9	5.9	1.5	17.0	2.2	72.2	1.74	0.10	45.0
Ramie (*Boehmeria nivea*)									
Fresh, midbloom	15.0	2.3	0.4	4.9	2.0	5.0	0.63	0.04	
hay, sun-cured, ground	91.0	21.1	2.9	10.9	19.2	36.6	–	–	
hay, sun-cured, ground, midbloom	86.0	19.3	2.4	13.2	15.9	35.2	3.70	0.24	
leaves, fresh	21.0	4.0	0.9	2.0	7.2	6.9	–	–	
leaves, sun-cured	88.0	17.7	4.2	15.8	19.5	30.4	–	–	
stems, sun-cured, midbloom	88.0	7.4	–	45.2	7.7	–	–	–	
Rice (*Oryza sativa*)									
hulls	90.0	6.5	5.1	20.9	12.4	45.2	0.12	0.18	
straw	92.6	3.7	1.5	31.4	21.2	34.8	0.43	0.12	31.2
Sincamas (*Pachyrrhizus erosus*)									
hay, sun-dried	89.2	15.5	3.7	26.9	7.8	35.3	1.11	0.32	
Sorghum (*Sorghum bicolor*)									
hay, sun-cured	91.0	9.4	3.2	32.1	8.2	37.8	0.35	0.14	
stover	81.7	5.2	1.3	22.5	9.1	43.6	0.36	0.16	54.2
Soybean (*Glycine max*)									
hulls	89.6	17.8	3.4	25.4	4.5	38.5	0.75	0.23	
leaves, fresh	18.0	3.5	0.5	5.8	1.7	6.7	0.25	0.07	
leaves, sun-cured	87.0	16.9	2.6	25.4	8.7	33.5	1.27	0.40	
pulp	91.3	27.5	11.0	19.0	3.1	30.7	1.20	0.38	70.0
Sugarcane (*Saccharum officinarum*)									
bagasse, dehydrated or sun-cured	93.0	2.5	0.8	39.70	4.50	45.45	0.48	0.27	
bagasse, wet	78.0	2.8	0.6	8.00	5.60	61.47	–	–	
filter cake press (sugar mud)	92.2	6.6	6.6	12.56	19.86	46.59	2.69	1.36	
leaves, fresh	24.0	1.7	0.5	8.80	2.10	11.11	0.08	0.06	
top, aerial part with leaves, fresh	31.0	1.6	0.5	10.40	2.70	15.62	0.06	0.05	
top, aerial part, sun-cured	91.3	3.6	1.4	28.2	7.9	50.2	–	–	
Sweet potato (*Ipomoea batatas*)									
hay, sun-cured	85.0	10.2	2.4	17.7	14.2	40.6	1.17	0.72	
leaves, fresh	27.0	7.8	0.3	2.9	2.5	13.2	–	–	
leaves, sun-cured	86.0	13.6	3.8	8.5	10.0	49.9	–	–	
Tamarind (*Tamarindus indica*)									
leaves, dehydrated	91.0	13.3	1.9	22.0	6.9	46.5	2.54	0.23	
leaves, fresh	36.0	5.2	0.8	8.6	2.7	18.3	1.00	0.07	
Tapilan (*Phaseolus calcaratus*)									
hay	84.5	13.5	–	31.1	9.8	–	–	–	
Tomato (*Lycopersicon esculentum*)									
pomace	90.8	16.0	8.2	30.4	5.7	30.6	0.34	0.37	
Winged bean (*Psophocarpus tetragonolobus*)									
seed meal	92.6	31.6	15.8	10.0	3.6	31.6	0.76	0.42	

[1]Adapted from: Gerpacio and Castillo (1988) and Zamora and Baguio (1984).

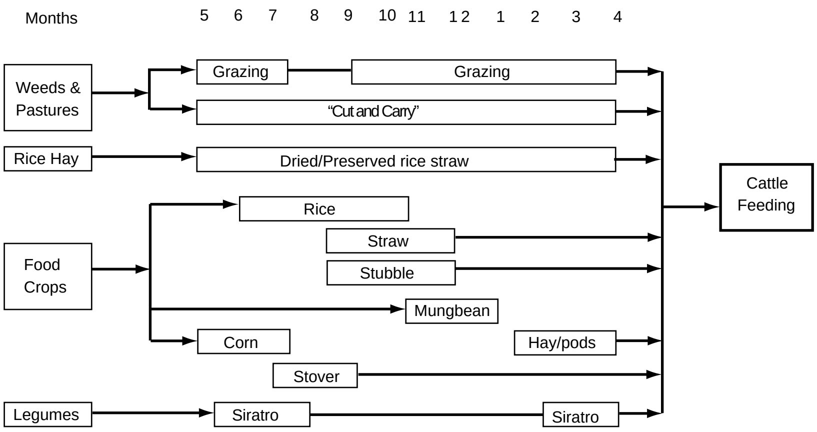

Figure 2. Cropping pattern and feed resources flow model for a crop/animal system practised in a sub-humid agro-ecozone in the Philippines (Palacpac 1994).

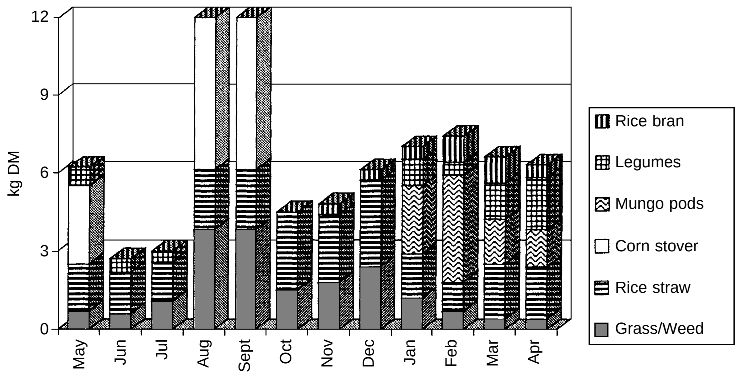

Figure 3. Diversity of feed resources utilized in a rainfed rice-based cattle system practised in the sub-humid agro-ecozone of the Philippines (Palacpac 1994).

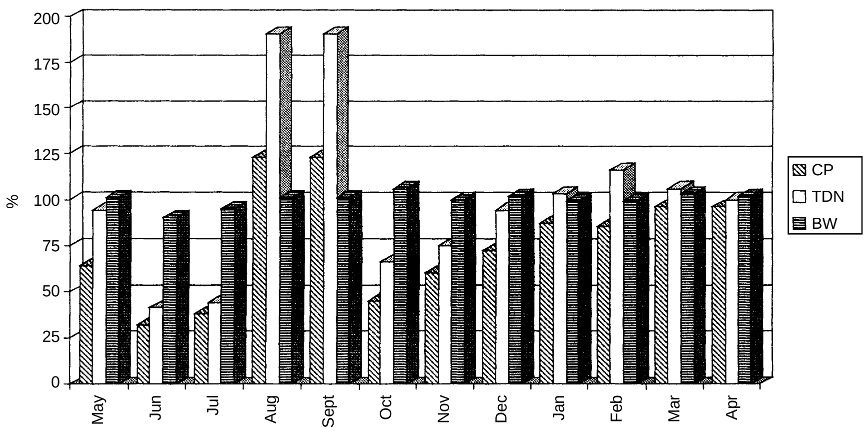

Figure 4. Seasonal variations in the proportion of nutrient requirements covered and BW changes in a rainfed rice-based cattle system in a sub-humid agro-ecozone of the Philippines (Palacpac 1994).

Use of improved forages

In most crop-livestock systems, where poor quality crop residues constitute the basal diet, action could be taken to increase the availability of leguminous shrubs and trees, as well as herbaceous legumes during the year (Steinbach 1997), in order to provide at least the fermentable nitrogen that is needed. This role is more likely to be played by legume trees and shrubs, since many of them can carry green leaves into the dry season, and they can be more readily grown in borders of crop fields and spare areas than herbaceous legumes. *Leucaena leucocephala* had been widely promoted as a popular fodder legume in Southeast Asia until the psyllid (*Heteropsylla cubana* Crawford) infestation became a major problem (Chin et al. 1998). However, the advent of psyllid resistant and acid tolerant genotypes, as well as natural predators, will ensure that *Leucaena* remains important (Shelton et al. 2000). *Gliricidia*, *Calliandra*, *Sesbania* and *Erythrina*, as well as some of the newly introduced legume shrubs and trees such as *Desmanthus* spp. and *Desmodium cinerea* (= '*D. rensonii*'), *Flemingia* spp., are also playing a major role in some Southeast Asian indigenous livestock systems.

Improved grasses should function as buffers in crop-animal systems, complementing the existing feed resources, especially during the most critical periods of the year. Improved grasses have been shown to be not only more productive, but also more drought resistant than native grasses (Stür et al. 2000).

A range of improved forage technology options based on forage species with broad adaptation to soils and climate is now available for different farming systems (Gabunada et al. 2000). Farmers are adopting different options to meet their own needs at the farm level. For example, those farmers that identify lack of labour as limiting, see intensively managed forage plots as an attractive way of reducing the demand for labour for livestock management. In many cases, farmers intend to use these intensively managed plots only at specific times, such as days when they have to go the market, when some family members are sick, or during periods of peak labour demand for other agricultural activities. Also, the availability of improved forages for 'cut and carry' has increased the capability to collect manure for crop production.

The range of technologies tested by farmers has increased as they become familiar with forages and they see more opportunities on their farms. The entry point is usually farmers' interest in growing forages in 'cut and carry' plots for feeding their animals. However, some technologies aimed at better

Table 5. Feed intake, digestibility and live-weight gain of ruminants fed roughages, supplemented with legumes.

Type of basal diet, legume and animal species used	Level of legume % DM	Straw/grass DM intake % BW	Total DM intake % BW	Ration digestibility %	Live-weight change g/day
***Gliricidia maculata* as supplement** (Doyle et al. 1986)					
Untreated rice straw/young bulls	0	2.7	2.7	47	–113
	10	2.8	3.0	46	–54
	20	2.5	3.0	49	–94
	33	2.2	3.3	55	10
Urea-treated rice straw/young bulls	0	3.2	3.2	41	–28
	9	3.1	3.4	45	63
	13	3.4	3.9	50	134
	26	2.8	3.8	52	130
***Gliricidia sepium* as supplement** for urea-treated rice straw/goats (Trung et al. 1989)					
	23	1.70	2.21	44	–30
	46	1.78	2.79	47	–10
***Calliandra callothyrsus* as supplement** for Napier grass/sheep (Wina et al. 1997)					
	0	3.46	3.46		66
Wilted *Calliandra*	30	2.21	3.80		54
Fresh *Calliandra*	30	2.30	3.91		78
***Stylosanthes guianensis* (SG) as supplement** for untreated rice straw/sheep (Lanting and Sevilla 1998)					
	58 (SG)	0.60	3.05	58	18
	40 (SG) + 7 (FM)[1]	0.58	3.00	55	22

[1]FM = *Flemingia macrophylla.*

resource management are emerging in the more intensive systems. These include grasses grown in contour hedgerows or for stabilising gully erosion, legumes as ground covers and grasses and legumes for feeding fish (Gabunada et al. 2000). In all cases, improved forages are used to complement and not replace existing feed resources such as native grasses, weeds and residues on old cropland and stored crop residues.

Supplementation

Animals fed low quality forages, such as fibrous crop residues or mature grasses, frequently require fermentable nitrogen and minerals for efficient rumen function. A sub-optimal level of any of these will result not only in poor rumen function, but also in a low protein to energy (P/E) ratio in the nutrients absorbed by the host (Leng 1993). To achieve higher production levels, there is a need to balance the ratio of protein (absorbed amino acids) to the energy (volatile fatty acids) derived from rumen fermentation. Supplementation with by-pass protein, starch and even long chain fatty acids can do this.

There are many opportunities to produce, at the farm level, the supplements needed for more efficient utilisation of the basal diet. Herbaceous or tree legumes (Doyle et al. 1986; Trung et al. 1989; Lanting and Sevilla 1998), as well as protein-rich crop residues, such as cassava leaves (Wanapat et al. 1997) and sweet potato vines, could be sources of fermentable nitrogen and minerals. On the other hand, non-marketable roots, grains, and fruits could provide starch and/or easily fermentable carbohydrates (Chimliang 1989). Table 5 shows the beneficial effects of the inclusion of legumes in the diet, to supplement a basal diet of rice straw.

Another strategy is the use of small quantities of concentrates (0.3 to 0.6%BW or 12 to 20% of the total ration DM) to supplement the basal fibrous component of the diet (Leng 1985), improving not only rumen function, but also animal performance through the provision of by-pass nutrients. However, emphasis should be put on locally available agro-industrial by-products, such as rice bran, copra meal and oil cake, or non-conventional feedstuffs, such as poultry litter, that can be produced on the farm or nearby, since smallholders usually have limited access to commercially available feeds, due to logistical and financial reasons (Steinbach 1997). Some examples of the responses of ruminants to the use of locally available concentrate feeds as supplements to a rice straw basal diet are shown in Table 6.

Another option to supplement low quality forages is the use of urea-molasses or multi-nutrient blocks, the latter being a source of by-pass nutrients, and even a vehicle for anthelmintic dosage. The advent of the cold process for the preparation of the blocks made this technology more accessible to smallholders. However, the degree of adoption varies with local conditions: characteristics of the basal diet, availability and cost of ingredients, end-product prices and marketing capacity (Sansoucy 1995).

Supplementation with urea-molasses blocks and multi-nutrient blocks improves rumen function efficiency, but to get increases in animal productivity, there needs to be sufficient roughage available (Ricca and Combellas 1993). The beneficial effects of these blocks are not only due to urea, but also to other microbial growth factors, such as sulphur and trace elements, contained in molasses (Sansoucy 1995). Positive effects of the use of blocks have been observed in Southeast Asia with different ruminant species and production systems. For example, Hendratno et al. (1991) found that supplementation with urea-molasses blocks increased the birth weight and live-weight of kids by 15% and decreased the kidding interval by 5.3%. Thu et al. (1993) found that working buffalo fed rice and urea-molasses blocks, at the beginning of the working period ploughed 20% more land, but after a month the difference was 40%, as supplemented buffalo worked at a higher speed, recovered faster from work and lost less weight. Wanapat et al. (1999a) observed that dairy cows having access to multi-nutrient blocks had a higher roughage intake, and improved milk yield by 2 kg/day, as well as higher milk fat content, resulting in higher economic returns.

Crop residues treatment

Alkali treatment of fibrous crop residues to improve their digestibility in ruminants has received a lot of attention from researchers (Devendra 1997). Its potential of being managed by small farmers in developing countries was demonstrated when urea-ammonification technology was studied in villages in Bangladesh (Dolberg and Finlayson 1995). Even though the benefits of urea treatment of crop residues on digestibility (Aryal 1989), intake and animal performance are well known (Table 7), its adoption by smallholder farmers has been limited.

Studies in Bangladesh and Sri Lanka demonstrated that smallholders apply this technology only when they have plenty of straw, lack access to grasses, and when milk production and market returns cover treatment expenses (Saadulah and Siriwardene 1993). Similar reasons have been expressed by farmers in India, but they also indicate they could apply this practice if water, urea, plastics and other covering materials are easily available (Singh et al. 1993). The extraordinary uptake of this technology by farmers of the Central Plains of China is an exception, since, in only six years, the amount of treated straw rose sharply from a negligible amount to 11 million tons. If used for beef production, this amount of treated straw supplemented with by-pass protein could produce over 500 000 tons of carcass meat. The adoption of the straw treatment technology in China has been facilitated by a strong government support in technical assistance at the village level, ready availability of subsidised credit (0.7% interest rate per month) and assured supply of urea at low prices (Dolberg and Finlayson 1995).

New Opportunities in Tropical Feed Resources Research and their Implications for Small Farmers in Southeast Asia

Genetic improvement of crop residues

Wide variation among genotypes has been detected in the ratio of leaf blade: leaf sheath: stem, as well as in chemical composition, in vitro digestibility and intake of rice straw (Table 8) (Pearce et al. 1988), but the effects appear to be strongly influenced by environmental factors (Roxas et al. 1997). Kush et al. (1988) suggest that only after environmental influences on quality attributes are understood and minimised, could an effective breeding program targeted to enhance rice straw quality be justified. However, an important goal in such a program should be to maintain or even improve grain yield and quality, parallel to the enhancement of the residue's nutritional quality (Kush et al. 1988).

Results obtained by Vadiveloo (1996) suggest that breeding rice for enhancing straw quality is not incompatible with grain yield improvement, but attention need to be given to other traits. For example, a reduction in lignin concentration could result in higher digestibility, but also may increase the lodging susceptibility (Ookawa and Kuni 1992), and insect resistance would also be at risk, unless high levels of antibiosis to pests could be developed in those low lignin genotypes (Pathak and Khan 1994).

In sorghum, Saini et al. (1977) suggested that digestibility, neutral detergent fibre and tannin contents are under genetic control, and consequently

Table 6. Effect of supplements on total intake, daily grain/milk production and feed efficiency in ruminants fed roughages as a basal diet.

Animal species and ratio	DM intake/% BW	Live-weight gain (g/day) or milk yield (kg/day)	Feed efficiency kg feed/kg animal product
Native sheep, fattening (Wina et al. 1995)			
Napier grass (NG)	2.55	44.4	11.5
60% NG + 40% *Calliandra calothyrsus* (CC)L	3.83	61.8	12.4
60% NG + 40% CC + Urea	3.24	64.1	10.1
60% NG + 40% CC + Urea + Ammonium Sulfate	2.82	60.9	9.2
60% NG + 40% CC + Cassava flour	3.23	73.5	8.8
Young bills, fattening, 126 days (Sevilla et al. 1976)			
50% RS + 50% Commerical Concentrate (C)	2.74[a]	540[b]	11.5[b]
35% RS + 30% C + 35% L	2.84[a]	710[a]	9.4[a]
Growing heifers, yearling to calving (Trung et al. 1987)			
35% RS + 65% C	2.19[a]	450[a]	12.0[a]
35% RS + 20% C + 45% Poultry Litter (PL)	3.10[b]	450[a]	18.0[b]
Milking cows, first lactation (Trung et al. 1987)			
35% RS + 65% C	2.70[a]	8.2[a]	1.1[a]
35% RS + 20% C + 45% Poultry Litter (PL)	3.50[b]	7.8[a]	1.4[a]
Milking cows, late lactation (Wanapat et al. 1999b)			
Urea-treated RS (TRS) ad lib + Concentrate: Milk (C:M) 1:2	2.0[1]	6.3[a]	
TRS ad lib + C:M 1:2 + 0.56 kg Cassava Hay (CH)	1.8	6.1[a]	
TRS ad lib + C:M 1:4 + 1.70 kg CH	2.3	6.1[a]	

[a,b]Means with the same superscript in a given column do not differ statistically ($p < 0.05$)
[1]DM intake of urea-treated rice straw only

improvements through breeding should be possible. Moreover, Rattunde (1998) detected large genetic variation for grain and stover yields in sorghum, with these attributes not negatively correlated. Hence, there are considerable opportunities for selection favouring both traits. An impact assessment study for sorghum and millet (Kristjanson et al. 1998) estimated that a 1% increase in digestibility of the stover would result in increases in milk, meat and draught power outputs ranging from 3.2 to 10.7%.

These results suggest that genetic manipulation of chemical and/or morphological attributes is another approach to enhance the nutritive value of crop residues, and could eventually contribute to the improvement of animal productivity in smallholder farms in Southeast Asia. There are opportunities to do so through traditional breeding programs, and through genetic engineering. This is an area of research that deserves joint efforts of agronomists and animal scientists.

Manipulation of rumen microbial populations

Some of the legume tree foliages commonly found contain anti-nutritional factors, for example, tannins, mimosine, that are toxic either to the animals or to rumen microorganisms (Kumar 1992), thus limiting their use as animal feeds. Previous exposure to some feeds containing those compounds can promote the proliferation of rumen microorganisms capable of tolerating or even detoxifying some of them (Odenyo et al. 1997). Jones and Megarrity (1986) demonstrated not only the presence of bacteria capable of degrading mimosine in animals previously exposed to *Leucaena leucocephala*, but also that it was possible to inoculate non-adapted animals, preventing toxicity problems. Odenyo and Osuji (1998) isolated *Selemononas* species capable of detoxifying condensed tannins. These bacteria were isolated from the rumen of East African native sheep, goats and antelopes adapted to *Acacia angustissima*. As in the case of the mimosine-tolerant bacteria, it is likely that these microorganisms could also be successfully transferred to non-adapted animals, to improve the efficiency of utilisation of high tannin forages, as well as decreasing the detrimental effects of tannins on rumen cellulolytic activity.

There are also some possibilities to manipulate the protozoa and fungal population in the rumen. Imai et al. (1995) demonstrated that Malaysian cattle and buffalo have a higher population of protozoa species, considered to be fermenters of cellulosic materials, than do cattle from temperate areas. Orpin and Ho (1991) showed that the population of rumen fungi is higher when animals are fed highly fibrous rations, but comparisons have not been made with animals across genotypes, feeding systems and environments.

Table 7. Effect of animal genotype and straw treatment on feed intake and live-weight gain in heifers receiving urea-treated or urea-supplemented straw (Schiere and Wieringa 1988).

Parameter	Sahiwal		Sahiwal × Native		Jersey × Native	
	Upgraded	Supplemented	Upgraded	Supplemented	Upgraded	Supplemented
Live-weight gain (g/day)	282[a]	105[bc]	185[b]	70[c]	–	39[c]
DM intake (% BW)						
Straw	2.33[a]	1.89[b]	2.49[a]	1.83[b]	–	1.70[b]
Grass	0.13	0.14	0.25	0.26	–	0.25
Rice bran	0.29	0.31	0.54	0.56	–	0.54
Total	2.75	2.34	3.27	2.65	–	2.49

[a,b,c]Values followed by the same letter are not significantly different ($p < 0.05$).

Table 8. Variability in morphological and quality attributes in rice straw from different genotypes.

Morphological attributes		Quality attributes			
Weight, % of total straw	Range	Nutritive value	Range	IVOMD[1]	Range
Blades	36–52	Nitrogen, %	0.38–1.52	Stem Internodes	42–77
Sheaths	29–43	Sulphur, %	0.01–0.13	Leaf Sheath	38–56
Stem	16–27	IVDMD[2], %	30–62	Leaf Blade	45–60
		Voluntary Intake, % BW	1.0–2.7		

[1]IVOMD = In Vitro Organic Matter Digestibility; [2]IVDMD = In Vitro Dry Matter Digestibility.
Adapted from: Pearce et al. (1988) and Kush et al. (1988).

Conclusions

- The increases in demand for meat and milk observed in Southeast Asia during the past few decades are creating opportunities for farmers not only to hold livestock as an asset, but also to increase productivity through improving calving rate and turnover (fattening). There are also some developments in the dairy sector, which require the availability of better quality forages, to reduce the dependence on external inputs.
- In Southeast Asia, there is scope for increasing the availability and utilisation of feedstuffs by livestock, and consequently animal productivity, within those systems integrating ruminants with annual crops and also a greater integration of livestock with plantation crops.
- The livestock feeding systems practiced in smallholder farms in Southeast Asia are complex, because of the number, as well as the diversity of feed resources utilised. These systems tend to be closely dependent on cropping patterns, and in most farms, crop residues are the major elements of the basal diet. Therefore, technological interventions designed to improve these systems should be built on the characteristics of the indigenous or existing systems, incorporating scientific knowledge in tropical ruminant nutrition, and looking for opportunities to favour synergistic effects to improve the utilisation of crop residues.
- The use of improved forages constitutes an option for improving the efficiency of current feeding systems in smallholder farming systems. Cultivated grasses should function as buffers complementing existing feed resources, whereas herbaceous and woody legumes can provide the limiting nutrients for efficient rumen fermentation in diets based on crop residues, mature grasses and weeds. There are also other opportunities for improved forages to function as multi-purpose species in these systems.

References

Aryal, I.K. 1989. The effect of urea treatment and/or supplementation on the feeding value of rice straw for sheep. MS Thesis. UPLB, Los Baños, Philippines, 80 p.

Chee, Y.K. and Faiz, A. 1991. Sheep grazing reduces chemical weed control in rubber. In: Shelton, H.M. and Stür, W.W., ed. Forages for Plantation Crops. ACIAR Proceedings No. 32, ACIAR, Canberra, 120–123.

Chimliang, T. 1989. Cassava as energy source for on-farm cattle fattening. M.S. Thesis, University of the Philippines, Los Baños, 57 p.

Chin, F.Y., Wong, C.C. and Halim, R.A. 1998. Commercialisation/exploitation of forage resources for the animal industry in Malaysia. In: Ong, H.K., Ho, Y.W., Wong, C.C., Idrus, Z. and Bejo, M.H., ed. Local Feedstuff Utilisation: Potential and Realities, Proceedings, 20th Annual Conference of the Malaysian Society of Animal Production (MSAP), 27–28 July 1998. Putrajaya, Malaysia, 1–12.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. 1999. Livestock to 2020: The Next Food Revolution, Food, Agriculture, and the Environment Discussion Paper No. 28. IFPRI – FAO – ILRI. Washington D.C., U.S.A, ILFRI, 72 p.

Devendra, C. 1997. Crop residues for feeding animals in Asia: Technology development and adoption in crop/livestock systems. In: Renard, C., ed. Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems. CAB International, Wallingford, UK, 241–268.

Devendra, C., Thomas, D., Jabbar M. and Kudo, H. 1997. Improvement of Livestock Production in Crop-Animal Systems in Rainfed Agro-ecological Zones of Southeast Asia, Nairobi, Kenya, ILRI (International Livestock Research Institute), 116 p.

Dolberg, F. and Finlayson, P. 1995. Treated straw for beef production in China. World Animal Review (FAO) 82(1). [ILRI/FAO. 1999. Farmers, their Animals and the Environment. Multi-document CD-ROM]

Doyle, P.T., Devendra, C. and Pearce, G.R. 1986. Some effects of chemical treatment or supplementation on the kinetics of fibre digestion in the rumen. In: Doyle, P.T., ed. Utilisation of Fibrous Agricultural Residues as Animal Feeds, Melbourne, Australia,. School of Agriculture and Forestry, University of Melbourne, 28–37.

Edwards, P. and Little, D.C. 1995. Integrated crop-fish-livestock improvements in Southeast Asia. In: Devendra, C. and Gardiner, P., ed. Global Agenda for Livestock Research. Proceedings of the Consultation for the Southeast Asia Region, IRRI, Los Baños, the Philippines, 10–13 May 1995, Nairobi, Kenya, ILRI (International Livestock Research Institute), 71–84.

FAO 1988. FAO Production Yearbook, 1998, Rome, FAO.

FAO 1999. FAOSTAT Database. Electronic Version. Rome, FAO.

Gabunada Jr. F., Heriyanto, Phengsavanh, P., Phimphachanhvongsod, V., Truong Thanh Khanh, Nacalaban, W., Asis, P., Vu Thi Hai Yen, Tugiman, Ibrahim and Stür., W.W. 2000. Integration of adapted forages on farms in Southeast Asia: Experiences form the Forages for Smallholders Project. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: The Key to Adoption of Forage Technologies. Proceedings, Workshop held in Cagayan de Oro, Philippines, 12–15 October 1999. These Proceedings, see Contents.

Gerpacio, A.L. and Castillo, L.S. 1988. Nutrient composition of some Philippine feedstuffs. Technical Bulletin No. 21, University of the Philippines at Los Baños, 108 p.

Hendratno, C.; Nolan, J.V. and Leng, R.A. 1991. The importance of urea-molasses multi-nutrient blocks for ruminant production in Indonesia. In: Proceedings International Symposium on Nuclear Related Techniques in Animal Production and Health. Vienna. 15–19 April 1991, Vienna, Austria, IAEA, 115–169.

Imai, S., Abdullah, N., Ho, Y.W., Jalaluddin, S., Hussain, H.Y., Onodera, R. and Kudo, H. 1995. Comparative study on the rumen ciliate populations in small experimental herds of water buffalo and Kedah Kelantan cattle in Malaysia. Animal Feed Science and Technology, 52: 345–351.

Jones, R.J. and Megarrity, R.G. 1986. Successful transfer of DHP-degrading bacteria from Hawaiian goats to Australian ruminants to overcome the toxicity of leucaena. Australian Veterinary Journal, 63: 259–262.

Kristjanson, P., Zerbini, E., Rao, K.P.C., Kiresur, V., Hofs, P. and Ravindra, K.V. 1998. Genetic enhancement of sorghum and millet residues fed to ruminants: An ex-ante assessment of returns to research, Nairobi, Kenya, ILRI, 67 p.

Kumar, R. 1992. Anti-nutritional factors, the potential risks of toxicity and method to alleviate them. In: Speedy, A. and Pugliese, P.L., ed. Legume Trees and other Fodder Trees as Protein Sources for Livestock. FAO Animal Production and Health Paper No. 102. FAO, Rome, Italy, 145–160.

Kush, G.S., Juliano, B.O. and Roxas, D.B. 1988. Genetic selection for improved nutritional quality of rice straw – a plant breeder's view point. In: Reed, J.D., Capper, B.S. and Neate, P.J.H., ed. Plant Breeding and the Nutritive Value of Crop Residues. Proceedings, Workshop. ILCA, Addis Ababa 7–10 December 1987. [ILRI/FAO. 1999. Farmers, their Animals and the Environment. Multi-document CD-ROM]

Lanting, E.L.F. and Sevilla, C.C. 1998. Improving the utilisation of *Stylosanthes guianensis* CIAT 184 in rice straw-based ration with the inclusion of tannin-containing legume for sheep. In: Sarabia, A.S. and Lihat, T.S., ed. Proceedings of the 35th Annual Convention of the Philippine Society of Animal Science, 15–16 October 1998, Manila, Philippines, 263–277.

Leng, R.A. 1985. Determining the nutritive value of forages. In: Blair, G.J., Ivory, D.A. and Evans, T.R., ed. Forages in Southeast Asian and South Pacific Agriculture. Proceedings. International Workshop. Cisarua, Indonesia. 19–23 August 1985. Proceedings No. 12, ACIAR, Canberra, Australia, 111–123.

Leng, R.A. 1993. Practical technologies to optimise feed resource utilisation in reference to the needs of animal agriculture in developing countries. In: Mack, S., ed. Strategies for Sustainable Animal Agriculture in Developing Countries. FAO Production and Health Paper No. 107, Rome, Italy, FAO, 107–120.

Nguyen, T.T. 1994. Role of women in the promotion of technology transfer in sustainable livestock production systems in Tuyen Quan Province. In: Preston, T.R., Ogle, B., Le Viet Ly and Lui Trong Hien, ed. Sustainable Livestock Production and Local Feed Resources, Ho Chi Minh City, Vietnam, Agriculture Publishing House, 110–114.

Nitis, I.M., Lana, K., Sutji, N. and Sudana I.B. 1982. Goat feeds during the wet season in Bali. In: Jainudeen, M.R. and Omar, A.R., ed. Proceedings on Animal Production and Health in the Tropics, Malaysia, University Putra Malaysia, 241–244.

Odenyo, A. and Osuji, P.O. 1998. Tannin-tolerant ruminal bacteria from East African ruminants. Canadian Journal of Microbiology, 44: 905–909.

Odenyo, A., Osuji, P.O., Karanfil, O. and Adinew, K. 1997. Microbiological evaluation of *Acacia angustissima* as a protein supplement for sheep. Animal Feed Science and Technology, 65: 99–112.

Ookawa, T. and Kuni, I. 1992. Varietal differences in the cell wall components affecting the bending stress of the culm in relation to lodging resistance in paddy rice. Japanese Journal of Crop Science, 62: 378–384.

Orpin, C.G. and Ho, Y.W. 1991. Ecology and function of the anaerobic rumen fungi. In: Ho, Y.W., Wong, H.K., Abdullah, N. and Tajuddin, Z.A., ed. Recent Advances in the Nutrition of Herbivores, Kuala Lumpur,Malaysia, Vinlin Press, 163–170.

Palacpac, E.P. 1994. Optimising utilisation of feed resources in rainfed lowland and rainfed upland rice–based farms in Pangasinan and Cavite. MS Thesis. University of the Philippines – Los Baños, Laguna, Philippines. 128 p.

Paris, T.R. and Sevilla, C. 1995. Priorities for socio-economic research in farming systems in Southeast Asia. In: Devendra, C. and Gardiner, P., ed. Global Agenda for Livestock Research. Proceedings of the Consultation for the Southeast Asia Region, IRRI, Los Baños, the Philippines, 10–13 May 1995, Nairobi, Kenya, ILRI (International Livestock Research Institute), 107–116.

Pathak, M.D. and Khan, Z.R. 1994. Insect Pests of Rice. Los Baños, the Philippines, IRRI, 89 p.

Pearce, G.R., Lee, J.A., Simpsom, R.J. and Doyle, P.T. 1988. Sources of variation in the nutritive value of wheat and rice straws. In: Reed, J.D., Capper, B.S. and Neate, P.J.H. ed. Plant Breeding and the Nutritive Value of Crop Residues. Proceedings, Workshop. ILCA, Addis Ababa 7–10 December 1987. [ILRI/FAO. 1999. Farmers, their Animals and the Environment. Multi-document CD-ROM]

Piggin, C. 1997. The role of leucaena in swidden cropping and livestock production. In: Conference on Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia. Bogor, Indonesia, 25–27 June 1997. ICRAF (mimeo).

Rattunde, H.F.W. 1998. Early-maturing dual-purpose sorghums: Agronomic trait variation and covaraition among landraces. Plant Breeding, 117: 33–36.

Ricca, R. and Combellas, J. 1993. Influence of multi-nutrient blocks on live-weight gain of young bulls grazing sorghum stubble. Livestock Research and Rural Development, 5(3): 31–38.

Roxas, D.B., Wanapat, M. and Winugroho, Md. 1997. Dynamics of feed resources in mixed farming systems in Southeast Asia. In: Renard, C., ed. Crop residues in sustainable mixed crop/livestock farming systems. Proceedings, International Workshop. ICRISAT, Patancheru (India). 22–26 April 1996, Wallingford, UK, CAB International, 101–112.

Saadulah, M. and Siriwardene, J.A. de S. 1993. Reasons for success and failure of straw treatment and straw feeding in Bangladesh and Sri Lanka. In: Singh, K. and Schiere, J.B., ed. Feeding of Ruminants on Fibrous Crop Residues. Proceedings, International Workshop. National

Dairy Research Institute. Karnal (India). 4–8 February 1991, Delhi, India, IARC, 277–288.

Saini, M.L., Paroda, R.S. and Arora, S.K. 1977. Interspecific hybridisation in sorghums for improvement in forage yield and quality. Indian Journal of Genetics and Plant Breeding, 37, 218–224.

Sansoucy, R. 1995. New developments in the manufacture and utilisation of multi-nutrient blocks. World Animal Review (FAO) 82(1). [ILRI/FAO. 1999. Farmers, their Animals and the Environment. Multi-document CD-ROM]

Sevilla, C.C. and Carangal, V.R. 1995. Research methodology appropriate for rainfed lowland crop-animal systems. In: Devendra, C. and Sevilla, C.C., ed. Crop-Animal Interaction. IRRI Discussion Paper Series No. 6. IRRI, Los Baños, Philippines, 251–263.

Sevilla, C.C., Perez, C.B. Jr. and Gatmaitan, O.M. 1976. The effect of ipil-ipil (*Leucaena leucocephala* Lam de Wit) leaves in rice straw-based rations on growth performance and carcass characteristics and yield of bulls. Philippines Journal of Veterinary and Animal Sciences, 2: 21–32.

Schiere, J.B. and Wieringa, J. 1988. Overcoming nutritional limitations of rice straw for ruminants: Response of growing Sahiwal and local cross heifers to urea-upgraded and urea-supplemented straw. Asian-Australasian Journal of Animal Science, 1: 209–212.

Shelton, M., Piggin, C., Acasio, R., Castillo, A., Mullen, B.F., Rika, I.K., Nulik, J. and Gutteridge, R.C. 2000. Case studies of locally-successful forage tree systems. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C., Working with Farmers: The Key to Adoption of Forage Technologies. Workshop held in Cagayan de Oro, Philippines, 12–15 October 1999. These Proceedings, see Contents.

Singh, M., Amrith Kumar, M.N., Rai, S.N. and Pradhan, P.K. 1993. Urea-ammonia treatment of straw under village conditions: Reasons for success and failure. In: Singh, K. and Schiere, J.B., ed. Feeding of Ruminants on Fibrous Crop Residues. Proceedings, International Workshop. National Dairy Research Institute, Karnal (India), 4–8 February 1991. IARC, Delhi (India), 289–296.

Steinbach, J. 1997. Alternatives to crop residues as feed resources in mixed farming systems. In: Renard, C., ed. Crop residues in sustainable mixed crop/livestock farming systems. Proceedings, International Workshop. ICRISAT, Patancheru (India), 22–26 April 1996. CAB International, Wallingford, UK, 197–213.

Stür, W.W., Ibrahim, T., Tuhulele, M., Le Hoa Binh, Gabunada, F., Ibrahim, Nakamanee, G., Phimphachanhvongsod, V., Liu Guodao and Horne, P.M. 2000. Adaptation of forages to climate, soils and use in smallholder farming systems in Southeast Asia. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C., Working with Farmers: The Key to Adoption of Forage Technologies. Workshop held in Cagayan de Oro, Philippines, 12–15 October 1999. These Proceedings, see Contents.

Thu, N., Dong, N., Hon, H. and Quac, V. 1993. Effect of urea-molasses cake on performance of growing and working local buffalo and cattle. Livestock Research and Rural Development, 5(1): 46–53.

Trung, L.T., Palo, L.P., Matias, J.M., Abenir, E.E., Lapinid, R.R. and Atega, T.A. 1987. Dried poultry manure and leucaena in rice-straw based blended diets for dairy cattle. In: Dixon, R.M., ed. Ruminant Feeding Systems Utilising Fibrous Agricultural Residues. International Development Program of Australian Universities, Canberra, Australia, 119–210.

Trung, L.T., Antonio, F.S., Palo, L.P., Atega, T.A., Lapinid, R.R. and Panaligan, O.G. 1989. Urea-molasses-mineral block as a supplement to rice straw and *Gliricidia* vs. copra meal + rice bran as supplements to urea-treated straw for goats. Terminal Report submitted to the International Development Research Centre (IDRC). UPLB, Los Baños, the Philippines, 20 p.

Vadiveloo, J. 1996. The relative importance of leaf and stem fractions on the nutritive value of whole rice straw. Proceedings, Silver Jubilee Malaysian Society of Animal Production Conference held in Kuching, Sarawak, Malaysia on 28–31 May, 1996. Malaysian Society of Animal Production, Kuala Lumpur, Malaysia, 210–211.

Vercoe, J., Coffey, S., Farrell, D.J., Rutherford, A. and Winter, W.H. 1997. ILRI in Asia: An assessment of priorities for Asian livestock research and development, Nairobi, Kenya, ILRI (International Livestock Research Institute), 54 p.

Wanapat, M., Petlum, A. and Pimpa, O. 1999a. Strategic supplementation of high-quality feed block on roughage intake, milk yield and composition, economical return in lactating dairy cows. Asian-Australasian Journal of Animal Sciences, 12(6): 901–903.

Wanapat, M., Pimpa, O., Petlum, A. and Boontao, U. 1997. Cassava hay: A new strategic feed for ruminants during the dry season. Livestock Research for Rural Development, 9: 2 (electronic version).

Wanapat, M., Puramongkon, T. and Siphuak, W. 1999b. Feeding of cassava hay for lactating dairy cows during the dry season. Asian-Australasian Journal of Animal Sciences, 12: in press.

Wina, E., Kayadu, M. and Tangendjaja, B. 1995. Effect of urea, ammonium sulfate or cassava flour on the performance of sheep fed a mixture of elephant grass and fresh *Calliandra*. In: Prosiding Sem. Nas. Sains dan Teknologi Peternakan, 176–181.

Wina, E., Tangendjaja, B and Gunawan. 1997. Wilting of *Calliandra calothyrsus*: Its effect on sheep performance. In: Prosiding Sem. Nas. II. Ilmu Nutrisi dan Makanan Ternak. 15–16 July 1997.

Zamora, R.G. and Baguio, S.S. 1984. Feed composition tables for the Philippines. Los Baños, Laguna, Philippine Council for Agriculture and Resources Research and Development (PCARRD), Book Ser. No. 13, 264 p.

Adaptation of Forages to Climate, Soils and Use in Smallholder Farming Systems in Southeast Asia

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Abstract

The Forages for Smallholders Project (FSP) actively involved farmers in evaluating forage varieties for smallholder farming systems in Southeast Asia. The combination of 'traditional' evaluation techniques (nursery and regional evaluations) with farmer-led, informal evaluation of forages by farmer experimenters on their own farms resulted in the identification of a small range of robust, broadly adapted forage varieties. Most of these varieties have already been adopted and integrated in various ways into upland farming systems in the region. Farmer experimenters not only provided a huge amount of information on environmental adaptation of forage varieties but also on ways of growing, managing and using forages in smallholder upland farms.

WORKING with smallholder farmers to develop appropriate technologies for their farms requires not only a sound 'partnership' approach but also 'knowledge' and 'technologies' which farmers can use and adapt to their particular situations. In the case of forages, farmers need **access** to forage varieties that are:

1. adapted to the climate and soils;
2. suited to the intended use (e.g. what type of feed, environmental application); and
3. fit into the farming system.

The 'traditional' approach to forage species evaluation was to conduct a small plot evaluation on agricultural research stations. Species with high yields were selected and further tested in larger plots to elicit agronomic information on management and feeding value. Much information on forage varieties has been generated in this way in many countries and is available in reports and the scientific literature. Unfortunately, few smallholder farmers have ever adopted forage varieties and thus little is known about needs of smallholder farmers, the suitability of different forages to fulfill these needs and how forages can be integrated into smallholder farming systems.

The Forages for Smallholder Project (FSP) tried to overcome this limitation by including farmers early in the species evaluation process and by providing feedback of their experiences to other partners in the evaluation process. The objective of the evaluation was to identify 'forage options' which development workers could offer smallholder farmers in Southeast Asia for adaptation and integration on their farms.

Evaluation Strategy

The FSP initially started with a traditional approach to evaluation but quickly realised that a different

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strategy was needed to achieve the objectives set by the Project. Several guiding principles emerged with time. These include:

(i) identify broadly adapted, robust varieties;
(ii) select only a small number of varieties;
(iii) involve farmers in the selection process.

Why select broadly-adapted varieties?

Broadly-adapted varieties were needed since smallholder farming systems are immensely diverse, both between and within farms. Soil fertility, slope of land, drainage and other soil factors vary from one field to the next. Similarly, rainfall varies considerably from one year to the next. Only varieties with broad adaptation to different environments can cope successfully with this variation. Robust varieties were needed since these were most likely to be able to cope with the varied management conditions expected in smallholder farming systems. Most smallholder farmers had never planted forages before and some 'rough management' was likely to occur.

Why a small number of varieties?

Using common varieties across countries in Southeast Asia has many advantages. Seed is more easily available, there is a much larger market for seed and information and experiences with these common varieties can be shared among users. Seed production can be conducted in many areas or concentrated in the most favourable environments and traded across the region.

Why involve farmers in the selection process?

Farmers are the clients who will decide which forages to adopt and integrate into their farms. This means that those who select forage varieties must have a good understanding of selection criteria of farmers (Figure 1). These selection criteria may or may not be similar to those researchers traditionally used (such as high forage yield and good feed quality) but researchers will not know until they involve their clients in the selection process.

Other principles of the selection process

Several general principles of forage evaluation were also seen as important. These included:

(i) build on both existing international and local knowledge;
(ii) develop partnerships with national and local researchers, local development workers (including extension workers, NGOs and agricultural development projects) and local government officials;
(iii) ensure that the farmers receive the best forage varieties, not just any variety of a species.

Building on existing knowlege is essential to avoid duplication and frustration by those who have experience already. Internationally, there is a wealth of experience available, particularly in Latin America and Australia. Drawing on experiences from others and obtaining the best possible germplasm of each

Figure 1. Selecting forages is a shared activity between researchers and smallholder farmers.

species to ensure a broad genetic base were seen as critical in the selection process.

Evaluation procedure

The evaluations built on experience by national partners, such as the Thai Department of Livestock Development and forage research and development projects. In particular, the FSP built on results of the Southeast Asia Regional Forage Seeds Project, managed by CIAT/CSIRO and funded by AusAID, which conducted extensive nursery and regional evaluations in Indonesia, Philippines, Thailand and Malaysia. This project introduced a comprehensive range of forage germplasm (more than 500 accessions) from the CIAT (Colombia) and CSIRO (Australia) germplasm banks to the region. These accessions included all successful varieties from Latin American countries and Australia and were evaluated in nursery and regional evaluations on infertile, acid soils in Indonesia and the Philippines to select the most promising varieties for on-farm evaluation (Cameron et al. 1995; Stür et al. 1995).

The FSP continued these evaluations (regional and farmer evaluations) in Indonesia and the Philippines, and started evaluations in Laos and Vietnam where there had been few previous evaluations. Here the FSP started with nursery evaluations that included a broad range of forage germplasm before commencing regional and farmer evaluations. An overall picture of the different types of evaluations and their timing is presented in Figure 2.

The main differences between different types of evaluations are:

Nursery evaluations

- many accessions (often >50 entries);
- few locations (typically conducted on infertile soils and areas with high disease-pressure, to eliminate susceptible accessions);
- researcher managed.

Regional evaluations

- fewer accessions (usually <20 entries);
- many locations (more information on environmental adaptation, specifically for the local area);
- researcher controlled but often managed by farmers;
- farmers provide feedback on the types of forage species they prefer, using tools such as open-ended evaluation, matrix and preference ranking;
- subsequently used as a source of planting material for farmer evaluations.

Farmer evaluations – formal

- researchers and farmers choose varieties to be evaluated by farmers and decide on an evaluation procedure;
- farmers manage and evaluate;
- researchers may do some additional measurements and facilitate evaluation and beedback;
- fewer varieties (often 6–8 varieties per farmer);
- many locations.

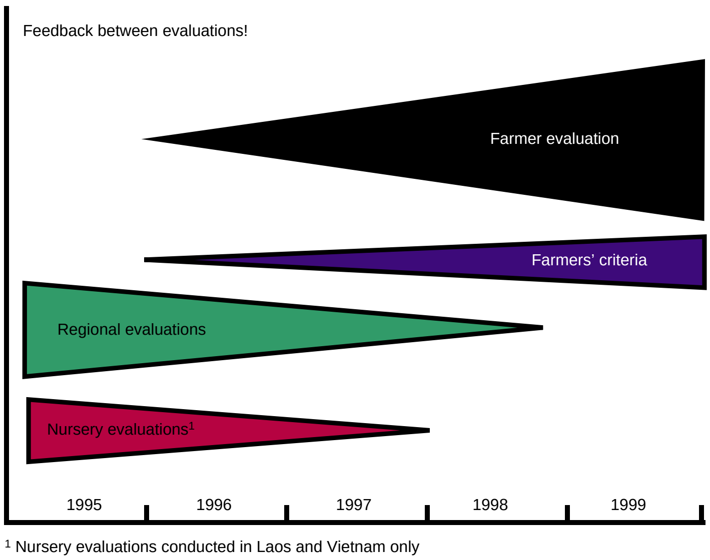

Figure 2. Timing and feedback between different evaluation types.

Farmer evaluations – farmer-led (informal)

- farmers individually choose varieties to plant on their farms;
- farmers manage and evaluate;
- researchers provide information and varieties;
- researchers facilitate feedback to other farmers and development workers;
- fewer varieties (often 2–4 varieties per farmer);
- numerous locations with a large range of conditions.

A key element in conducting evaluations is to provide feedback of results and experiences to those conducting the different types of evaluation (Figure 2). Timely feedback can accelerate the overall process of evaluation.

Traditionally, nursery and regional evaluations were followed by large-plot evaluations on management, seed production and feeding value of promising varieties. For the majority of forage species there is already a lot of information available on these issues from different countries. There was therefore limited need to conduct research on these aspects, and species with known characteristics could be released immediately for on-farm evaluation.

Outcome of Evaluations

This evaluation strategy has resulted in identification of a range of forage varieties for use in Southeast Asia (Tables 1 and 2). Many are adapted to a wide range of environments ranging from humid to subhumid (and cool) tropics and from fertile to extremely acid, infertile soils. All of the varieties are robust and have been adopted by smallholder farmers at one or more of the FSP sites and integrated in various ways into their farming system. There are choices of grasses for every situation. The choice of legumes is more limited, particularly for infertile, extremely acid soils. Table 3 cross-references the variety names with other identifiers of each variety. Full details on varieties recommended for different smallholder farming systems are included in the booklet 'Developing forage technologies with smallholder farmers: how to select the best variety to offer farmers in Southeast Asia' (Horne and Stür 1999).

Table 1. Forage varieties identified for use by smallholder farmers in different climates and soils.

Species	Varieties	Climate			Soil fertility and acidity		
		Wet tropics with no or short dry season	Wet/dry tropics with long dry season	Cooler tropics (e.g. high elevation)	Fertile (neutral to moderately acid soils)	Moderately fertile (neutral to moderately acid soils)	Infertile (extremely acid soils)
(a) Grasses							
Andropogon gayanus	'Gamba'	•	••		•	•	•
Brachiaria brizantha	'Marandu', 'Karanga', 'Serengeti'	•	••	••	•	••	•
Brachiaria decumbens	'Basilisk'	•	••	••	•	••	•
Brachiaria humidicola	'Tully', 'Yanero'	••	•	•	•	•	••
Brachiaria ruziziensis	'Ruzi'	••		•	••	•	
Panicum maximum	'Si Muang'	••	•	•	••	•	
Paspalum atratum	'Terenos'	••		•	•	••	•
Pennisetum purpureum and *Pennisetum* hybrids	'Napier', 'Mott', 'King'	••		•	••	•	
Setaria sphacelata	'Lampung', 'Solander'	••	•	••	••	•	
(b) Legumes							
Arachis pintoi	'Itacambira', 'Amarillo'	••		•	••	••	
Calliandra calothyrsus	'Besakih'	•		••	•	••	
Centrosema pubescens	'Barinas'	••	•	•	••	•	
Centrosema macrocarpum	'Ucayali'	••	•		••	•	
Desmanthus virgatus	'Chaland'	••		••	••	•	
Desmodium cinerea	'Las Delicias'	•	•		•	•	
Gliricidia sepium	'Retalhuleu', 'Belen Rivas'	••	••		•	••	
Leucaena leucocephala	'K636', 'K584'	••	••	•	••	•	
Stylosanthes guianensis	'Stylo 184'	••	•	•	••	••	••

•• = highly suitable; • = possible; no mark = not suitable.

Assessment of the Value of Different Evaluation Types

Involving farmers in the evaluation process was extremely beneficial. For most smallholder farmers, planting forages was a new concept; few farmers had experience with growing and using forages. It was therefore important to encourage farmers to grow forages on their own farms to gain experience with forages.

Farmers' criteria

Farmers' criteria are necessarily based on prior experience and thus varied between farmers with and without experience. Thus, farmers' criteria varied with time as farmers gained experience with growing and using forages. Although involving farmers in nursery and regional evaluations (using tools such as open-ended evaluation, matrix ranking and preference ranking) was useful, since it improved the understanding of researchers and development workers of farmers' needs, it only resulted in some general criteria which farmers applied in selecting species. It was not sufficient by itself since these criteria tended to be based on limited experience.

Forages are different from annual crops which are grown over a single growing season and then harvested. Forages are mostly perennial species which are harvested for feed (depending on need for feed), then regrow and are harvested again. They often have multiple uses, such as also protecting the soil from erosion and can only be assessed by personal experience.

Encouraging farmers to grow and select forage varieties on their own farms, where they could gain experiences with the different varieties and experiment themselves, was an essential part of the selection process. Details on farmers' criteria are provided in another paper in these proceedings (Gabunada et al. 2000) and included factors such as ease of cutting and animal preferences.

Table 2. Suitability of forage varieties to different forage systems.

Species	Varieties	Ways of growing forages							
		Cut & carry plots or rows	Grazed plots	Living fences	Contour hedgerows	Improved fallows	Cover crops in annual crops	Cover crops under trees	Ground covers for erosion control
(a) Grasses									
Andropogon gayanus	'Gamba'	••	•		•				
Brachiaria brizantha	'Marandu', 'Karanga', 'Serengeti'	••	•		•				
Brachiaria decumbens	'Basilisk'	•	••						•
Brachiaria humidicola	'Tully', 'Yanero'	•	••						••
Brachiaria ruziziensis	'Ruzi'	•	••						•
Panicum maximum	'Si Muang'	••	•		•				
Paspalum atratum	'Terenos'	••	••		••				
Pennisetum purpureum and *Pennisetum* hybrids	'Napier', 'Mott', 'King'	••			•				
Setaria sphacelata	'Lampung', 'Solander'	••	•		••				
(b) Legumes									
Arachis pintoi	'Itacambira', 'Amarillo'		•					••	••
Calliandra calothyrsus	'Besakih'	••		•	•				
Centrosema pubescens	'Barinas'	•				••	••	•	•
Centrosema macrocarpum	'Ucayali'	•				••	••	•	•
Desmanthus virgatus	'Chaland'	••			•				
Desmodium cinerea	'Las Delicias'	••			••				
Gliricidia sepium	'Retalhuleu', 'Belen Rivas'	••		••	•				
Leucaena leucocephala	'K636', 'K584'	••	•	•	•				
Stylosanthes guianensis	'Stylo 184'	••	•		•	••	••	•	

•• = highly suitable; • = possible; no mark = not suitable.

Farmer experimenters

Feedback from farmer experimenters growing forages in a broad range of environments and farming systems provided not only a clearer picture of environmental adaptation of forages but also resulted in detailed feedback on selection criteria and on ways of integrating forages into smallholder farming systems (Gabunada et al. 2000).

Farmer-led (informal) evaluations provided more information than formal farmer evaluations in the case of the FSP, since it allowed farmers to experiment with the varieties of their choice and develop innovations for their particular circumstances. Farmers wanted to grow forages on their own farms, but were happy to incorporate ideas and suggestions from researchers and development workers. It was

Table 3. Identification/cross-reference of forage varieties used in Southeast Asia.

Species	Variety name	Other identification
Grasses		
Andropogon gayanus	'Gamba'	cv. Kent (Australia); CIAT 621; also released in many other countries
Brachiaria brizantha	'Karanga'	CIAT 16835
	'Serengeti'	CIAT 6387
	'Marandu'	cv. Marandu (Brazil); CIAT 6780; ILCA 16550; also released in many other countries
Brachiaria decumbens	'Basilisk'	cv. Basilisk (Australia); CIAT 606; also released in many other countries
Brachiaria humidicola	'Yanero'	cv. Llanero (Colombia); CIAT 6133; also released in many other countries
Brachiaria humidicola	'Tully'	cv. Tully (Australia); CIAT 679; also released in many other countries
Brachiaria mutica	'Para'	naturalised throughout Southeast Asia
Brachiaria ruziziensis	'Ruzi'	Ruzi (Thailand); cv. Kennedy (Australia)
Digitaria milanjiana	'Jarra'	cv. Jarra (Australia)
Panicum maximum	'Si Muang'	T-58 'Purple Guinea' (Thailand); cv. Tanzania 1 (Brazil); CIAT 16031; ILCA 16554
	'Tobiata'	cv. Tobiata (Brazil); CIAT 6299
Paspalum atratum	'Terenos'	BRA 009610; CIAT 26986; cv. Hi Gane (Australia); cv. Suerte (USA)
Paspalum guenoarum	'Bela Vista'	BRA 003824; CIAT 26985
Pennisetum purpureum	'Napier'	many local varieties
	'Mott'	cv. Mott (USA)
Pennisetum purpureum × *Pennisetum glaucum* hybrid	'King'	King grass (Indonesia); many similar hybrids available (e.g. Florida napier in the Philippines)
Setaria sphacelata	'Solander'	cv. Solander (Australia)
S. sphacelata var. *splendida*	'Lampung'	'Splendida' (Indonesia); CPI 15899
Stenotaphrum secundatum	'Vanuatu'	naturalised in Vanuatu
Legumes		
Arachis pintoi	'Itacambira'	CIAT 22160
	'Amarillo'	cv. Amarillo (Australia); CIAT 17434; also released in many other countries
Calliandra calothyrsus	'Besakih'	naturalised in Indonesia; CPI 115690
Centrosema macrocarpum	'Ucayali'	cv. Ucayali (Peru); CIAT 25522
Centrosema pascuorum	'Cavalcade'	cv. Cavalcade (Australia)
Centrosema pubescens	'Barinas'	CIAT 15160
Codariocalyx gyroides	'Belize'	CIAT 3001; ILCA 14924
Desmanthus virgatus	'Chaland'	'Maiyara' (Thailand); CPI 52401
Desmodium cinerea (previously *Desmodium rensonii*)	'Las Delicias'	'Rensoni' (MBRLC, Philippines); CPI 46562
Flemingia macrophylla	'Chumphon'	CIAT 17403
Gliricidia sepium	'Belen Rivas'	'Belen Rivas' (Oxford Forestry Institute, UK)
	'Retalhuleu'	'Retalhuleu' (Oxford Forestry Institute, UK)
Leucaena leucocephala	'K 584'	K 584 (University of Hawaii, USA)
	'K 636'	cv. Tarramba (Australia); K636 (University of Hawaii, USA)
Macroptilium gracile	'Maldonado'	cv. Maldonado (Australia)
Sesbania grandiflora	'Turi'	naturalised throughout Southeast Asia
Stylosanthes guianensis	'Stylo 184'	cv. Pucallpa (Peru); CIAT 184; cv. Reyen II Zhuhuacao; also released in many other countries
Stylosanthes hamata	'Verano'	cv. Verano (Australia)

important to support this process of farmer-led evaluation with information and exchange of experiences. One way to do this was through farmer focus groups where farmers could discuss and exchange experiences on a regular basis and development workers could provide additional information and guidance.

Farmer-led experimentation resulted in feedback on the performance of forage varieties in a broad range of environments and circumstances. In the FSP, more than 500 farmers provided feedback on species performance and this information was incorporated into the final recommendations. Nursery and regional evaluations alone could not provide this depth of information.

Farmer experimenters also provided valuable feedback on all aspects of planting, managing and using forages. Farmers developed new ways of integrating and using forages in their farming systems. For example, farmers in Makroman, Indonesia, used *Centrosema pubescens* as a cover crop in annual crops to suppress weeds. They found that growing the legume together with maize or cassava reduced the regrowth of *Imperata cylindrica* in the cropping area and the legume cuttings could be used as animal feed. Farmers in Tuyen Quang, Vietnam, started to feed grasses such as *Panicum maximum* 'Simuang' and *Paspalum atratum* 'Terenos' to fish. At other sites, farmers fed *Stylosanthes guianensis* 'Stylo 184' to pigs and *Arachis pintoi* 'Itacambira' and 'Amarillo' to pigs and poultry. Many farmers planted different grasses together in the same rows or plots, arguing that animals liked to eat a mixture of grasses rather than only one particular grass and planting grasses together made it easier to manage and harvest. There are many other examples which are described in other papers in these proceedings (e.g. Vie Thi Yen et al. 2000; Ibrahim et al. 2000).

Encouraging farmers to experiment with forages was an easy task. Most farmers are always on the lookout for ideas and technologies which may improve their farming operation, so evaluating new forages was natural for farmers who felt that forages may solve particular problems they experienced on their farms.

Nursery and regional evaluations

Nursery evaluations were necessary in new areas where there was little information on potential forage species. Similarly, regional evaluations provided a useful way of introducing a broad range of forages into new areas. These provided farmers with information on adaptation and growth habit and formed a good basis for discussions. Evaluation plots also provided planting material for farmer evaluations.

Has 'Science' Suffered by the Involvement of Farmers?

The active involvement of farmers in the evaluation process provided an enormous amount of valuable information on environmental adaptation, ways of growing forages, farmers' criteria and innovations of using forages on smallholder farms. Fast and 'user-oriented' evaluation would not have been possible without the active involvement of farmers. However, most of the information was in the form of experiences rather than 'hard' experimental data, making synthesis and objective analysis difficult. To obtain a quantitative assessment of the performance of forage varieties selected in the evaluation program, FSP partners decided to conduct a formal, researcher-managed, geno type by environment (G × E) experiment. The selected varieties are being grown at 12 sites representing the range of environments in Southeast Asia and their performance is being measured over a two-year period. Final results will be available in 2001.

Farmer and traditional evaluations are complementary and timely feedback between evaluations can speed up the total process considerably.

Conclusions

The Forages for Smallholders Project was able to identify a small range of robust, broadly-adapted forage varieties for offering to smallholder farmers in Southeast Asia through a combination of traditional evaluation techniques and the active involvement of farmers in the evaluation process. Informal, farmer-led evaluations were extremely useful. They not only provided an enormous amount of information on environmental adaptation but also on farmers' needs, their criteria for selecting forage varieties and innovative ways of integrating and using forages on smallholder farms. A booklet 'Developing forage technologies with farmers: how to select the best varieties to offer farmers in Southeast Asia' has been published in English and is available from CIAT and ACIAR (Horne and Stür 1999). Asian language versions will be published in Indonesian, Thai, Lao, Vietnamese and Chinese.

The selected varieties and the suggested ways of growing and using these varieties provide a solid basis for forage development in the uplands of Southeast Asia. Although it is tempting for researchers to continue evaluation and development of forage technologies, further selection should be limited to address specific needs such as legumes in cropping systems, until clear needs have been identified and expressed by farmers.

References

Cameron, A.G., Gibson, T.A., Ibrahim, Winarno, H., Hariadi, A. and Supriyadi. 1995. Performance of forages introduced into Kalimantan, Indonesia by the Southeast Asian Forage Seeds Project. Genetic Resources Communication No. 21, Brisbane, Australia, CSIRO Division of Tropical Crops and Pastures, 38 p.

Gabunada, F. Jr., Heriyanto, Phengsavanh, P., Phimphachanhvongsod, V., Truong Thanh Khanh, Nacalaban, W., Asis, P., Vu Thi Hai Yen, Tugiman, Ibrahim and Stür, W.W. 2000. Integration of adapted forages on farms in Southeast Asia – experiences from the Forages for Smallholder Project. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Horne, P.M. and Stür, W.W. 1999. Developing forage technologies with smallholder farmers – how to select the best variety to offer farmers in Southeast Asia. ACIAR Monograph No. 62, Canberra, ACIAR, 80 p.

Ibrahim, Truong Tan Khanh and Heriyanto. 2000. Forage technologies for smallholders in grassland areas. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Stür, W.W., Cameron, A.G. and Hacker, J.B. 1995. Forages for Smallholders – Proceedings of the Third Meeting of the Southeast Asian Forage Seeds Project, Samarinda, Indonesia, 23–28 October 1994. CIAT Working Document No. 143. Cali, Colombia, CIAT, 149 p.

Vie Thi Hai Yen and Le Hoa Binh 2000. Forage options for fish and pigs. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Case Studies of Locally-Successful Forage Tree Systems

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Abstract

Case studies of successful adoption of forage tree legumes in farming systems are reviewed. Case studies included (a) adoption of *Leucaena leucocaphala* in northern Australia; (b) farmer uptake of MPTs (multi-purpose trees) in Honduras, Malawi and Sri Lanka; (c) responses to the new hybrid leucaena in Batangas Province of the Philippines; (d) uptake of calliandra in Bali, Indonesia; and (e) long-term use of *Leucaena leucocephala* in the islands of Timor and Flores, Indonesia. Success was achieved where the innovation was simple. Complex systems required sustained, high profile intervention. Common factors to successful adoption are elucidated. Technical factors were: (a) constraints must be resolved promptly; (b) information needed to flow frequently, accurately and in a variety of appropriate formats; (c) a range of MPT species was needed to meet the diverse needs of farmers, their environments and farming systems; and (d) the best planting material should be available to farmers. Socio-economic factors included: (a) farmers, local leaders and groups, and government needed to be closely involved in the process; (b) communication/training/extension and research networks were important; and (c) innovation needed positive commercial outcomes for individual farmers as well as for the environment. Other factors of significance were the need for long-term commitment and direction from institutions due to the complexity of many of the tree legume systems. However, successful adoption through a process of on-farm and participatory research was a consistent theme.

EXAMPLES of locally successful adoption of exotic and indigenous tree legumes, for multi-purpose uses including forage, are too numerous to list. Outstanding examples are *Leucaena leucocephala* in Queensland, Australia (Middleton et al. 1995) and parts of eastern Indonesia (Moog et al. 1998), *Gliricidia sepium* in Southeast Asia (Stewart 1996), *Sesbania grandiflora* in Lombok, Indonesia (Gutteridge 1994), *Calliandra calothyrsus* in Indonesia (Palmer et al. 1994), and *Acacia* spp. in Africa (Wickens et al. 1995). However, adoption has not been widespread even within the countries listed above and despite high levels of promotion, farmer uptake has been lower than anticipated.

Recent attempts to achieve adoption of new varieties and agroforestry packages, particularly the more complex agroforestry packages such as alley cropping, have been only partially successful, and in some cases unsuccessful (Gutteridge 1998). Difficulties in achieving high levels of adoption for *Leucaena* are reported for Africa (Dzowela et al. 1998), South America (Argel et al. 1998) and Asia (Moog et al. 1998).

This paper uses the approach of case studies to examine the strategies used in successful adoption of forage tree legumes. Case studies reviewed are: (a) adoption of leucaena in northern Australia, (b) a comparative analysis of farmer uptake of MPTs (multi-purpose trees) in Honduras, Malawi and Sri Lanka conducted by the Overseas Development Institute (Cromwell et al. 1996); (c) responses to a *Leucaena pallida* × *Leucaena leucocephala* hybrid in Batangas Province of the Philippines; (d) uptake of calliandra in Bali, Indonesia; and (e) long-term use of

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leucaena in the islands of Timor and Flores, Indonesia. Conclusions are made as to common elements of successful promotion and adoption strategies.

Case Study 1: *Leucaena* in Northern Australia

In Australia, leucaena (*Leucaena leucocephala*) is used mainly for fattening beef cattle for the domestic Australian markets and for export markets in Southeast Asia, Japan, Korea and the USA. Leucaena is highly nutritious and is the only tropical forage system in northern Australia capable of finishing beef animals that can meet all export carcase specifications. Currently, in northern Australia, *L. leucocephala* is mostly grown on fertile alkaline clay soils in the 600–750 mm rainfall zone. It is sown in rows with companion grasses in the inter-row space, and is grazed in situ at a stocking rate of 1–2 ha per beast (Middleton et al. 1995). A recent grazing demonstration (Esdale and Middleton 1997) showed that, under favourable seasonal conditions, liveweight gains of 1.25 kg/steer/day from raingrown leucaena/grass were possible. Furthermore, carcase quality was no different from carcases from grass or grain feeding (Larsen et al. 1998). Leucaena systems may therefore replace more costly annual forage crop and feed-lot systems.

Leucaena has been naturalised in Australia for more than 100 years and its potential forage value was recognised 40 years ago (Hutton and Gray 1959). However, growers have been slow to adopt it. A recent GIS analysis identified approximately 12 million ha of land suitable for leucaena development in northern Australia (Coates 1997).

Progress of research and development

In the 1960s and 1970s, leucaena promotion was researcher led (CSIRO), but there was little commercial development. Not enough was known about its management, potential value, agronomy, geographic limits and establishment requirements, and there were concerns (exaggerated) about mimosine toxicity.

In the early 1980s, a DPI extension agent in central Queensland began a long-term commitment to leucaena extension involving informal participatory collaboration with several leader farmers. As a result of the field days and farmer contacts he organised, the potential productivity of leucaena, and methodology for planting leucaena, became more fully appreciated among the farming community and interest dramatically increased.

By the mid-1980s, the toxicity problem had been resolved (Jones 1985), but the arrival of the leucaena psyllid (*Heteropsylla cubana*) in 1986 caused interest to wane. Throughout this period, a small group of committed farmers, extension agents from QDPI and research scientists from the University of Queensland and CSIRO, continued their activities despite a lack of support from key industry and research bodies. A new variety (cv. Tarramba) was released with improved seedling vigour and psyllid tolerance.

It was not until the late 1980s that funds were made available for leucaena research. These were aid funds from the Australian Centre for International Agricultural Research (ACIAR) which has a mandate to support projects which also have Australian relevance.

An international evaluation of the agronomic and feeding value of the *Leucaena* genus was conducted under the auspices of this project. Establishment problems related to seed scarification, *Rhizobium* inoculation, soil and seed insect control, weed control, grazing management and forage quality issues were all overcome through a participatory research process.

Today the resurgence of interest in leucaena development remains largely farmer driven but with strong support from committed individuals within the University of Queensland, QDPI and CSIRO, and no funds are contributed by the industry we are supporting.

What currently limits adoption in Australia?

Despite its known production potential and the large areas of suitable soils, adoption in the past has been disappointing, although there has been a recent increase in interest among farmers and graziers in expanding sowings of leucaena.

A detailed analysis of key issues in adoption is now given.

Technical restrictions

(a) Inadequate availability of technical information on establishment procedures presented in a form accessible to farmers (e.g. farmer establishment manual, videos);

(b) Lack of government registration of chemicals to control insects and weeds;

(c) Excessive psyllid damage in wetter environments or in seasons of above average rainfall;

(d) Uncertainty about effects of leucaena on product quality e.g. eating quality of beef and tainting of milk from dairy cows; and

(e) Lack of information on methods to restrict excessive height growth of leucaena in direct grazing systems.

Social and economic restrictions

(a) Farmers, and especially graziers, have difficulty in meticulously following the detailed agronomic recommendations that underpin successful establishment;
(b) There is concern about the cost of establishment, especially in view of the high risk of failure. Lesleighter and Shelton (1986) reported that 2/3 of plantings in the 1980s and early 1990s had failed;
(c) There is concern about the loss of flexibility associated with conversion of good agricultural land (suitable for dryland cropping) into long-term leucaena and cattle production;
(d) Misinformation, exaggerating concern regarding mimosine toxicity, die-back during dry years, psyllid damage during wet years, and difficulties in establishment;
(e) Some farmers have planted small trial areas not sufficiently large to demonstrate clearly production advantages.

Institutional

There has been a lack of long-term support from industry, research and extension agencies and this has limited research and extension activities. The only research funds have come from ACIAR and this has given the research an international focus.

Some strategies and priorities

In order to realise the great potential from using leucaena beef production systems in northern Australia, industry, research and extension agencies must develop a long-term strategy and commitment to leucaena research and development. Targets need to be set and worked towards e.g. 500 000 ha of leucaena planted by the year 2010. To achieve such targets, the following strategies are suggested:

(a) The benefits accruing from planting leucaena in terms of improved long-term productivity and sustainability, access to premium prices and ultimately, improved economic returns need continually to be emphasised.
(b) The risks of establishment failure need to be reduced by improved information flows to graziers. This can be partly achieved by the production of a high quality technical manual providing technical information on establishment and management, and containing experiences from farmers.
(c) Continuing enthusiasm and long-term commitment is required from all those involved in promotion, including: graziers, cattle breeders, meat processors, supermarkets, extension officers and scientists.
(d) Greater involvement of experienced and successful leucaena growers in the extension process is vital. Producer demonstration sites, producer workshops, and single and group producer visits to successful leucaena plantings have been used with good success. The formation of a Leucaena Growers Association for self-help, exchange of information, and for promotion of *Quality Assurance* of leucaena properties would be helpful. One goal might be to establish a regular newsletter to communicate and exchange information among graziers.
(e) The beef industry and leucaena growers need to press for increased support for R&D through the regional Beef Industry Research Committees, the Queensland Beef Industry Institute, and the private sector (seed and chemical companies, meat processors). In the past, new problems which emerged over time were not always resolved in a way that ensured the continuing interest of farmers and extension workers. The continuing availability of scientific resources (personnel and funds) to resolve problems is vital.

Case study 2: Honduras, Malawi and Sri Lanka

Cromwell et al. (1996) initiated a study in 1994–995 on farmer uptake of MPTs with the objective of providing feed-back to researchers on the effectiveness and relevance of their plant improvement programs. They wanted to know if the new provenances being produced by researchers, and subsequently promoted by field projects, met the needs of farmers, and whether they were able to access them. Their specific objectives were to:

- Assess the factors influencing farmer decision to grow MPTs;
- Assess the extent to which currently available provenances met farmer needs;
- Study the availability of MPTs to farmers; and
- Review the potential for improving availability of MPTs to farmers.

The study drew on experiences of groups promoting and distributing *Gliricidia sepium* to farming communities in Honduras, Sri Lanka and Malawi. In Honduras, two projects were visited in northern Honduras (PACO-CARE and Agroforestry Project Rio Choloma (APRC), and three projects in southern Honduras (World Neighbours, PROCONDEMA, and the Land Use and Productivity Enhancement Prioject (LUPE). The projects were all selected because they promoted the use of MPTs in agroforestry systems attempting to alleviate rural poverty. Together they served 30 000 farm families (Cromwell et al. 1996).

In Malawi, five projects were visited (EC funded ADDFOOD, the USAID funded Malawi Agroforestry Extension Project, ICRAF-Malawi programs at Chitezde Agricultural Research Station, and the NGOs Christian Services Committee and ACTIONAID Malawi-Dowa. All projects were significantly involved in promotion and distribution of MPTs. Together they worked with 20 000 farm families.

In Sri Lanka, seven organisations were visited. They were the Upper Mahaweli Watershed Project, Hadabima Authority of Sri Lanka, Nuwara Eliya Integrated Rural Development Project, Promoting Multi-functional Household Environments, CARE, Ceylon Tobacco Company, and Aitken-Spence Tea Estate Management Group. The projects worked with over 4000 families (Cromwell et al.1996).

Major issue and key findings were (Cromwell et al.1996):

Socio-economic issues

(a) Most projects had not carried out surveys to ensure that they understood farmer needs for MPTs, and that they had the identified appropriate solutions. Projects often assumed which species and agroforestry systems were required by farmers. In reality, the reasons for farmer choices were often complex and determined by a diversity of specific needs and resource constraints. They concluded that there needed to be a range of species and management options available.

(b) Farmers did not conceptualise the multi-functions of MPTs the way researchers do. The attributes that farmers appreciate needed to be better understood. Trees were managed on-farm to fulfil a range of requirements. Projects needed to balance the promotion of MPTs for single and multiple functions. For instance, although use of MPTs for soil improvement may be crucially important, promotion on these grounds alone, may not be sufficient.

(c) Most projects were short term (up to 4 years). They often achieved short-term success due to farmer trust in outside interventions, but not long-term success, as farmers did not have the opportunity to observe predicted benefits before the end of the life of a project.

(d) It was difficult to achieve environmental and conservation benefits at the macro community level, while at the same time provide tangible benefits to individual farmers. For instance, for *Prosopis*, Dutton (1992) suggested that the benefits must involve:- Ecological sustainability (improved soil fertility, control of soil erosion, reduced contamination of water resources, improved self-sufficiency for on-farm energy, reduced emissions of greenhouse gases); sociological sustainability (changed attitudes to management of species, employment opportunities, improved self-reliance); and, in addition, target groups needed to benefit from their labour through value added product and cash income.

(e) Often seed and/or seedlings were distributed free of charge and farmers may not have been interested if payment was required. Simons (1996) suggested that substantial advantage in woody and leaf biomass yields was needed to interest farmers in new varieties. New germplasm would have to be markedly superior.

Technical issues

(f) The study revealed that there was insufficient evidence that MPT species used for fertility improvement were capable of making the significant improvement to crop yields that were claimed,

(g) MPT planting material was often distributed to farmers in a form with which they were not familiar e.g. seeds were distributed when farmers normally used seedlings. Farmers were often not clear as to how to manage planting material once they had received it.

(h) Planting material was initially distributed by projects, but post-project, farmers were unable to obtain further supplies. There was very limited evidence of active seed suppliers, especially community based supply mechanisms. Seed multiplication orchards producing planting material of the elite varieties were required.

(i) Purchase of planting material from international sources was often expensive, and projects often obtained seed locally, as it was cheaper and more accessible. For farmers, the dominant source of planting material was on-farm and they infrequently acquired germplasm off-farm. For this reason, germplasm was often of unknown genetic quality; it was collected and distributed with weak protocols; it was selected on timber criteria; or it was distributed with no knowledge or understanding of provenance quality, provenance origins, or the importance of genetic diversity. Urgent attention was required to establish supply mechanisms to allow farmers to access elite germplasm early in the development process. There is a strong need for a clear and sustainable strategy for supply of high quality seed. Community based germplasm therefore had potential to ensure such a sustainable supply.

However, the technology for production of planting material needed to be relatively simple and there needed to be resources for storage and seed treatment.

Case study 3: The role of *Leucaena* in swidden cropping and livestock production in Nusa Tenggara Timur, Indonesia

Nusa Tenggara Timur (NTT) province in eastern Indonesia comprises the eastern Lesser Sunda Islands of Timor, Flores, Sumba, Roti, Savu and numerous smaller islands. The area of NTT is about 50 000 km^2 and the total population about 3 million. Population densities range from 15–100 persons per km^2.

Slash and burn cultivation commenced in NTT after the introduction of maize from the Americas by Dutch and Portuguese colonialists around the 1670s. Over the last century, there has been severe and increasing land degradation because of:

1. Increasing human population, longer crop and shorter fallow cycles, and consequent increasing deforestation and reduced forest regeneration.
2. An increasing cattle population since introduction in 1912, and the introduction and spread of weeds like lantana (*Lantana camara*), which have reduced forest regeneration and placed increasing grazing pressure on grasslands.
3. Extensive annual burning of forest and grassland vegetation in the long and extreme dry season, which leaves the soil bare and unprotected.
4. High intensity rainfall events which are common in the short and variable wet season, have caused severe erosion of unvegetated slopes and consequent silting of streams and rivers.

There are two regions in NTT where this severe land degradation has been arrested and reversed through the development of stable agricultural systems based on *Leucaena leucocephala* (leucaena). One is in the Kecamatan (district) of Amarasi in West Timor, and the other is in the Kabupaten (regency) of Sikka on the island of Flores. Leucaena has probably been in the eastern Lesser Sunda Islands for several centuries. According to Dijkman (1950), it was brought to Indonesia from central America by early Spanish explorers. It has been used in Java and Sumatra to provide shade and firewood, improve soil fertility and reduce erosion since the early 1800s (Metzner 1982, 1983). The two regions are now described.

Kecamatan Amarasi, Kabupaten Kupang, West Timor

Amarasi occupies a 740 km^2 strip of land 10–25 km wide and 65 km long located on the south coast of West Timor. In the 1930s, experimental plantings of leucaena were made under the guidance of the Dutch administration on abandoned fields around the village of Baun (Ormeling 1955; Metzner 1981, 1983). The species was then sown widely in response to an adat (traditional) regulation which obliged every farmer in Amarasi to plant contour rows of leucaena. Failure to comply carried the threat of a fine and/or jail. Leucaena-based cropping systems were further promoted in 1938 after successful implementation of land use zoning regulations eliminated the need for fences, and farmers had more time for other agricultural activities.

Adat regulations were reinforced in 1948 when the Government introduced the Peraturan Tingkat Lamtoro (Leucaena Increase Regulation) that compelled all shifting cultivators to plant leucaena hedges along contour lines (Ormeling 1955). Over time, the plant moved out from the rows and quickly formed an even cover, apparently because hedges were not trimmed, and leucaena colonised the inter-row spaces (Metzner 1981).

By 1980, Metzner (1981) estimated that leucaena covered two thirds or 500 km^2 of Amarasi, and that lantana had been largely eliminated as a weed problem. By the 1960s, seasonal famine had been eliminated, and food was being exported from Amarasi.

Cattle production, which began in 1912, was further stimulated by the Provincial Government with the introduction in 1971 of the paron cattle fattening scheme. The government bought store cattle from central Timor and distributed them to interested farmers for fattening with cut-and-carry legume fodder, principally leucaena, but also sesbania, *Acacia leucophloea*, and *Tamarindus indica*.

Widiyatmike and colleagues in 1989 (Komang Surata 1993) reported that farmers raised 5–7 head per year, purchasing at 100 kg and selling after 12–14 months at 300 kg body weight, at a profit of Rp 200 000 per animal. Leucaena density over the whole farm was approximately 10 000 plants per ha. Each farm averaged 2 ha, of which 1–1.3 ha was used for fodder, and the remaining 0.6–1.3 ha was used for crop production. Liveweight gains have been reported to be as high as 1.3 to 1.7 kg/head/day, and this was attributed to the high proportion of leucaena in the animals' diet. Other reports have put liveweight gains at only 0.2–0.4 kg/day which increased to 0.5–0.8 kg/day with mineral supplementation and use of a bacterial digestion starter (Nulik et al. 2000). The extra income fulfils crucial family needs such home refurbishment, educational needs and ceremonial events (Nulik et al. 2000).

It was not necessary to resow leucaena after cropping because of the strong regrowth from cut stems and establishment of seedlings from fallen seed. Real incomes were estimated to be 20–30% higher than the average for West Timor, and this was attributed to the stable farming system based on leucaena (Jones 1983).

Unfortunately, continuing increase in population pressure and shortening fallow length, have put even this robust system under threat. Leucaena is becoming sparse, weeds are invading and there is increasing risk of erosion (Nulik et al. 2000).

Kabupaten Sikka, Flores

Sikka covers a 1670 km^2 area 15–30 km long on the eastern end of the island of Flores. Sikka has few cattle but serious erosion, and leucaena was introduced to provide vegetative cover and soil stabilisation. Efforts to popularise the plant were first made by the Dutch in the 1930s but farmers feared that thickets would get out of control and spread onto arable land (Metzner 1976).

In 1967–1968, a Catholic priest and a local farmer successfully established demonstration rows of leucaena which collected soil and formed indirect terraces between the leucaena rows. Over the three years to 1971, yields from the garden were stable, eliminating the need to shift to a new garden area (Cunha 1982).

This experience prompted a farmer group, Ikatan Petani Pancasila (IPP), to establish indirect terracing in 1972 at Kloangpopot, using contour rows of local leucaena spaced 5 m apart with clove trees between the rows. This demonstration was shown regularly to farmers and participants in IPP training courses, and stimulated great interest and activity in indirect terracing (Metzner 1976, Borgias 1978, Cunha 1982).

In 1973, the district government of Sikka and the Catholic Biro Social Maumere, with the support of IPP, established the Program Penanggulangan Erosi Kabupaten Sikka (Sikka Erosion Control Program) to stabilise 30 000 ha of land in five years. The pro gram held farmer training courses, distributed water levels for making contours, purchased and distributed seed, encouraged farmer cooperation through prizes, and supervised and evaluated plantings. Leucaena planting was also stimulated at this time by the introduction of Hawaiian giant leucaena varieties from Hawaii and the Philippines in 1978–1979, and by the introduction into Sikka in 1974 of the national food crops intensification program (BIMAS). Credit for crop inputs was restricted to farmers who planted leucaena in their cropping areas. Cunha (1982) put the leucaena area at this time between 27 000 and 43 500 ha.

For indirect terracing, leucaena was sown at about 70 kg seed per ha in furrows or banks cultivated along the contour with the aid of an A-frame or water level. Early establishment was slow, and seedlings were protected from weeds and grazing. With reasonable management, thick hedges formed within 2 years. Once established, hedges were usually cut at 4–6 week intervals and cut material was thrown on the upper slope to fertilise the soil (Metzner 1976). Unlike in Amarasi, leucaena has been maintained in hedgerows in Sikka and cropping is practised in the inter-row strips.

The primary aim of the leucaena planting program in Sikka was to control erosion. Evidence of the improvement in water balances could be seen from the Batikwair River, which ceased to flow in the dry season in the 1920s, but has been flowing continuously since 1979. Maumare, once a flood-prone town, has not been flooded since 1976 (Parera 1980; Prussner 1981; Metzner 1982).

Other benefits have followed. Established areas were being cropped more intensively and were more productive. Leucaena also controlled weeds such as *Imperata cylindrica*.

Leucaena herbage was fed mainly to small animals (chickens, pigs, goats) in Flores. Unlike in Timor, cattle have not traditionally formed a significant role in the livestock industry, partly because of the lack of water and extensive grasslands (Metzner 1982).

Effects of *Heteropsylla cubana* on *Leucaena* productivity

The arrival of the psyllid to eastern Indonesia in 1986 initially devastated leucaena plantings, as trees were bared and in places died. One study suggested leucaena productivity was reduced by 25–50% (Piggin et al. 1987). This was reflected in an 11% fall in cattle numbers sold in trade markets, from 88 000 head in 1986 to 77 000 in 1987. Psyllid numbers have now declined and productivity of leucaena has gradually recovered over the years, perhaps due to a build-up of psyllid predators.

The psyllid experience highlighted the danger of over-dependence on a single species and has prompted a concerted effort to find alternative shrub legumes. Research has shown that *L. diversifolia*, *L. collinsii*, and *L. pallida*, and several *Leucaena* hybrids are well adapted and exhibit good resistance or tolerance to psyllids (Piggin and Mella 1987a and b; Mella et al. 1989). Other species, such as *Sesbania*, *Acacia villosa*, *Gliricidia sepium*, *Calliandra callothrysus* and *Desmanthus virgatus*, were also shown to be well-adapted and useful as multipurpose trees.

Reasons for success of *Leucaena*

Two contrasting systems to utilise leucaena in local farming systems have developed and persisted in eastern Indonesia, both prompted by concerns about land degradation, low productivity, and poverty. There were many reasons why the leucaena-based systems were successfully developed and persisted in Amarasi and Sikka. They include:

- Local leaders, NGO and church groups, and government departments recognised the need for more sustainable systems, and were instrumental in demonstrating the potential of leucaena to local villagers. Alternative systems had failed. Church and farmer cooperative groups were prominent in Sikka, while Dutch and local government officials provided the impetus in Amarasi. The successful adoption of leucaena in Amarasi was only possible because of the introduction of a series of supportive regulations, introduced and enforced by the adat ruler (raja). Clearly this represents a top-down extension approach.
- Compatibility of leucaena with local environment and farming systems. Leucaena is a robust plant, which, once established, was able to persist and regenerate under traditional swidden systems of cropping which involved regular and quite severe cutting and burning. It was attractive to farmers because it provided livestock forage, wood for the construction of fences, mulch for crops, weed suppression, shade for tree crops, and soil stabilisation.
- Leucaena could be relatively easily established under corn crops, and could re-establish from cut stumps or seed in subsequent years.

Contribution of leucaena to development of more commercial farming systems. Leucaena has helped village farmers to move from subsistence farming to more commercial farming systems. This potential for commercial development has been important in farmer acceptance and enthusiasm for the use of leucaena-based systems.

Case study 4: *Leucaena* use in two villages in Batangas Province, Philippines

This is a case study of leucaena use in two villages in the Philippines, and of our experiences with introduction of improved varieties. The villages are Malimatoc 1 and 2 and are located in the Mabini District in Batangas Province. They are positioned on low hills overlooking Batangas Bay, and are about 500 m above sea level. The population of the two villages is 1781 and they cover a land area of about 400 ha. Land owned per farming family is small (approx. 1.0–1.5 ha). Soils in the area are formed on volcanic parent materials (Lipa series). Rainfall is 1,200 mm per annum. Some relevant aspects of their production systems are listed below.

(a) The two villages practise mixed cropping, horticulture and cattle enterprises, with jackfruit, coconut, mangoes, chico, citrus, bananas, sugar apples, corn and vegetables grown in mixed garden and agroforestry combinations. Leucaena is grown in hedgerows across slope, as farm boundaries and as single trees throughout the villages and is cut and fed to cattle and goats. It was first introduced to the villages in 1978 by Governor Leviste for the purposes of livestock feed. Most farmers raise cattle (an average of 2–3 each) and this provides approximately 30% of their cash income. Before psyllid infestation cash income from livestock raising ranged from 70–90% of total farm income. Growing cattle are purchased from Mabini and Lemery auction markets at a live weight of 150–250 kg and fattened to approx. 300–400 kg live weight. Fat cattle are sold to middlemen in the area, or in auction markets at neighboring towns of Lemery, Taal and Batangas City for approximately $1.10 per kg live weight. At times, prices are dictated by the middlemen.

(b) Feed resources for cattle fattening include leucaena, in conjunction with crop residues (corn stover), naturalised grasses, weeds and other tree and shrub fodders. However, leucaena is a key component of the diet due to its high forage quality and its capacity to give good live weight responses. There are multiple uses for leucaena in the villages. The most important, ranked in order, are:
- livestock feed;
- erosion control on sloping land;
- firewood;
- fertiliser mulch for cropping;
- shade tree for animals.

(c) The proportion of leucaena fed in the diet varies seasonally. During the dry season, it is the main part of the diet as long as it is not devastated by the psyllid, which is usually at its worst in the dry season (January to May). During the rainy season (June to October), when psyllids are less of a problem, the leucaena shows excellent growth. Other sources of feed are also in good supply at this time.

(d) The psyllids were first noticed in late 1985 when they caused great devastation, reducing leucaena productivity almost to zero. Since that time, natural predators have gradually reduced the psyllid challenge, and production has steadily increased to the present time. Farmers estimate that leucaena is back to 70% of pre-psyllid productivity. However, severe defoliation still occurs from the break of the dry season to the early wet season. As leucaena is the predominant feed resource, this causes serious disruption to forage supply and liveweight gains.

The villages were chosen for promotion of our new psyllid resistant hybrid (KX2, an F_1 cross between *Leucaena pallida* and *Leucaena leucocephala*) because of their prior experience with leucaena, and their obvious interest in testing new more productive and psyllid resistant varieties. The leucaena hybrid exhibits a combination of psyllid resistance and superior dry matter production (Mullen et al. 1998), but has one significant drawback. It needs to be vegetatively propagated as F_2 and subsequent generations segregate strongly. With assistance from the local Municipal Agricultural Officer, approximately 50 farmers were trained in vegetative propagation and propagation chambers were constructed from locally available materials. Two training courses, one in each village, provided information concerning procedures for establishing the cuttings as well as for marcotting and grafting. Farmers' response was very good. They saw KX2 as a good alternative to common leucaena, and it was resistant to psyllids.

However, the strike rate for cuttings was only 1–2% in the village propagation chamber. At the University of Queensland, we were achieving greater than 50%. The reasons could have been disease, poor watering, or too high temperature. Consequently, farmers have less confidence with the cutting technology and rely more on marcotting and grafting. Most had had prior experience in using these techniques.

Despite the poor strike rate, approximately 200 plants were distributed among a few farmers in Malimatoc 1 and 2. Some were planted in October 1998, but most were planted after January 1999. Growth of the KX2 trees has been excellent and they looked especially good in April 1999 when psyllids were seriously challenging common leucaena. Cuttings and grafts planted in March/April were more than 2 m in height in September of the same year and were being used to produce more cuttings as well as for grafting and marcotting. Initial feeding experiences gave good results as the hybrid was well eaten by cattle and goats. Early results and the response of farmers to the new hybrid have been excellent.

Reasons for the success of the extension effort to date are:

(a) There was an urgent need to increase the diminishing forage resource brought about by psyllid infestation on existing leucaena plantings. Farmers had high hopes that the hybrid would answer this need.

(b) We introduced a simple innovation that complemented a well established and successful farming system i.e. a new variety that overcame the key limitation of the common variety.

(c) The fattening enterprise of the farming system had important commercial outcomes for farmers, and they accorded high priority to improvement, Mutual trust and confidence between farmers and BAI and Municipal Agriculture Staff.

(d) Continuous monitoring and follow-up by BAI and local government staff and Australian collaborators.

However, before the innovation can be viewed as permanently adopted by farmers, the following criteria still need to be met:

(a) The methodology for supply of new seedlings from propagation chambers must be more robust i.e. capable of delivering a regular supply of large numbers of rooted cuttings at low cost, without significant difficulties.

(b) Teething problems, such as the low strike rate for cuttings, must be overcome quickly so as not to discourage government officers and farmers into thinking that the idea is impractical and therefore not relevant, and

(c) The Municipal Agricultural Office must continue to provide support for the propagation units, for training courses and for village promotion activities, until the nurseries are self-supporting and well established.

Case Study 5: *Calliandra calothyrsus* for Cattle Fattening in Bali

Calliandra calothyrsus (calliandra) was introduced to Bali between 1970 and 1975, after Mount Agung (nearly 3200 m high) erupted in 1963. Most of the villages nearby were destroyed by lava or covered by sand material. Calliandra was introduced as a component of reforestation programs in the south and west of Mount Agung, mainly around Besakih village, about 900 m asl. Besakih village has a population of around 5100 and covers 2100 ha, half of which is used for dryland farming. Annual rainfall is 1500 mm and the soil is volcanic.

The forestry officials cooperated with smallholder farmers asking them to look after the plantation trees (mainly *Pinus* and *Albizia*) which had been planted by government on land bordering areas belonging to farmers. As compensation, the farmers were allowed to plant calliandra and king grass (*Pennisetum purpureum* × *P. glaucum*) under the *Pinus* trees and were allowed harvest the calliandra and king grass regularly for forage. Planting materials of calliandra and of king grass were provided by government. Calliandra grew vigorously in the volcanic and cooler environment of Besakih and produced large quantities of seed which quickly colonised the area. This system was successful and has spread to nearby regions of Bangli, Gianyar, Badung and Tabanan at 700–1100 m above sea level. Farmers now plant calliandra as live fences, together with king grass about 2 m from the fence line. The live fence of calliandra produce about 1.8–3 ton/km dry matter in 10 months (Wiersum and Rika 1992). *Gliricidia sepium* (gliricidia) was also introduced and planted as live fences and as single trees for forage.

The spread of calliandra and gliricidia was through the efforts of the farmers themselves. This occurred after they learned that calliandra was a very good forage for the cattle.

Table 1 shows the amount of edible herbage of tree legume produced in five regions. The highest production of *Calliandra* is in Bangli sub region followed by Gianyar and Tabanan. Furthermore, it is worthwhile to note that *Calliandra* is the second most popular tree forage in Bali (after *Gliricidia*) despite the fact that it was the most recently introduced species.

Utilisation and benefits of *calliandra*

Calliandra has been used both as forage and fuelwood by farmers. For fuelwood, farmers collect the branches after the leaves have been fed to cattle.

Farmers cut calliandra about 3–4 times a year. Calliandra is eaten by cattle when fed fresh, but if wilted, it is not eaten, and leaflets shatter. Calliandra is often not fed throughout the year and is combined with the grass *Pennisetum polystachion* for dry season feeding. During the rainy season, when *Pennisetum* and other pioneer grasses grow well, farmers just use grass for their cattle although calliandra may be cut for fuel.

In addition to *Calliandra, Erythrina, Gliricidia* and *Leucaena*, broad-leaved weeds and grasses are also fed to cattle. Sometimes, farmers around Besakih feed boiled sweet potato mixed with drinking water and a little salt.

Thus the composition of the feed for fattening cattle in Besakih area village is mostly *Calliandra* + *Pennisetum* (about 70–80%), pioneer grasses, broad leaf weeds and sweet potato pulp in the drinking water. Farmers raise an average of 3–4 head of cattle per family. There are 8500 cattle in Besakih. Cattle are purchased at 6 months of age, housed, and fed by cut and carry methods. Live weight gains are 500–750 g/day. Cattle are sold at an age of 1.5–2 years at Rp 8500 to 9000 per kg live weight. Farmers can earn about Rp. 2 M–Rp 2.5 M per year from cattle sales. In addition, they earn about Rp. 75 000 to 80 000 if they sell the manure.

Cattle in Besakih area are more expensive because they have higher live weight than cattle from other areas in Bali. Cattle sales provide 70% of farmers' cash income. Recently (late 1997) new provenances of *Calliandra* and *Gliricidia* were introduced to 10 farmers in the Besakih area. The new provenances of calliandra were adopted quickly because of their high productivity and ease of spread.

Reasons for successful uptake

(a) The intervention was supported by government agencies for an extended period of time during which the calliandra/king grass system became established.
(b) The farming community had few forage options available at the time of the initial intervention due the eruption of Agung The calliandra/king grass system was simple and effective, and it spread naturally by seed dominating other vegetation.
(c) Feeding calliandra provided a much needed source of cash return from cattle sales.
(d) The use of callianda met multipurpose needs of forage, wood, erosion control and green manure.
(e) The Balinese have a long history of integrated farming systems using MPTs so that the inclusion of the tree legume calliandra was not a new concept.

Table 1. Production of major tree/shrub legumes used in five sub regions of Bali.

Tree/shrub Legume	Production of tree legumes (DM tonnes/year)				
	Badung	Tabanan	Gianyar	Bangli	Karangase
					m
Gliricidia	16.3	12.0	1.9	8.5	6.3
Leucaena	1.0	8.3	0.4	2.1	0.4
Calliandra	0.2	7.1	13.9	17.8	1.3
Erythrina	2.3	14.1	2.2	7.8	1.0

Source: Forage Survey for Bali 1992.

Conclusions

There are many reasons put forward for success or lower than anticipated levels of adoption (Smith 1992, Cromwell et al. 199; Larsen et al. 1998). The innovation may be simple (a new variety overcoming a key problem), and effective adoption may be achieved with relatively little intervention. However, complex systems, involving a new farming system, generally require sustained, high profile intervention to achieve significant adoption.

From the case studies, several factors were common to successful adoption including:

Technical

Technical constraints must be resolved promptly to avoid farmers and extension workers becoming discouraged and losing interest. To achieve this, back-up R&D services must be available to ensure that problems that appear can be resolved.

Technical information needs to flow frequently, accurately and in a variety of appropriate formats (field visits, manuals, videos, newsletters, discussion groups) to farmers.

A range of MPT species may need to be available to meet the diverse needs of farmers, their environments and farming systems. Simons (1996) suggested that substantial advantage is needed to interest farmers in new varieties. He suggested that farmers may not be prepared to buy improved germplasm of low value crops if existing material is available for free. New germplasm would have to be markedly superior, as is the case with the KX2 *Leucaena* hybrid being introduced into the Philippines.

The best planting material should be available to farmers. This will require education of both extension agents and farmers to ensure adequate farmer knowledge concerning suppliers and their varieties available. Planting material may be prohibitively expensive (if it is imported).

Socio-economic

Farmers, local leaders and groups, and government all need to be closely involved in the process and there needs to be frequent contact among all players. All need to feel some ownership and all need to be respected for their contribution to the innovation. The importance of communication/training/extension and research networks needs to be stressed. Adequate training of specialists and technicians in all aspects of the management and use of tree legumes is important (Dutton 1992).

Innovation needs to have positive commercial outcomes for individual farmers as well as other beneficial outcomes. Cook et al. (1989) stressed the importance of understanding the economics of agroforestry systems from the farmer's point of view as well as from the broader perspective of benefits to society. Project implementation should take into account local markets and opportunities for off-farm employment offered by tree products, as well as the opportunity costs perceived by farmers in making adoption decisions. A full cost-benefit analysis of new agroforestry systems is essential. There is often a lack of information on the economics and long-term benefits of new systems. It is unlikely that farmers will adopt new MPT systems on the basis of environmental benefit only.

Other

Interestingly, successful tree legume-based interventions have commonly involved long-term, top-down extension methodologies. The need for institutional direction and long-term commitment may be necessary due to the complexity of many of the tree legume systems being promoted. It could be argued that uptake of leucaena systems in northern Australia has been limited by a lack of institutional direction. However, successful adoption of tree legume interventions through a process of on-farm and participatory research has also been a consistent theme.

Perhaps the most important elements of successful adoption are the time, enthusiasm and long-term commitment, of farmers, researchers, and extension agents involved. Successful innovation needs champions to ensure continuity of interest and support over an extended time period (often >10 years and sometimes up to 30 years).

One thing is certain – without improved levels of adoption, and more explicit demonstration of the relevance and benefits of forage tree legumes, the good will and support of funding and donor agencies will be limited.

References

Argel, P.J., Lascano, C.E. and Ramirez, L. 1998. *Leucaena* in Latin American farming systems: Challenges for development. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A. ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. Canberra, ACIAR Proceedings No. 86, 319–323.

Borgias, F. 1978. Lamtoronisasi – usaha anti erosi dan pengawetan tanah di Kabupaten Dati II Sikka. Semarang, Jawa, Indonesia, Skripsi, Academi Farming.

Coates, F.J. 1997. The use of a geographical information system (G.I.S.) to map areas in northern Australia suitable for the establishment of *Leucaena leucocephala* cvv. Cunningham, Peru, and Tarramba; and the KX2 F1 hybrid (*L. pallida* × *L. leucocephala*). Unpublished fourth year report, University of Queensland, 56 p.

Cook, C.C., Grut, M. and Christoffersen, L.E. 1989. Agroforestry in Sub-Saharan Africa: a farmer's perspective. World Bank Technical Paper No. 112, Washington, World Bank. 99 p.

Cromwell, E., Brodie, A. and Southern, A. 1996. Germplasm for Multipurpose Trees: Access and Utility in Small-Farm Communities. Case studies from Honduras, Malawi, & Sri Lanka. Overseas Development Institute, 93 p.

Cunha, I. 1982. Proses usaha lamtorinisasi di Kabupaten Sikka (di P. Flores – Propinsi Nusa Tenggara Timur). report from Lembaga Penelitian dan Pembangunan Sosial (Institute of Social Research and Development), Nita, Maumere, Flores, Nusa Tenggara Timur, Indonesia.

Dijkman, M.J. 1950. Leucaena – a promising soil-erosion-control plant. Economic Botany, 4, 337–349.

Dutton, R.W. 1992. A research and development strategy for *Prosopis*. In: Dutton, R.W., Powell, M. and Ridley, R.J., ed. *Prosopis* species – Aspects of their value, research and development. Proceedings of *Prosopis* symposium held by CORD, University of Durham, UK, 3–27.

Dzowela, B.H., Wandera, P.F., Were, J. and Mohammed-Saleem, M.A. 1998. *Leucaena* in smallholder systems in Africa: Challenges for development. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. ACIAR Proceedings No. 86, 311–318.

Esdale, C. and Middleton, C. 1997. Top animal production from leucaena. Leucnet News No. 4, 9–10.

Gutteridge, R.C. 1994. The perennial *Sesbania* species. In: Gutteridge, R.C. and Shelton, H.M., ed. Forage Tree Legumes in Tropical Agriculture, Wallingford, UK, CAB International, 49–64.

Gutteridge, R.C. 1998. *Leucaena* in alley cropping systems: Challenges for development. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. Canberra, ACIAR Proceedings No. 86, 337–341.

Hutton, E.M. and Gray, S.G. 1959. Problems in adopting *Leucaena glauca* as a forage for the Australian tropics. Empire Journal of Experimental Agriculture, 27: 187–196.

Jones P.H. 1983. Amarasi household survey. Report to Bappeda, Kupang, NTT. March 1983, 12 pp.

Jones, R.J. 1985. Leucaena toxicity and the ruminal degradation of mimosine. In: Plant Toxicology. Proceedings of the Australia-USA Poisonous Plants Symposium, Brisbane, 111–119.

Komang Surata, I. 1993. Amarasi system: agroforestry model in the savanna of Timor Island, Indonesia. Savana, 8: 15–23.

Larsen, P.H., Middleton, C.H., Bolam, M.J. and Chamberlain, J. 1998. *Leucaena* in large-scale grazing systems: Challenges for development. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. Canberra, ACIAR Proceedings No. 86, 324–330.

Lesleighter, L.C. and Shelton, H.M. 1986. Adoption of the shrub legume *Leucaena leucocephala* in central and southeast Queensland. Tropical Grasslands, 20: 97–106.

Mella, P. Zaingo, M. and Janing, M. 1989. Resistance of *Leucaena* and some other tree legumes to *Heteropsylla cubana* in West Timor, Indonesia. In: Nampompeth, B. and MacDicken, K.G., ed. Leucaena Psyllid: Problems and Management, Bangkok, Winrock International F/FRED Coordinating Unit, 56–61.

Metzner, J.K. 1976. Lamtoronisasi: an experiment in soil conservation. Bulletin of Indonesian Economic Studies, 12: 103–109.

Metzner, J.K. 1981. Old in the new: Autochthonous approach towards stabilising an agroecosystem – the case from Amarasi (Timor). Applied Geography and Development, 17: 1–17.

Metzner, J.K. 1982. Agriculture and population pressure in Sikka, Isle of Flores. A.N.U. Development Series Monograph No. 28. Canberra,The Australian National University.

Metzner, J.K. 1983. Innovations in agriculture incorporating traditional production methods: The case of Amarasi. Bulletin of Indonesian Economic Studies, 19: 94–105.

Middleton, C.H., Jones, R.J., Shelton, H.M., Petty, S.R. and Wildin, J.H. 1995. Leucaena in northern Australia. In: Shelton. H.M., Piggin, C.M. and Brewbaker, J.L., ed. *Leucaena – Opportunities and Limitations.* Proceedings of workshop held in Bogor, Indonesia. Canberra, ACIAR Proceedings No. 57, 214–221.

Moog, F.A., Bezkorowajnyj, P. and Nitis, I.M. 1998. *Leucaena* in smallholder farming systems in Asia: Challenges for development. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. Canberra, ACIAR Proceedings No. 86, 303–310.

Mullen, B.F., Shelton, H.M., Basford, K.E., Castillo, A.C., Bino, B., Victorio, E.E., Acasio, R.N., Tarabu, J., Komolong, M.K., Galgal, K.K., Khoa, L.V., Co, H.X., Wandera, F.P., Ibrahim, T., Clem, R.L., Jones, R.J., Middleton, C.H., Bolam, M.J.M., Gabunada, F., Stür, W.W., Horne, P.M., Utachak, K. and Khanh, T.T. 1998. Agronomic adaptation to environmental challenges in the genus *Leucaena*. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. *Leucaena* – Adaptation, Quality and Farming Systems. Proceedings of workshop held in Hanoi, Vietnam. Canberra, ACIAR Proceedings No. 86, 39–50.

Nulik, J., Kana Hau, D. and Asnah. 2000. The Amarasi farming system, its economic aspects and the adoption of improved cattle feeding and group pen systems. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. Canberra, These Proceedings, see Contents.

Ormeling, F.J. 1955. The Timor Problem, A Geographical Interpretation of an Underdeveloped Island, Djakarta, Gröningen, J.B. Wolters.

Palmer, B. Macqueen, D.J and Gutteridge, R.C. 1994. *Calliandra calothyrsus* – a multipurpose tree legume for humid locations. In: Gutteridge, R.C. and Shelton, H.M., ed. Forage Tree Legumes in tropical Agriculture, Wallingford, UK, CAB International, 65–74.

Parera, V. 1980. Lamtoronisasi in Kabupaten Sikka. Leucaena Newsletter, 1: 13–14.

Piggin C.M. and Mella, P. 1987a. Investigations on the growth and resistance to *Heteropsylla cubana* of *Leucaena* and other tree legumes in Timor, Indonesia. Leucaena Research Reports, 8: 14–18.

Piggin, C.M. and Mella, P. 1987b. Pengaruh *Heteropsylla cubana* terhadap pertumbuhan dan daya tahan *Leucaena* dan jenis legume lainnya di Timor, Indonesia. Paper presented to a symposium on psyllid and *Leucaena* held at the Nusa Cendana University, Kupang, NTT, Indonesia, on 24–25 September 1987.

Piggin, C.M., Mella, P., Janing, M., Aklis, M.S., Kerridge, P.C. and Zaingo, M. 1987. Report on results from pasture and forage trials 1985–87. NTT Livestock Development Project, Kupang, Indonesia.

Prussner, K.A. 1981. *Leucaena leucocephala* farming systems for agroforestry and the control of swidden agriculture. Agroforestry and the Control of Swidden Agriculture Seminar, Forest Research Institute, Bogor, Indonesia, 19–21

Simons, A.J. 1996. Seed orchards and breeding. In: Stewart, J.L., Allison, G.E. and Simons, A.J., ed. *Gliricidia sepium* – Genetic resources for farmers. Tropical Forestry Paper 33. Oxford Forestry Institute, 119–125.

Stewart, J.L. 1996. Utilisation. In: Stewart, J.L., Allison, G.E. and Simons, A.J., ed. *Gliricidia sepium* – Genetic resources for farmers. Tropical forestry Paper 33. Oxford Forestry Institute, 33–48.

Wickens, G.E., Sief El Din, A.G., Sita, G. and Nahal, I. 1995. Role of *Acacia* species in the rural economy of dry Africa and the Near East. Rome, FAO-Conservation-Guide, No. 27, 56 p.

Wiersum, K.F., and Rika, I.K 1992. *Calliandra calothyrsus* Meissn. In: Mannetje, L.'t and Jones, R.M. ed. Plant Resources of Southeast Asia No 4, Forages, Wageningen, Pudoc Scientific Publishers, 68–70.

Factors Encouraging Intensification of Forage Production by Smallholder Dairy Farmers

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Abstract

Dairying is carried out in most tropical countries, usually by smallholders. Important factors affecting the success of smallholder dairy farming are: credit for buying dairy cows, barn construction and pasture establishment; availability of quality forages and farmer priorities in their management, access to information, disease control, milk processing facilities, and access to dairy cooperatives. Adoption of forage grasses has generally been more widespread than forage legumes, although Arachis is becoming popular in Central and South America, and recent reports indicate that Calliandra calothyrsus is being grown by many dairy smallholders in Kenya. In Southeast Asia, the country with the best developed dairy industry is Thailand, where 99% of the 20 000 farms are classed as small holdings. The main factors contributing to the success of the Thai dairy industry are promotion through government policy which has been aimed at increasing farmer income; reducing imports and hence saving foreign exchange; improving the health of the Thai people, especially children; and alleviating the risk of crop failure and the depressed prices of farm products. The goal of increased dairy production is being promoted by the Thai Government through provision of credit to farmers for establishing pastures and purchasing cattle, establishing a farm gate price for milk, expanding governmental and private sector milk processing, and supporting and subsidising seed production. Research is directed towards developing quality grasses which combine dry-season yield and better perennation than the currently grown Brachiaria ruziziensis, which largely owes its popularity to good seed production.

DAIRYING is widespread throughout the tropics, with smallholder production being a significant activity in many countries, including Ethiopia, Kenya, Uganda (Freeman et al. 1998), Tanzania (Wiggins and Mdoe 1997), Central and South America, from Mexico to Panama and Venezuela to Bolivia (C.E. Lascagno pers. comm. 1999), Pakistan (Aziz 1990), India (Krishnan 1997) and Thailand (Khemsawat 1996). Kenya is largely self-sufficient in dairy products, with more than 400 000 smallholder farmers producing 70% of the marketed milk in the country (Reynolds et al. 1996), whereas neighbouring Tanzania is a net importer (Wiggins and Mdoe 1997).

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In some countries in Central and South America, for economic reasons, there has been a tendency for dairying in recent years to move to lower altitudes (C.E. Lascano pers. comm. 1999). Eighty percent of dairy producers in Brazil are smallholders, although they are responsible for only 20% of the country's production (R. Reis, pers. comm. 1999 to L. Jank). In Thailand and India, smallholder dairy farming is actively being encouraged.

In Thailand, raw milk production grew 13.9% over the period 1985–1995 (Regional Office for Asia and the Pacific 1996) and there are now more than 20 000 dairy farmers in the country. Total dairy cattle number 355 000 head and raw milk production is 462 000 tonnes per year (Office of Agricultural Economics 1999b). Most dairy farms are located in central and northeastern Thailand. Almost all (99%) are smallholder operations, with fewer than 40 cattle/farm, mostly 1–10 head. A high proportion of these dairy farmers rely on sown forages for feeding their cows. Most of the cattle are 75% Holstein-Friesian, with an average milk yield of 10.7 kg/head/day (Planning Division 1997).

Unlike other forms of animal production, the marketable product from dairying enterprises mostly needs to be collected from the farm daily and requires a complex infrastructure to ensure the product – commonly milk, cheese or butter – is delivered to the consumer in an acceptable condition. If such an infrastructure is not provided, marketing is necessarily restricted to the local (village) level. The provision of such infrastructure is seen as a priority by some governments (e.g. Kenya, Reynolds et al. 1996) and in some cases is provided by commercial companies (e.g. Brazil, L. Jank, pers. comm. 1999). Dzowela (1993) pointed out that the widespread adoption (in Kenya) of forage legumes would be favoured by the high incentives created by a readily available market infrastructure. In many countries, smallholder dairying is a peri-urban activity, facilitating the delivery of milk to urban communities. Urban areas in developing countries are particularly important markets for butter, cheese and milk. For smallholder dairy farmers to expand and plant improved forages, there needs to be: (i) adequate infrastructure and marketing opportunities; (ii) availability of credit for purchase of livestock and planting pastures; (iii) available productive and adapted forage species; (iv) ready access to information; and (v) a farm management system which ensures adequate feed throughout the year. There also need to be disease control measures and adequate hygiene for milk collection, but these are outside the scope of this paper.

Table 1. Milk consumption per head of population in Thailand, national milk demand and milk production, 1997–2001.

Year	Milk consumption kg/head/year	Milk demand (tonnes × 1000)	Milk production (tonnes × 1000)
1997	10.9	673	415
1998	12.8	796	443
1999	14.9	943	485
2000	17.4	1116	574
2001	20.4	1322	666
Annual rate of increase (%)	16.9	18.4	12.8

Source: Office of Agricultural Economics

Provision of Infrastructure

Increase in milk consumption depends on the economic situation and development of the country. The Thai Government has had a continuous plan to develop dairy farming, seeking to promote milk consumption demand for its nutritional value. In Thailand, various projects were established such as the 'School Milk Project', which created some demand for milk (Table 1). Emphasis was placed on provision of agricultural infrastructure, such as irrigation, electricity, roads and dams.

As a result, by 1986, there were 56 000 head of dairy cattle in Thailand, producing 64 000 tonnes of raw milk per year. Since 1994, the Thai Government has been actively promoting the replacement of areas of rice and cassava with livestock farms and sown forage (Ministry of Agriculture and Cooperatives 1994). This has been associated with funding for research which has led to identification of adapted dairy cattle breeds and solution of farm management problems. As a result, from 1994 to 1996 average milk production per cow increased from 7 kg/head/day to 10 kg/head/day, dairy cattle numbers increased from 165 700 head to 266 100 head and raw milk production increased from 193 900 tonnes to 326 400 tonnes/annum.

To support the anticipated increased demand for milk in the future, the Thai Government plans to:

- Establish Dairy Farming Development and Training Centres for both extension officers and farmers.
- Increase the capacity of the existing dairy plants and establish new dairy plants in order to ensure that milk can be sold at the guaranteed price.
- Support the establishment of milk collecting points in dairy farming areas.

Although most farmers in Thailand establish their own pasture, some farmers do not produce enough good-quality roughage to meet their needs. In an effort to solve this problem, the government is promoting production and marketing of forages, as green forage, hay and silage, and as forage seed. The pilot project for developing the marketing of conserved forage is to start this year (1999). The strategies are as follows:

a) Selection of sites and farmers. Sites are areas which have large populations of livestock, especially dairy cattle; selected farmers are those who live in the selected areas, are willing to participate in the program and who have their own land, mostly farmers who have had experience with forage seed production.
b) Farmers receive training at a nearby DLD (Department of Livestock Development) centre on forage establishment, management and hay making.
c) The DLD signs a contract with farmers, guaranteeing to purchase legume hay at 2 baht/kg (at the time US$1 = 40 baht. Seed for establishment is supported by DLD.

d) The DLD staff regularly advise the farmers, from planting to harvesting.

The DLD staff organise a direct contract between hay producers and the end-users (dairy farmers). In 1999, the DLD had a target to buy back 18 tonnes of hay. We believe that if contact between the producers and dairy farmers can be established, conserved forage marketing will be a success and help the dairy farmers solve their feed shortage problem during the dry season.

Infrastructure to support dairying in Central and South America varies widely, from farmer-cooperatives in Costa Rica to minimal infrastructure for cheese-making in Honduras and Nicaragua, for consumption by the family and for sale within the village (C.E. Lascagno pers. comm. 1999). In the Cuaca Valley of Colombia, there is a resurgence of interest in smallholder dairying associated with a processing facility which has been under-utilised owing to change in land use to sugar cane. Funding from the commercial company Nestlé and the building of a satellite milk-processing facility in another district has encouraged smallholder dairy producers to increase production (C.E. Lascagno pers. comm. 1999). In Brazil, 10 large companies (including Nestlé) control dairy production, promote intensification and enter into annual contracts with producers, hence stabilising the industry.

Only a small fraction of the milk produced by smallholders in sub-Saharan Africa enters the commercial market, owing to a lack of milk-collection systems in rural areas and scarcity of small-scale processing techniques (O'Mahoney and Peters 1987). In East Africa, the costs of dairying limit its profitability and dairy cooperatives have a role in reducing these costs (Staal et al. 1997; Wiggins and Mdoe 1997). The Kenya Government has an active policy to promote dairying through the National Dairy Development Program (NDDP) (Reynolds et al. 1996), and the milk production per cow was higher in NDDP farms than comparable farms with extensive dairying systems in coastal districts (Leegwater et al. 1992).

In India, cooperatives are being promoted to support small producers, including for milk supply, but it has been emphasised that cooperatives need to 'follow the rules of the market' if they are to maintain viability (Brahme 1984). In 1988, the International Fund for Agricultural Development (IFAD) granted a loan to the Small Holder Dairy Development Project in Punjab Province, Pakistan, with, inter alia, the aim of improving marketing systems (Aziz 1990).

Economics of Dairy Farming and Availability of Credit

Dairying is profitable for smallholder farmers in Thailand, as there is a stable market and a guaranteed price. The guaranteed price for milk in 1998 was set at 10.75 baht/kg and the factory price was 12.50 baht/kg (Office of Agricultural Economics1999c). Dairy farming gives a better return on capital investment than rice growing or cassava growing, and the high gross margin encourages more farmers to venture into dairy farming. In Uthaithani Province, the benefit/cost ratio for rice production and dairy farming has been calculated as 0.95 and 1.09, respectively (Duangpatra et al. 1999). Net annual profit from dairy farming is US$868 per hectare (US$1 = 36 baht, 1996) whereas the net profit from rice and cassava are US$61–122 and US$ 42–194 per hectare, respectively (Ministry of Agriculture and Cooperatives 1996).

In Thailand, despite an anticipated annual increase of 13%, milk production is projected to meet only 50–60% of domestic demand in 2001, as demand for milk is expected to increase 18% per annum (Ministry of Agriculture and Cooperatives 1996). As an incentive to increase national milk production, credit is provided by the Bank of Agriculture and Agricultural Cooperatives under the Agricultural Infrastructure Project. Each farmer cooperator receives 250 000 baht (US$7000) with 5% interest and a 2-year grace period. This credit is for purchasing five cows, barn construction and pasture establishment. Payment of the loan is to be complete within 15 years.

In the State of Kerala in India, regional rural banks have been providing credit for the purpose of purchasing milking cows. This has been found to have a positive impact on income and employment generation, although repayments are very low (Krishnan 1997). The requirements for credit for working capital and for investment capital to support peri-urban smallholder dairy farmers in Nigeria, Ethiopia and Uganda vary widely between farmers (Freeman et al. 1998).

In Kenya, the NDDP assists farmers, where appropriate, to obtain finance for the purchase of dairy heifers (Reynolds et al. 1996).

Available Productive and Adapted Forage Species

The Thai Government has a policy to reduce the cost of milk production by increasing the use of good quality roughage, including pasture, and decreasing the use of concentrate feed. Many trials have been conducted to identify the most promising species (e.g. Kasuo and Kodpat 1992; Thinnakorn et al. 1992). Three grass species, *Brachiaria ruziziensis* (ruzi grass), *Panicum maximum* TD 58 (purple guinea) and *Pennisetum purpureum* (Napier grass) and three legume species (*Stylosanthes hamata* cv. Verano, *Desmanthus virgatus* and *Leucaena leucocephala*) are recommended and widely used by smallholder dairy farmers (Bunyanuwat et al. 1995; Jiumjetjaroon and Angthong 1998). Critical to the success of these species is that they are reliable and heavy seed producers in Thailand. Other species listed as promising, but which require further evaluation, are *Paspalum atratum*, *Brachiaria brizantha, B. decumbens*, *Arachis pintoi*, *Stylosanthes guianensis* CIAT 184 and *Centrosema pascuorum*. One of the more promising grass species is *B. decumbens* (cv. Basilisk), which is much better adapted to areas with a long dry season than *B. ruziziensis*, but seed production is poor in the Thai climate. Research in association with the Forages for Smallholders Project has recently identified *Brachiaria* accessions with comparable dry season yield and good seed production (Nakamanee and Phailkaew 2000).

Forage seed production in Thailand has expanded steadily over the past 20 years to reach an annual production of over 1000 tonnes in 1995. Village farmers in contact with the DLD produce 80% of this seed (Phaikaew et al. 1996; Phaikaew and Hare 1998). In 1995, grass seed made up most of the production with *Brachiaria ruziziensis* and *Panicum maximum* TD 58 accounting for 904 and 138 tonnes of seed, respectively. Seed production of *Stylosanthes hamata* cv.Verano greatly exceeded seed production of any other forage legume, with 150 tonnes of seed harvested in 1995. Vegetative planting material such as stem cutting of dwarf Napier, common Napier and king grass (*P. purpureum* × *P. glaucum*) is also made available for farmers at eight Animal Nutrition Research Centres and 25 Animal Nutrition Stations all over the country. Some private companies also sell forage seed and an increasing amount of seed is now being sold from one farmer to another.

In 1998, feed cost accounted for 54% of the raw milk production cost in Thailand (Office of Agricultural Economic 1999a). The major problem of the dairy farmers is a lack of good quality roughage, especially in the dry season, when farmers commonly feed crop residues. Formerly, crop residues were available free of charge, but raising demand resulted in increased prices and crop residues becoming increasingly scarce. There is a trend towards increasing the sowing and feeding of forage, owing to its lower cost per unit of total digestible nutrient (TDN) than crop residues. The cost per kg of TDN of a forage crop is 1.5 baht per kilogram, whereas the equivalent costs for rice straw are 3.4 baht and for baby corn husk and stover, 2.7–2.8 baht. For concentrates, cost per kg of TDN is 6.6 baht.

Karnjanasirm et al. (1999) reported that the location of the farms is an important factor affecting the success of dairy farming in Nakorn Pathom Province, in central Thailand. The unsuccessful farmers had an inappropriate area for forage cultivation so they had to buy baby corn stover for feeding their cattle. The price of corn stover was high and also, because the source of corn stover was far from their farms, it was expensive. In northeastern Thailand, farmers who had a larger area per head for forage cultivation benefited more from the forage than the farmers who had smaller areas for forage cultivation (Bunyanuwat et al. 1995). Most (80–98%) dairy farmers established their own pasture (Bunyanuwat et al. 1996; Poathong et al. 1998).

During the recent and current economic crisis, Thailand has had to import costly raw material such as maize and soybean for concentrate feed. This has resulted in increased prices for concentrates and there is a need to decrease the use of concentrate feed by using high quality forage. Local studies have shown that hay made from ruzi grass mixed with the legumes centro (*Centrosema pubescens*), leucaena or lablab (*Lablab purpureus*)) produce more milk than cows fed with pure ruzi hay (Tudsri et al. 1997; Thinnakorn et al. 1998). Inclusion of a legume in the feed not only increases milk production but also decreases the cost of production. Lekchom et al. (1989) reported that dairy cows which grazed either grass-legume pasture or were fed good quality grass with low concentrate supplement (1 kg concentrate: 3 kg milk production) gave higher economic benefit than cows fed on grass with a high concentrate rate (1 kg concentrate: 1 kg milk production).

Although there has been some uptake of sown grass forages in sub-Saharan Africa, the adoption of forage legumes has been slow, despite their demonstrated benefits (Dzowela 1993; Paterson et al. 1998). In coastal Kenya sown forages have been promoted by NDDP, and the most popular are *Pennisetum purpureum*, *Leucaena leucocephala* and *Clitoria ternatea*, but sown forages contribute <40% and <25% of dairy cattle feed during the wet and dry seasons respectively. This is attributed to the farmers allocating their resources to the staple food crop maize, rather than to sown forages, even though they recognised the increased feeding value of the sown forages (Mureithi et al. 1998).

Although herbaceous legumes have not been widely accepted by dairy farmers in subSaharan Africa, there is now strong evidence that the shrub *Calliandra calothyrsus* is being enthusiastically adopted in the highlands of Kenya (Franzel et al.

1999). It has been estimated that 3 kg of fresh fodder of this species has the same effect on milk production as 1 kg of commercial meal (Paterson et al. 1998). Studies by Muinga et al. (1992) in coastal Kenya showed an increase in milk production of 1 kg/cow/day when cows fed on napier grass were supplemented with 8 kg/day of *L. leucocephala*.

Trials in Nigeria showed that the margin of profit for home-grown forage legumes *Stylosanthes hamata*, *Lablab purpureus* and *Chamaecrista rotundifolia* was 5–8 times that of purchasing feed for dairy cattle in peri-urban dairy systems, and that dairying was substantially more profitable than cropping to sorghum (Agyemang et al. 1998).

In Costa Rica, feeding of *Cratylia argentia* as a supplement to sugar cane tops is becoming popular. Farmers are intensifying production on less steep land, feeding *C. argentea* in the dry season and *Brachiaria decumbens* in the growing season. This has the desirable side effect that the steeply sloping land is made available for re-afforestation (C.E. Lascagno pers. comm. 1999). In Costa Rica, increased dairy production is made possible through the use of protein banks (*Erythrina berteroana*), or *Arachis pintoi/ Brachiaria brizantha* pastures (Holman et al. 1992). These authors stated that stocking rates could be 25% higher and milk production substantially higher on grass/legume than grass only pastures, for the same cost of establishment. *A. pintoi* is also the key legume in the smallholder dairying development in the Cuaca Valley, Colombia.

Smallholder dairy farmers in Brazil need to intensify and increase their production if they are to stay competitive with large-scale producers. This is achieved with sown-grass pastures, heavily fertilised and rotationally grazed. The main species used are *Brachiaria brizantha*, *B. decumbens*, *Pennisetum purpureum*, and *Panicum maximum* cv. Tanzania-1 (L. Jank, pers. comm. 1999). Alternatively, some farmers rely heavily on feeding concentrates to increase production. Sown pastures rarely include a legume component.

Access to Information

Dairy farming is a new and complex activity for farmers in many parts of the tropics, and, where there is a need for improved forages, there is a requirement for readily available information at an appropriate level. Most farmers find it a novel concept to plant grasses and legumes as feed for livestock. Intensive and continuous training for farmers, including formal and informal training, field visits and provision of advice are a necessity.

In Thailand, the Department of Livestock Development and the Dairy Promotion Organisation (DPO) have been responsible for the promotion and implementation of dairy farming. Under DLD, Regional, Provincial and District Livestock Offices are responsible for this task. District Livestock Officers are the key persons who closely interact with farmers. Farmers need technological advice from different sources. The main sources of information for farmers are friends and relations, dairy farmer groups, DPO officers and district livestock officers (Bunyanuwat 1995; Suthirat 1997).

Management System

In Thailand, the Division of Animal Nutrition of the DLD has developed guidelines for establishment, management and utilisation of the species which have been selected. Reliable establishment is critical if a smallholder is to adopt improved pasture technology, and includes suitable techniques of land treatment, and appropriate sowing rates and methods of sowing. Mineral nutrient requirement for each species (e.g. Khemsawat et al. 1993; Suksaran et al. 1997) and the role of cutting in crop management (e.g. Phaikaew et al. 1984; Punyavirocha et al. 1994a, b; Nakamanee et al. 1995) have also been defined. *B. ruziziensis* provides good roughage for feeding cattle and buffalo but quality of ruzi straw (after seed harvesting) is low. It should be used in conjunction with good quality feed (Chuenpreecha et al. 1992). Dried *Desmanthus* leaves can be used as a protein supplement to improve feed quality of rice straw when fed to cattle in the dry season (Nakamanee et al. 1997). New information arising from research is conveyed to farmers by direct contact, via extension officers, or through training courses.

Management systems adopted by smallholders may be open grazing, semi-grazing or zero grazing. In Uganda, it was concluded that productivity by cattle was higher under a zero grazing system (Okwir et al. 1998). However, in Kenya, many farmers ($\frac{1}{3}$ of those sampled) do not provide adequate quantities of feed in the feed trough to allow ad libitum feeding (Reynolds et al. 1996), and this is likely to be the case in other tropical countries where zero grazing is practiced. Failure to provide ad libitum and high quality feed will inevitably have an adverse effect on milk yields.

Conclusions

Many tropical countries still have to import a large amount of milk products. As the cost of production of milk in the tropics is generally high, processing companies often prefer imported milk powder to domestic raw milk. The liberalisation of trade through the General Agreement on Tariffs and Trade

(GATT) should provide scope for dairy farmers in countries such as Thailand to compete with the imported milk products, as milk products from countries supported by subsidies are reduced. However, as a result of population growth and increasing urbanisation, land is become increasingly scarce.

Strategies for increasing milk production should aim at increasing yield per animal rather than increasing numbers. Lack of good quality roughage in the dry season is the major problem of the farmers. Appropriate technologies such as improved feed conservation techniques and intensive forage management (e.g. fertilisation and irrigation) should be transferred to farmers. Farmers have to decrease cost of production in order to compete in the markets.

Intensification of forage production in the tropics is dependent on availability of adapted high-quality cultivars, promotion of dairy development through government policy, provision of infrastructure, credit for increasing herd size, and access to reliable markets for increased milk production. A smallholder farmer's commitment to planted improved forages depends on economic return and his/her other priorities.

Where economic returns justify expansion of smallholder dairy farming, sown or planted grasses are becoming widely accepted. Sowing legumes as a source of feed for dairy cattle is practiced in some countries but not in others.

In Thailand, intensification of forage production has been dependent on an expanding and profitable dairy industry, which has developed through government policy, provision of infrastructure, consumer demand and greater profitability than other farming enterprises. Factors affecting the use of forage for dairy cattle in Thailand are availability of adequate seed of good quality grasses and legumes; advice from extension officers and farmer groups; and job satisfaction.

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References

Agyemang, K., Dogoo, D.L. and Makun, H.J. 1998. Profitability of smallholder peri-urban dairy production systems. Experimental Agriculture, 34: 423–437.

Aziz, S. 1990. Smallholder livestock development in Pakistan. Rural Development in Practice, 2: 22–23.

Brahme, S. 1984. Producers' cooperatives; experience and lessons from India. ISS Occasional Papers (Netherlands) No. 99, 39 p.

Bunyanuwat, K., Inthrarachote, U., Sirikul,V. and Boonjeu, C. 1995. Economic cost-return analysis of dairy farm in Saraburi Province. Dairy Cattle Journal, Thailand, 14: 86–92.

Bunyanuwat, K., Intharachote, U. and Intra, N. 1996. Effect of farm size and pasture ratio on the success of dairy farmers of Pakchong Dairy Cooperative. In: Annual Report on Animal Production Research 1996 Animal breeding and Farm Management. Bangkok, Thailand, Department of Livestock Development, Ministry of Agriculture and Cooperatives, 154–166.

Chuenpreecha, T., Jenkollop, D. and Boonpakdee, W. 1992. Cassava meal or rice as a supplement to ruzi hay for feeding buffalo. Proceedings of the 11th Annual Livestock Conference, Chiangmai, Thailand, 16–19 September 1992. Thailand, Department of Livestock Development, Ministry of Agriculture and Cooperatives, 342–352.

Duangpatra, P., Jumwasorn, S. and Shrestha, R.P. 1999. The preliminary study on the use of Geographic Information System (GIS) techniques to identify an appropriate area for dairy production in Uthaithani Province. In: Kasetsart University Annual Conference. Bangkok, Thailand 3–5 February 1999. Bangkok, Thailand, Kasetsart University Proceeding, 136–142.

Dzowela, B.H. 1993. Advances in forage legumes: a sub-Sahara perspective. Proceedings of the XVII International Grassland Congress, 2115–2119.

Franzel, S., Arimi, H., Murithi, F. and Karanja, J. 1999. *Calliandra calothyrsus*: Assessing the early stages of adoption of a fodder tree in the highlands of central Kenya. In: Franzel, S. and Scherr, S. ed. Trees and Farmers: Assessing the Adoption Potential of Agroforestry Practices in Africa. Agroforestry Research Network for Africa Report No. 127. Nairobi, ICRAF, in press.

Freeman, H.A., Jabbar, M.A. and Ehui, S.K. eds 1998. Role of credit in the uptake of improved dairy technologies in sub-Saharan Africa. Socioeconomic and Policy Research Working Paper No. 22, Ethiopia, ILRI, 87 p.

Holman, F., Romero, F., Montenegro, J., Chana, C., Oviedo, E and Banos, A. 1992. Rentabilidad de sistemas silvopastoriles con pesquenos productores de leche en Costa Rica: primero aproximacion. Turrialba, 42: 79–89.

Jiumjetjaroon, W. and Angthong, W. 1998. Preliminary report on feed management of beef cattle and dairy cattle in 11 provinces in the central part of Thailand. Annual Research Report. Animal Nutrition Division, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand, 328 p.

Karnjanasirm, K., Tumwasorn, S., Markvichitr, K. and Thanindratarn, B. 1999. The certain factors affecting on the success of dairy production in Nakorn Pathom Province. [online] http://www.rdi.ku.ac.th/project/DAIRYSIZ.html. (13 September 1999).

Kasuo, E. and Kodpat, W. 1992. Method of establishment of Ruzi sward. Final report of technology for pasture establishment in Thailand. Animal Nutrition Division, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand. 139 p.

Khemsawat, J., Punyavirocha, T. and Nakamanee, G. 1993. Yield and chemical composition of hedge lucerne (*Desmanthus virgatus*) at different phosphorus rates under irrigation. In: Proceedings of the 13th Annual Livestock Conference, 18–21 July 1994, Bangkok, Thailand, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand, 129–134.

Khemsawat, C. 1996. Livestock production: Policy, constraints and future development in Thailand. In: Halim, R.A. and Chen, C.P. ed. Feed Resources for Smallholder Livestock Production in Southeast Asia. Proceedings of the 5th Meeting of Forage Regional Working Group on Grazing and Feed Resources of Southeast Asia, Vientiane, Lao PDR, 16–20 January 1996, 19–22.

Krishnan, C. 1997. Dairying for rural development: a study. Journal of Rural Development, 16: 387–400.

Leegwater, P., Ngolo, J. and Hoorweg, J. 1992. Dairy development and nutrition in Kilifi District, Kenya. Food and Nutrition Studies Programme Report African Studies Centre (Netherlands), 35: 129–134.

Lekchom, C., Witayanuparpyunyong, K., Sukpitaksakul, B. and Watkin, P.R. 1989. The use of improved pastures by grazing dairy cows for economic milk production in Thailand. Proc. XVI. Internaltional Grassland Congress, Nice, France, 1160–1164.

Ministry of Agriculture and Cooperatives. 1994. The Reformed Agricultural System Project. Bangkok, Thailand, Ministry of Agriculture and Cooperatives, 60 p.

Ministry of Agriculture and Cooperatives. 1996. Dairy Promotion Project. 1996–2001. Bangkok, Thailand, Ministry of Agriculture and Cooperatives, 67 p.

Muinga, R.W., Thorpe, W. and Topps, J.H. 1992. Voluntary food intake, live-weight change and lactation performance of crossbred dairy cows given ad libitum *Pennisetum purpureum* (napier grass var. Bana) supplemented with leucaena forage in the lowland semi-humid tropics. Animal Production, 55: 331–337.

Mureithi, J.G., Njunie, M.N., Muinga, R.W., Thorpe, W. and Mwatate, C.D. 1998. Adoption of planted forages by smallholder dairy farmers in coastal lowland Kenya. Tropical Grasslands, 32: 221–229.

Nakamanee, G. and Phaikaew, C. 2000. Potential new *Brachiaria* cultivars for the seasonally dry tropics. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C., Working with Farmers: The Key to Adoption of Forage Technologies. Proceedings, Workshop held in Cagayan de Oro, Philippines, 12–15 October 1999. These Proceedings, see Contents.

Nakamanee, G., Punyavirocha, T., Punpipat, W., Khemsawat, J. and Phaikaew, P. 1995. Growth characteristics and adaptability of 6 accessions of *Desmanthus virgatus* in Chainat environment, Annual Reseach Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand, 176 p.

Nakamanee, G., Punpipat, W. and Ponbamroong,T. 1997. Dried desmanthus (*Desmanthus virgatus*) as a protein supplement for feeding cattle in dry season. Annual Reseach Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand, 223 p.

Office of Agricultural Economics. 1999a. Production cost of raw milk in March, 1999. Bangkok, Thailand, Agricultural Economic News, Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, 513–55.

Office of Agricultural Economics.1999b. Number of members, dairy cows, farm price and quantity of fresh milk collecting points, 1993–97. [online] URL:http// www. oae.go.th/newsinfo/1996-97/table 97.html..

Office of Agricultural Economics.1999c. Forecast for Agricultural Economic Trend in 1999. [online] URL:http// www.oae.go.th/news/sum 41/bani.html. (14 September 1999).

Okwir, J.H., Mdoe, N.S.Y. and Ashimogo, G.C. 1998. Efficiency and comparative advantage of smallholder dairy production in Kampala-Jinja milkshed, Uganda. Quarterly Journal of International Agriculture, 37: 338–350.

O'Mahoney, F. and Peters, K.J. 1987. Options for smallholder milk production in sub-Saharan Africa. ILCA Bulletin, 27: 2–17.

Paterson, R.T., Karanja, G.M., Roothaert, R.L., Nyaarta, O.Z. and Kariuki, I.W. 1998. A review of fodder production and utilisation within smallholder agroforestry systems in Kenya. Agroforestry Systems, 41: 181–189.

Phaikaew, C. and Hare, M. 1998. Thailand's experiences with forage seed supply systems. In: Horne, P.M., Phaikaew, C. and Stur, W.W. Forage Seed Supply Systems, Proceeding of a workshop. Animal Nutrition Research Centre, Tha Pra, Khon Kaen, Thailand, 31 October–1 November 1996, Los Baños, Philippines, CIAT Working Document No. 175, 7–14.

Phaikaew, C., Suriyachantrathong, W., Indraramanee, S., Senagasp, U., Kawitsarasai, P., Nakamanee, G. and Phonboon, P. 1984. Yield and nutritive value of Verano stylo (*Stylosanthes hamata* cv. Verano) at different cutting intervals. In: Proceedings of the Annual Livestock Conference, Department of Livestock Development, Nakornpathom, 7–9 August 1994. Thailand. Department of Livestock Development, Ministry of Agriculture and Cooperatives, 62–77.

Phaikaew, C., Udchachon, S., Pholsen, P. and Chompoosor, B. 1996. Annual forage yield from mixed and pure pasture of ruzi and signal grasses. Annual Research Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand, 223 p.

Planning Division. 1997. Yearly Statistics Report 1997. Planning Division, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand, 191 p.

Poathong, S., Puipanthavong, P. and Ritreuchai, V. 1998. Survey Dairy Cattle Raising at Thumbol Pangkwang Amphor Muang Sakonakorn Province. Annual Research Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand, 328 p.

Punyavirocha, T., Khemsawat, C., Nakamanee, G., Kanjanapibul, N. and Punpipat, W. 1994a. Yield and nutritive value of hedge lucerne (*Desmanthus virgatus*) at different cutting intervals under irrigation. In: Proceedings of the 13th Annual Livestock Conference, Department of Livestock Development, Bangkok, Thailand, 18–21 July

1994. Department of Livestock Development, Ministry of Agriculture, Thailand, 176–182.

Punyavirocha, T., Nakamanee, G., Khemsawat, C., Punpipat, W. and Sugrarugi, P. 1994b. Effect of spacing and cutting height on yield and chemical composition of hedge lucerne (*Desmanthus virgatus*). In: Proceedings of the 13th Annual Livestock Conference, Department of Livestock Development, Bangkok, 18–21 July 1994. Department of Livestock Development, Ministry of Agriculture, Thailand, 183–189.

Regional Office for Asia and the Pacific (RAP). 1996. Selected indicators of food and agriculture development in Asia-Pacific Region, 1985–1995. Bangkok, Thailand, 135–136.

Reynolds, L., Metz, T. and Kiptarus, J. 1996. Smallholder dairy production in Kenya. World Animal Review, 87: 66–73.

Staal, S., Delgado, C. and Nicholson, C. 1997. Smallholder dairying under transaction costs in East Africa. World Development, 25: 779–794.

Suksaran, W., Vongpipat, C. and Nonthanawong, T. 1997. Response of *Panicum maximum* TD58 to nitrogen and phosphorus fertilisers on Ubon soil series in Thung Kula Ronghai. Annual Research Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, 99–117.

Suthirat, M. 1997. An application of technology in dairy production of farmers in Amphoe Hanka, Changwat Chainat. Theses on Agricultural Extension and Communication, Kasetsart University, Bangkok, Thailand, 148 p.

Thinnakorn, S. and Witayanupapyuenyong, S. 1992. Improving quality of ruzi pasture by different seed rate of Verano and Graham Stylo. In: Proceedings of the 11th Annual Livestock Conference, Department of Livestock Development, Chiangmai, Thailand, 16–19 September 1992. Department of Livestock Development, Ministry of Agriculture and Cooperatives Proceeding, Thailand, 260–287.

Thinnakorn, S., Snitwong, C. and Intharamanee, S. 1998. Effect of grass-legume hay feeding on milk production of dairy cow in the dry season. Annual Research Report, Division of Animal Nutrition, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand, 328 p.

Tudsri, S., Prasanpanich, S., Sawadipanich, S. and Jarikapakong, P. 1997. Milk production, grazing behaviour and reproductive performance under grazing conditions on different improved pastures. In: Proceedings of the 35th Kasetsart University Annual Conference, Kasetsart University, Bangkok, Thailand, 3–5 February 1997, Bangkok, Kasetsart University, 67.

Wiggins, S. and Mdoe, N. 1997. Returns to smallholder dairying in the Kilimanjaro region, Tanzania. Agricultural Economics, 17: 75–87.

Adoption of Legumes for Soil Improvement and Forage by Smallholder Farmers in Africa

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Abstract

The potential for legumes is increasing for many smallholder farming systems in Africa as soil fertility declines and livestock management is intensified. Successes in achieving significant adoption of forage and soil-improving legumes are few, despite much investment in such technology. Even with the successes, the legumes may be in a stage of rapid adoption but, thus far, have been adopted by only a small proportion of the population in the larger target areas and the practices have not endured the test of time. Experiences suggest that the niches for new legumes need to be well defined and narrowly defined. Numerous factors, in addition to agronomic performance, affect adoption, and some determinants are frequently significant. Farmers' perceptions of the need to improve soil management and livestock nutrition, and their knowledge of the potential of legumes, are often determinants of adoption. Farmers need an early return on their investment and multiple-use legumes may be more easily adopted. Land-poor farmers are not likely to adopt. Security of land tenure, amounts of fallow land, and risk due to uncontrolled grazing or burning, are important determinants. Strong institutional support was important for adoption in all cases. However, the capacity is small to reach the millions of smallholder farmers. Enhancement of farmers' capacity to adapt and disseminate technology may be a major role for extension agencies. This requires an understanding of obstacles and opportunities for exchange of information and seed among neighbours, and for farmer experimentation. The institutional support may focus on farmers inclined to experiment, who may also be early adopters, and especially if they are those who readily disseminate seed and information. Alternatively, the institutional effort may focus on groups or on the whole community.

CROP and animal productivity is low throughout much of sub-Saharan Africa, and is threatened by land depletion and declining soil fertility. Little inorganic fertilizer is used, and nutrient balances for cropland are typically negative. Better integration of nitrogen-fixing legumes into smallholder farming systems is a potential element of improved, integrated crop management. The success rate in achieving significant adoption of introduced legumes in sub-Saharan Africa for soil improvement and forages has been low (Thomas and Sumberg 1995; Franzel et al. 1999).

Effective dissemination of legume technology is difficult to achieve and requires well conceived and implementation dissemination and diffusion strategies. Early adopters benefit from the technology, or they may be discouraged. Therefore, the legumes need to be well targeted and the information effectively delivered. The boundary conditions, or niches, need to be narrowly defined to improve the probability that farmers will have a successful experience. Once farmers have found a place for the legumes in their systems, opportunities to extend the technology to other niches can be tried, either by farmers themselves or together with research or extension collaborators.

Good definition of the boundary conditions requires farmer participation in the research, so that information for a legume option is refined, and opportunities and constraints for different sets of farmer conditions are known. Dissemination methods may vary, with more or less farmer participation. Systems of information and seed flow among farmers need to be considered, as well as farmers' processes of adapting prototypes to their systems.

This paper addresses determinants of adoption at a farm household level, issues of targeting technical options to niches, and planning institutional support to dissemination.

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Legumes and their Niches

We drew lessons from several cases where legumes have been promoted for soil improvement or as forage. The cases included those where the practice was well adopted by farmers, as well as cases of unconfirmed promise, and adoption failure.

1 Mucuna (*Mucuna pruriens*) in Benin. In this well-studied case, mucuna has been widely adopted, primarily for suppression of weeds, but also for soil fertility maintenance. The studies were done in villages with known adoption and have yielded much valuable information about determinants of adoption (Manyong et al. 1996; Versteeg et al. 1998; Vissoh et al. 1998). In 1997, 100 000 farmers were estimated to have been exposed to mucuna in Benin, and 10 000 farmers (or 7% of the farmers surveyed) were estimated to be using mucuna.

2 *Sesbania sesban* and *Tephrosia vogellii* fallows in Zambia. Two-year fallows, improved with leguminous trees, are being adopted by farmers in eastern Zambia for maize-production systems. Determinants of adoption have been studies (Franzel et al. 1999; Peterson 1999). Prior to and including the 1997–1998 season, approximately 3000 farmers had tried the improved fallows.

3 Calliandra (*Calliandra calothyrsus*) as fodder in Central Kenya. Franzel et al. (1999) examined 'the early stages of adoption of *Calliandra calothyrsus*, a leguminous fodder tree, among smallholder dairy producers in the highlands of Central Kenya.' Calliandra was introduced to farmers through on-farm trials and, later, through a dairy development project. A random sample of 45 of these 83 farmers was interviewed in 1995. At least two years had passed for all farmers since they had received the seedlings. About one third of the farmers continued to participate in trials and had regular contact with researchers until the time of the survey. Total adoption was estimated to be 2037 farmers in 1999 (Roothaert 2000).

4 Improved fallows and green manures in Rwanda. Various projects invested much in the development and dissemination of improved fallow and green manure technology in Rwanda in the 1980s and early 1990s. The work of several projects was reviewed by Drechsel et al. (1996).

5 *Stylosanthes* for fodder and soil improvement in West Africa. *Stylosanthes* spp. (especially *S. guianensis* and *S. hamata*) have been adopted in sub-humid West Africa, especially in Nigeria and, to a lesser extent, in Cameroon, Cote d'Ivoire and Mali (Tarawali et al. 1997). In Nigeria, stylosanthes fodder banks were adopted for strategic feeding of cattle during the dry season. Some 27 000 adopters, with 19 000 ha, have been identified (Elbasha et al. 1999), with an internal rate of return of 38% on the research investment.

6 Tephrosia (*Tephrosia vogellii*) in eastern Uganda. Farmers in eastern Uganda identified mole rats (*Tachyoretes splendens*) as a priority problem. Researchers suggested that farmers experiment with *T. vogellii* as a means of repelling mole rats from their fields. Several farmers collected seed and experimented. After six seasons, researchers and farmers assessed the results and were convinced of the effectiveness of tephrosia. The pest management practice has been promoted through the media and providing input stockists with posters and packets of seed which they sell to farmers. Adoption has not been formally assessed, but scattered plants of tephrosia in farmers' fields are now often observed in the target areas.

7 Best-bet niche options for soil-improving legumes in central and eastern Uganda. Seven promising legume options are promoted by extension-oriented partners and farmer-to-farmer, mainly through farmer-groups visiting farmers involved in research on green manures and cover crops. Leaflets have been distributed, as well as farmer-experimentation mini-kits through development projects. Preliminary adoption was assessed, but effectiveness of dissemination efforts has not been formally assessed. However, the rate of adoption appears to be slow.

8 Lablab (*Lablab purpureus*) in the Kitale district, western Kenya. Relay intercropping of lablab with maize is being investigated with farmers and appears promising. The lablab is sown two to three months before maize harvest and continues to grow for four to five months after the maize is harvested, utilizing moisture from the late rains and residual soil water. Farmers selected lablab over mucuna as the leaves and grain are edible and it has an erect growth habit.

We also refer to the Central American case of adoption of the *abonera* system, a mucuna cover crop system used by farmers on hillsides in Honduras (Buckles et al. 1998).

Biophysical conditions

Variability in agronomic effectiveness

A legume practice must be effective for its niche, whether the purpose is to improve soil productivity, suppress weeds, yield a valued product, or any other purpose. However, if the results are highly variable, the practice is not likely to be attractive to farmers. Inconsistent results were seen as a major cause of farmer rejection of green manure and fallow alternatives in Rwanda.

Rainfall season

Length of growing season and amount and reliability of rainfall are determinants of boundary considerations. Mucuna in Benin was more preferred in the humid south than the drier north, and adoption was most likely to occur where the growing season was seven months or more. The relay intercrop of lablab with maize at Kitale, Kenya, requires a long rain season as the legume makes much of its growth after the maize harvest. An important consideration in central and eastern Uganda where bimodal rainfall allows two cropping seasons per year is that mucuna and canavalia (*Canavalia ensiformis*) can mature and set seed in one season. Excess rainfall early in the season was judged to be a problem in the use of high-quality green manure in Rwanda, as much nitrogen and potassium were lost to leaching. Legumes may deplete soil water and induce water deficits, with a negative effect on the survival and performance of a subsequent crop (Gachene et al. 1997).

Soil fertility level

Low soil fertility may favour greater use of legumes, but legume performance may be poor on soils which are acidic or have low phosphorus concentrations. Low soil fertility appeared to favour adoption of mucuna in Benin. The effectiveness of green manures and improved fallows was reduced on low phosphorus soils in Uganda and Zambia. Stylosanthes, however, has been competitive with other plant species under conditions of low soil phosphorus. In Rwanda, farmers preferred to put improved fallows on marginal or degraded lands, and to use better land for crop production. In Zambia, the sesbania and tephrosia fallows were less suited to shallow soils because of severe water deficits, and, on sandy soils, due to increased infection by rootknot nematodes.

Weeding requirements

Some legumes grow vigorously and compete well with weeds. Suppression of *Imperata cylindrica* was the primary reason for farmers to adopt mucuna in Benin; adoption was more likely if more than two weedings were required to produce a food crop. Ugandan farmers also appreciate mucuna for weed suppression, as less tillage and weeding are needed following a good crop of mucuna. Strica infestation (*Strica hermontheca*) was reduced by mucuna and *Crotalaria ochroleuca* in the South Nyanza district of Kenya; more farmers have adopted Crotalaria than mucuna, as Crotalaria is a vegetable crop in this area (C.W. Onyango pers. comm. 1999).

Non-competitive legume species may be rejected as weed management may be too costly to justify the practice. *Imperata cylindrica* and *Sida acuta* can invade *Stylosanthes* pastures and suppress the legume.

Cropping system

Proper integration of a legume into existing cropping systems is essential. Relay intercropping of lablab in Kitale is promising; late-sown lablab does not suppress maize yields and it occupies otherwise idle land during the dry season. Intercrop production of mucuna was preferred by farmers in the more humid southern Benin, while farmers in the drier north preferred mucuna as a sole crop. The presence of palm trees in the field was a negative determinant of mucuna adoption in Benin as the mucuna suppressed the young plants. In Zambia, most farmers establish their tree fallows in pure stand, but some prefer to intercrop with maize. Ugandan dairy farmers sow mucuna at low density to produce fodder.

Availability of tools

Farmers in Rwanda complained of inadequate tools for handling green manures and improved fallows. Kitale farmers preferred lablab as mucuna vines become tangled in ox-drawn ploughs, while lablab was more easily incorporated.

Livestock

Intensification of livestock production can drive the demand for more legume production. Nearly all adopters of calliandra in Central Kenya owned dairy cows. Mucuna is finding a place with smallholder dairy farmers in eastern Uganda.

Pests

Legume pest problems have not been much mentioned in the studies. Mesoplatys beetle as a pest of sesbania in Zambia is of concern. Nematode infection of tephrosia and sesbania, and of the subsequent crops, was a concern on sandy soils in Zambia, and increased *Meloidogyne* rootknot nematode infection of susceptible crops occurs near, and following, sesbania and tephrosia in Uganda. Anthracnose resistance in stylosanthes was essential to its success in West Africa.

Socio-economic conditions

Farmer profiles

In Zambia, well-established farmers were most likely to test improved fallows. Single women (unmarried, widowed, divorced) were more likely to test fallows than married women as 'married women lacked the authority to plant improved fallows without their husbands' consent'. Poorer farmers were less likely to try improved fallows, but poorer single female testers of fallows were more likely to continue with improved fallows than other testers. However, female testers were generally less likely to adopt than male testers. Owners of oxen were more likely to try fallows, but testers dependent on hoe cultivation were more likely to adopt. Club members were likely testers. Farmers with off-farm income were less likely to adopt. Farmers planted improved fallows primarily to restore fertility.

The farmers interviewed in Central Kenya about adoption of calliandra were mostly from male-headed households, generally middle-aged, and over half were judged to be 'high-income farmers', while 7% were 'low income'. They were considered to be more oriented to dairy production than typical farmers. Among the farmers interviewed, however, adoption of calliandra was not associated with farm size, wealth, nor number of cows. Young farmers were more likely to adopt than older farmers.

Age, level of education and sex were not significant determinants of adoption of mucuna in Benin.

Farmers' perceptions, needs and knowledge of legume technology

Farmers may have little interest in legumes if they do not know the potential of legumes, or if low soil fertility or poor animal nutrition are of low priority. It may be that 'most farmers seem to consider the lack of fertiliser a more serious problem than soil fertility itself.' (Evans et al. 1999).

In eastern Zambia, most farmers use fertilisers, as did farmers in Kitale and Central Kenya when fertiliser prices were lower, indicating their concern with low soil fertility. Ugandan farmers often rate low soil fertility as a constraint of low importance, and may not be prime candidates for soil-improving legumes; however, perceptions have changed in recent years.

African smallholder farmers generally lack a tradition of producing a crop for use by livestock, and the value of animals is perceived more in terms of numbers rather than their productive potential (Thomas and Sumberg 1995). Views of farmers practicing intensive management of livestock are different and planting of napier grass for cut-and-carry feeding is common, but planting of legumes is uncommon.

Legume technology may be knowledge-intensive, whether for soil management or improving livestock rations. Farmers are generally unaware of the potential soil-improving effect and nitrogen contribution of soil-improving legumes; improved understanding of potential benefits associated with legumes may increase adoption, but the importance of this was not clear from the studies.

Security of land tenure/ownership

Farmers are more likely to improve their own land than when tenure is insecure. Security of land tenure or ownership was a positive determinant of mucuna in Benin, as it was in Honduras, and it is likely to be important for any investment where the major benefits are not gained in the first season.

Farm size

Green manures and improved fallows may be inappropriate when farms are small. Adoption of mucuna decreased in Benin as amount of fallow land increased, as natural fallow was perceived to be a less costly means of reducing weeds and restoring soil fertility. In Honduras, farm size was not a determinant, but amount of crop land and access to rented cropland during the first season (i.e. opportunity cost of crop land) were significant determinants. The mean land area owned by farmers who had dairy cows and planted calliandra in Central Kenya was above average; however, within the sample of farmers, farm size was not related to adoption. Acute land shortage was a disincentive to adoption of improved fallows in Rwanda and Benin, where farmers preferred to use the land to produce traditional crops, accepting the low production. Rwandan farmers were most likely to plant improved fallows on marginal and relatively degraded land. Amount of grazing land was negatively related to adoption of abonera, reflecting a conflict between livestock and crop production. The improved fallow option in Zambia, however, is favoured by having more land available as the land is out of crop production for two years.

Management requirements

Some legume options may require new skills and/or high standards of management to be successful; improper implementation can cause poor to disastrous results. Establishment of sesbania and tephrosia in Zambia was generally better for farmers who received training. Inexpensive expansion of calliandra in Central Kenya will require the seedlings to be produced in the community. Proper handling of calliandra fodder is important to minimise the effects of polyphenols on digestibility. Intercropping mucuna can be detrimental to the associated maize if not properly managed.

Labour demand

Timing of labour demand may be more important than total labour demand. Critical labour peaks commonly occur at the time of planting and weeding food crops. If the legume requires much labour at peak times of farm activities, labour demand may be a major disincentive. However, labour required for transplanting sesbania and weeding improved fallows apparently did not prevent farmers from testing the fallows in Zambia, but it may be important in limiting the area a farmer allocates to the practice. In central Uganda, farmers found the labour requirements of *Crotalaria ochroleuca* to be too high, but many thought that net labour savings occur with mucuna due to suppression of weeds. Relay intercropping of lablab with maize in Kitale conflicts with planting of the second bean crop, but this may not be important as lablab is a partial substitute for beans. Labour availability per household was not a determinant in adoption of *abonera*, a labour-saving practice which may have benefited labour-scarce and labour-abundant families similarly. Adoption of stylosanthes pastures was constrained by reduced labour availability. The opportunity cost of labour has increased in many communities with the increased incidence of AIDS.

Risk

Rwanda farmers found performance of green manure species and the residual effects to be highly variable, and therefore too risky. In Zambia, however, farmers found less risk with improved fallow that with fertiliser use; the loss associated with failed establishment of the fallow was less than if fertiliser was applied and the crop failed to respond. Uncontrolled burning, and grazing by livestock owned by others, can greatly increase the risk of using soil-improving and fodder legumes. In West Africa, some farmers found the investment in stylosanthes too risky unless they were able to establish firebreaks. Successful adopters of stylosanthes had to fence their pasture to protect their fodder banks from uncontrolled grazing. In Zambia, sesbania and tephrosia were preferred to pigeon pea (*Cajanus cajan*), which was more likely to be consumed by other people's cows during the dry season; in the more recent study, however, uncontrolled grazing was not a significant constraint. Uncontrolled dry-season grazing is perceived to be an obstacle to adoption of legume cover crops in Kitale.

Products, by-products and other benefits

Resource-poor farmers need to earn early and high returns on their investments while benefits from green manures, improved fallows and trees for fodder production are late to be achieved and often insufficient to justify the practice. Farmers in Rwanda appreciated the firewood and stakes produced in improved fallow on marginal lands. Zambian farmers found wood from larger sesbania trees to be suitable for firewood, but considered that from smaller trees and tephrosia only to be suitable for tinder. Improved soil fertility and weed suppression were complementary benefits gained by farmers with mucuna in Benin. Fine-tuning of the use of tephrosia as an insecticide would add value to tephrosia fallows.

Seed sales often drive early adoption of new legume species, giving farmers some returns while they integrate the legume into their systems. The NGO Sasakawa Global 2000 bought much seed from farmers in Benin to be used to promote the mucuna technology more widely. At the time of the adoption study, the effect of this on adoption could not be assessed. In Tanzania, adoption of *Crotalaria ochroleuca* increased when there was a demand for seed, but most farmers discontinued use of crotalaria when demand for seed diminished (C.K.K. Gachene pers. comm. 1999). Demand for soybean to supply food relief to Mozambique stimulated production of the Magoye soybean, a promiscuously nodulating variety with low nitrogen harvest index; sowing of Magoye soybean declined when the demand for grain declined (R.A. Gilbert, pers. comm. 1999).

The maize-lablab system in Kitale is preferred to growing other legume species with maize as the leaves and grain of lablab are known foods in Kenya.

A simple process for reducing L-dopa in mucuna seed to levels well below toxicity is now available, giving added market value to mucuna seed. While unpalatability of mucuna seed, lack of a market for mucuna products, and the fodder value of the leaves apparently were not significant determinants of adoption in Benin, Vissoh et al. (1998) suggested that 'adoption is likely to be stimulated by new markets for mucuna seeds.'

Intensive livestock management is increasing in Africa and therefore stimulating demand for nutritious feeds and farmer interest in legumes. Unfortunately, if the leaves and grain are consumed, the legumes will not result in significant addition of nitrogen to the system.

Costs of inputs and commodity prices

High costs of fertilisers, herbicides and processed dairy rations may make some legume options more attractive. Feeding of calliandra leaves was profitable compared to the full supplementation of the dairy cows' diet with purchased rations. Returns to labour were similar for continuous maize with fertilizer applied and for the improved fallow-maize system in Zambia at the time of the study. An increase in fertiliser price would make the fallow system more profitable, while an increase in maize price would favour profitability of continuous fertilised maize (even so, most testers of fallows in Zambia said they would continue with improved fallows even if fertiliser prices were less). In most countries in sub-Saharan Africa, little fertiliser is used in any case, and an increase in price is not expected to result in increased adoption of green manure or improved fallow practices.

Institutional conditions

Good institutional support came out in several of the studies as an important determinant of adoption. According to Peterson (1999) 'the success of the program in the four target villages (in Zambia) is the result of over five years of intensive on-farm research and dissemination efforts.' Coordination of promotional activities of development agencies active in the area was important in Benin and in Zambia. Supply of planting material and advice were important to adoption of improved fallows in Zambia, and calliandra in Central Kenya. Availability of extension services was a significant determinant in Benin. EAT (Environmental Action Team) has facilitated farmer experimentation and farmer-to-farmer exchange visits for the lablab technology. In Rwanda, however, strong institutional support was not sufficient to override other constraints to the adoption of green manure and improved fallow technology.

The time frame and cost of research/extension for soil-improving and forage technology are significant due to the technical complexity, farmers' experience and low knowledge base with such technology and the need to target well-defined niches. Many donors and organisations are unwilling to make such commitments and prefer efforts with early exit strategies, confident that there are quick-fix solutions to Africa's problems of agricultural production.

Coordination of institutional support may be hindered. Government extension staff may be allowed to promote only officially-sanctioned messages. The findings of a NGO and its collaborating farmers may not get such recognition. Competition among potential development partners is intense for scarce funding and for recognition.

The cited studies do not give much insight to the farmers' role in the technology adaptation and diffusion process, and when it can proceed without institutional support. Peterson (1999) recommends that Zambian farmers be supported during the adoption phase for trouble-shooting and brainstorming improved fallow technology. More support may be needed with tree-planting options, especially if farmers have had little experience in planting trees and less in raising seedlings.

Identifying Niches for Legume Technology

Early adoption of agronomically sound legume technology requires that it be targeted within well-defined boundary conditions. The experiences gained in the above studies suggest the conditions to consider:

1. Farmers must perceive low soil fertility or poor animal nutrition as problems which can be addressed with legumes.
2. The most appropriate opportunities for integration of the legume into the farming system need to be determined. The legume can be extended to less promising options once early adoption has been achieved.
3. Farmers need an early return on their investment, and multiple-purpose legumes are likely to be more readily adopted.
4. Farmers with relevant tools and skills may adopt more easily.
5. More capable managers might be targeted when much management is required.
6. Male farmers, married couples and single women have been the most likely adopters of new legume options.
7. Middle-aged, established farmers have been the most likely to adopt.
8. Security of tenure was important to adoption.
9. Land-poor farmers were not likely to adopt.
10. Farmers with relatively more fallow land may be less likely to adopt soil-improving legumes.
11. Forage legumes need to be targeted to small-holder farmers who intensively manage livestock.
12. Farmers with more labour available might be targeted initially to achieve early success, but later adoption may not be much affected by labour availability.
13. Risk-prone farmers may be less likely to test and adopt.
14. Farmers were more likely to adopt if input costs were high.
15. Institutional support was needed to achieve significant adoption.
16. Farmers may be most responsive to testing on high-value crops (Franzel et al. 1998).

Dissemination, Farmer Adaptation and Diffusion of Legume Technology

Institutional support is important to adoption of soil-improving and fodder legumes, but the capacity for such support is little, relative to the task of reaching the millions of smallholder farm families in Africa. A challenge is to enhance the farmers' role in the dissemination and adaptation process. This requires consideration of farmers' major sources of information, their means of fine-tuning technology to their situation, and means of enhancing these processes.

Farmers' sources of information

In western Kenya, farmers said their major sources of information were the government extension service, their own experience (gained through observation, reasoning and experimentation), relatives and schools (Anon. 1999). Neighbours as sources of information were mentioned only one third as often as government extension; information obtained from neighbours was primarily through observation rather than through communication. In southwest Uganda, farmers frequently attributed adoption to copying from their neighbours (Munro 1998); observation of neighbours' practices apparently was important, but communication between neighbours was not important to adoption. In the Central Kenya study, 58% of the calliandra farmers had not visited another farmer with calliandra, and only 34% had visited on their own initiative (Franzel et al. 1999)! Farmers working with EAT normally do not share much information within communities unless the NGO intervenes to organise farmer field days. However, they eagerly share information with farmers from other communities. The Kenya farmers do get information from the radio; 'my neighbour is more likely to believe what he hears on the radio than he is to believe me.'

Farmers in Kenya reported that different sources emphasised different messages. Government extension emphasised animal health care, soil conservation and fertiliser applied to maize; NGOs were seen as sources of information on agroforestry. Church groups emphasised food crops and intercropping.

Diffusion of seed

Successful diffusion of legumes requires diffusion of seed. In Kenya, 33% of the calliandra farmers gave seed to a median of four farmers; however, two farmers gave seed to many farmers. In Uganda, a similar trend occurred among farmers involved in research on soil-improving legumes, where the median for 88% of the farmers was four recipients, but 12% gave to more than 20 farmers (Wortmann et al. 1998). In Uganda and Rwanda, as well, a few farmers provided bean seed to many farmers while most gave to none or a few (Sperling 1994; David et al. 1997). Farmers readily buy seed at premium prices if they are convinced of its value. Enterprising Kitale farmers carry seed to sell on farmer-to-farmer tours.

Farmer adaptation of technology for their systems

Most farmers are not inclined to experiment; rather they use a new practice assuming it is better than their current practice, either based on their observation of a neighbour's experience or because they are convinced by advocates of the practice. The more observant of these farmers learn from the experience and some will use the information to fine-tune the practice to their conditions. On the other hand, a minority of farmers do much experimentation; they seek and accept new things with skepticism. They then apply the practice with the intent of testing it, and eventually adapting it for their farming systems. The extent to which the experimenting farmers are early adopters has not been evaluated, but significant overlap of these two categorical classes is expected.

Improving institutional support to technology dissemination

Institutional support apparently is needed to facilitate the flow of information to and among farmers, assist them to adapt practices, and enable feedback to research on constraints and opportunities to accelerate the adoption process elsewhere. However, resources available for this task are scarce relative to the magnitude of the task. We must be aware of obstacles to farmer-to-farmer diffusion, as well as farmer adaptation, of technology, possibly including the difficulties in sharing information and seeds among neighbours, and that most farmers may not be inclined to experiment for the adaptation of new practices.

There are likely to be opportunities, however, as a few farmers are inclined to disseminate seed, and possibly information, to many farmers. Also, some farmers are very active in seeking information, testing and adaptation. The extent of overlap between disseminators of seed and information and farmer experimenters has not been studied. If there is much overlap, and there probably is, there may be opportunity efficiently to provide institutional support to these rather special farmers, possibly by bringing them into an extension network with similar farmers. These experimenting and disseminating farmers would then have major roles in the disseminating of technology, its adaptation to local farming systems, and in farmer-to-farmer diffusion.

This type of extension network would be different from, and should not be confused with, participatory research approaches for technology development and verification. If this is done with the intent of developing varieties and technology options for the larger agro-ecological zone, the investment of more of the scarce resources available to strengthen institutional support may be justified. Such participatory research efforts are often community based, and numerous farmers, preferably with their spouses, should be involved in the research to obtain input which represents the human as well as bio-physical diversity in the community. Through the process, more farmers are expected to become more inclined to experimentation and the skills of the natural experimenters will improve.

Other considerations for providing institutional support to technology adoption might be considered. Working with farmer groups may improve efficiency, as with the production of calliandra seedlings in Kenya. Placement of fields by farmer experimenters and early adopters may be important, considering that farmers do observe and copy from their neighbours. Farmers' willingness to exchange information with farmers from other communities, and the willingness of farmers to listen to other farmers living in another community, is worth consideration.

We do not attempt to draw conclusions. The information provided is intended for application to efforts to achieve adoption of soil-improving and forage legume technology. The factors which will be important in identifying species-niche opportunities and in providing institutional support will differ with the technology, resource availability and farmers' situation.

References

Anon. 1999. Pathways of information dissemination in Vihiga and Busia Districts in Western Kenya. Swift, M.J. ed. TSBF Annual Report. Nairobi, Kenya.

Buckles, D., Triomphe, B. and Sain, G. 1998. Cover Crops in Hillside Agriculture: Farmer innovation with *Mucuna*. Ottawa, Canada, International Maize and Wheat Improvement Centre and International Development Research Centre.

David, S., Wortmann, C. Kasozi, S. and Mugisha-Mutetikka, M. 1997. Using trial follow-up surveys to assess varietal adoption: the case of beans. African Crop Science Journal 5(3): 285–294.

Drechsel, P., Steiner, K.G. and Hagedorn, F. 1996. A review on the potential of improved fallows and green manure in Rwanda. Agroforestry Systems, 33: 109–136.

Elbasha, E.H., Thornton, P.K. and Tarawali, G. 1999. An ex-post economic assessment of fodder banks in West Africa. ILRI Impact Assessment Series No. 2. Nairobi, Kenya, International Livestock Research Institute, ISBN 92 9146 049 4.

Evans, J., Banda, A. and Seymour, T. 1999. Opportunities for better soil management. Draft final report. A study supported by the European Union, DfID, DANIDA and USAID.

Franzel, S., Arimi, H., Murithi, F. and Karanja, J. 1999. *Calliandra calothyrsus*: Assessing the early stages of adoption of a fodder tree in the highlands of central Kenya. In: Franzel, S. and Scherr, S. ed. Trees and Farmers: Assessing the Adoption Potential of Agroforestry Practices in Africa. Agroforestry Research Network for Africa Report No. 127. Nairobi, ICRAF.

Franzel, S., Coe, R., Cooper, P., Place, F. and Scherr, S.J. 1998. Assessing the adoption potential of agroforestry practices: ICRAF's experiences in subSaharan Africa. International Symposium of the Association for Farming Systems Research-Extension. 29/11/98–4/12/98, Pretoria, South Africa.

Franzel, S., Phiri, D. and Kwesiga, F. 1999. Assessing the adoption potential of improved fallows in Eastern Zambia. AFRENA Report No. 24. In: Franzel, S. and Scherr, S. ed. Trees and Farmers: Assessing the Adoption Potential of Agroforestry Practices in Africa. Agroforestry Research Network for Africa Report No. 127. Nairobi: ICRAF.

Gachene, C.K.K., Makau, M. and Haru, R. 1997. Soil moisture extraction of different legume crops. Presented at the Soil Management Project Conference held at Kanami, Mombasa, Kenya, 23–28 March 1997.

Manyong, V.M., Houndekon, A.V., Gogan, A., Versteeg, M.N. and van der Pol, F. 1996. Determinants of adoption for a resource management technology: the case of *Mucuna* in Benin Republic. In: Zhang Senwen and Wang Yunlong. Advances in Agricultural and Biological Environment Engineering. Proceedings of a Conference (ICABE), Beijing, 15–19 August 1996, Beijing, China, China Agricultural University Press, I–86 to I–93.

Munro, J. 1998. Development communication: the appropriateness and effectiveness of theatre as agricultural extension tool. MSc Thesis, University of Guelph, Canada.

Peterson, J.S. 1999. Kubweleza Nthaka: ethnographic decision trees and improved fallows in the Eastern Province of Zambia. For the University of Florida Gender and Soil Fertility in Africa Collaborative Research Support Program (CRSP) and the International Center for Research on Agroforestry (ICRAF), April 1999.

Roothaert, R. 2000. Development of fodder tree technologies through participatory research: experiences from Central Kenya. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Sperling, L. 1994. Analysis of bean seed channels in the Great Lakes Region: South Kivu, Zaire, Southern Rwanda, and selected bean growing areas of Burundi. CIAT African Occasional Publication Series, No. 13, CIAT/RESAPAC, Butare, Rwanda.

Tarawali, G., Dembele, E., N'Guessan, B. and Youri, A. 1997. The use of *Stylosanthes* by smallholder farmers for sustainable food production in sub-humid West Africa. International Workshop on Green Manure Cover Crops systems for Smallholders in Tropical and sub Tropical Regions, Chapeco, Brazil, 6–12 April 1997.

Thomas, D. and Sumberg, J. 1995. A review of the evaluation and use of tropical forage legumes in Sub-Saharan Africa. Agriculture, Ecosystems and the Environment, 54: 151–163.

Versteeg, M.N., Amadji, F., Eteka, A., Gogan, A. and Koudokpon, V. 1998. Farmers' adoptability of Mucuna fallowing and agroforestry technologies in the Coastal Savanna of Benin. Agricultural Systems, 56: 269–287.

Vissoh, P.V., Manyong, V.M., Carsky, R.J., Osei-Bonsu, P. and Galiba, M. 1998. Green manure cover crop systems in West Africa: Experiences with Mucuna. In: Buckles, D., Eteka, A., Osiname, O., Galiba, M. and Galiano, G. Green Manure Cover Crops and Sustainable Agriculture in West Africa., Ottawa, Canada, IDRC, 1–32.

Wortmann, C.S., Kaizzi, C.K. and Fischler, M. 1999. Farmers' experimentation on green manure/cover crops: A component of participatory research for improvement of Ugandan farming systems. In: Fujisaka, S. ed. Systems and Farmer ParticipaOtory Research: Developments in Natural Resource Management, Cali, Colombia, CIAT, 118–127.

Stylo 184 as a Protein Source in Rice Straw-based Rations for Sheep

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THE SUPPLEMENTATION of concentrate to poor quality basal rations effectively improves animal production. However, this feeding strategy entails costs because concentrates are expensive. An alternative for smallholder livestock production systems may be the use of a combination of forage legumes instead of commercial concentrates. This could be considerably cheaper in smallholder situations.

It has been suggested that combining a tannin-rich legume with a legume with a high N solubility could improve N retention (Barry and Manley 1984; Poppi and Norton 1995). Condensed tannins in forages form a complex with protein that is resistant to microbial degradation in the rumen, but soluble in the acid medium in the small intestine (Kumar and D'Mello 1995). This can increase animal production but not necessarily feed intake.

Two legumes which might be suitable for this purpose are *Stylosanthes guianensis* CIAT 184 (Stylo 184 – high N solubility) and *Flemingia macrophylla* (flemingia – containing tannin).

Stylo 184 is used extensively in smallholder farming systems. It is a semi-erect herb which can be used for cut-and-carry feeding systems as well as for grazing. Its dry matter production is high and it contains considerable amount of crude protein (19%), making it a possible source of by-pass protein for animals. Its N solubility ranges from 38% to 45% and its in vitro dry matter digestibility (IVDMD) is approximately 51%. Flemingia is a leguminous tropical shrub which contains medium levels of tannin (8.7% TAE), and has a crude protein content of 22%. It can grow in infertile, acid soils and remains productive even during dry periods of the year.

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Materials and Methods

Eighteen growing sheep, each weighing about 12 kg, were blocked according to liveweight and randomly distributed to three dietary treatments in a randomised complete block design as follows:

Treatment 1: 50% rice straw (RS) + 50% concentrate (C);
Treatment 2: 50% RS + 50% Stylo 184 (S);
Treatment 3: 50% RS + 40% S + 10% flemingia (F).

A 7-day digestion trial was conducted during the middle part of the 60-day feeding trial. The proximate components of all samples were analysed using the procedures of AOAC (1975). Detergent fibre analysis was done following the procedure of Goering and Van Soest (1970). Intake and apparent digestibilities of proximate and cell wall components were computed. Digestible nutrients, total digestible nutrients (TDN) and nitrogen utilisation were determined. The body weight changes, rumen fermentation indicator and the economics of the feeding strategy were also determined.

Results and Discussion

Intake, digestibility and nitrogen utilisation

Daily Dry Matter Intake (DMI) varied little between treatments, ranging from 388 to 403 g. DMI expressed as percent of the body weight and in grams per kilogram of metabolic body size ranged from 3.0% to 3.05% of body weight and 57.0–57.4 g/kg $LW^{0.75}$, respectively. Crude protein intake values were similar in all animals.

Legume supplementation significantly improved the apparent digestibility of proximate and cell wall components of the rations, and values for digestible nutrients showed similar patterns to coefficients of apparent digestibility (data not presented). Total digestible nutrients (TDN) of the test rations ranged from 52.9–58.3%. These values were higher than the 40% TDN required for animals to maintain weight (Kearl 1982) and may explain the modest weight gain of all animals in spite of their seemingly low DMI.

Nitrogen utilisation

The N intakes, N balance and efficiency of N use varied only little between treatments, ranging from 8.6 to 8.8 g/d, 4.2 to 4.3 g/d and 48.2 to 49.5%, respectively. All animals had a positive N balance that led to weight gain (Table 1). This result agrees with other research. For example, Moran et al. (1983) reported that N retention of animals was improved by legume supplementation and Battad (1991) observed an increasing N balance in sheep supplemented with increasing levels of the legume Desmanthus virgatus. Similarly, Fassler and Lascano (1995) reported a slightly higher N retention in sheep supplemented with legume mixtures than those fed grass alone or supplemented with a single legume.

Average daily gain and feed efficiency

Sheep supplemented with concentrate (T-1) had significantly the highest liveweight gain (1.79 kg), average daily gain (30 g) and feed conversion efficiency (13.9) of any of the treatments (Table 1). The higher liveweight change and ADG of sheep of this treatment may be attributed to the higher DMI and quality of this ration.

The bulk of the feed and protein intake of sheep in rations T-2 and T-3 was derived from the legume component of the rations. Thus, the positive change in body weights of sheep in rations T-2 and T-3 reflected the legume's potential as a supplement to the low quality basal diet. The combination of legumes (Stylo 184 + flemingia) resulted in average daily gains intermediate between the other two treatments, but not significantly different from either. However, the results suggest that the tannin-containing legume flemingia may have had a small effect. Tannins in legumes form complexes with plant proteins, making them less degradable by the rumen microorganisms, and hence more available as bypass proteins for absorption in the lower digestive tract. Barry and Manley (1984) observed that when tannin-rich plants are used as a supplement (less than 25% of the ration DM) their inclusion in the ration may be beneficial.

The feed efficiency ranged from 13.9–26.2. The feed efficiency of ration T-3 was intermediate between the other two rations, but did not differ significantly from either.

Rumen fermentation indicators

The pH values (6.7–6.9) obtained before feeding were within the range of 6.4–7.0 which are considered favorable for microbial protein synthesis (Dixon 1986). A lowered rumen pH and increased total volatile fatty acid (TVFA) concentrations were observed 3 hr after feeding. TVFA productions of sheep supplemented with stylo alone (1.37 mmol/100 mL) or Stylo 184 + flemingia (1.47 mmol/100 mL) were slightly higher than those supplemented with concentrates (0.92 mmol/100 mL).

Economic Implications

Although concentrate feeding resulted in the highest liveweight gain, this came at considerable cost. In Los Baños, the cost of the concentrate mixture was Peso 6.80/kg. The cost of cutting, hauling and chopping of Stylo 184 was Peso 2.15/kg dry matter resulting in a feed cost per kg liveweight of Peso 39 compared with Peso 51 for concentrate feeding. If farmers are able to produce legumes cheaply on farms then legume supplementation is a viable alternative to concentrate feeding.

Conclusion

The results show the potential of Stylo 184 as a protein supplement in low-quality basal diets. There were some indications that this potential can be enhanced by including a small amount of a tannin-containing legume.

Table 1. Daily feed intake, liveweight change, average daily gain and feed efficiency of sheep fed a basal diet of rice straw and supplemented with concentrate or Stylo184 with or without Flemingia.

Feed ration	Daily feed intake (DM g/day)				Liveweight change (kg)[1]	Average daily gain (g)[1]	Feed efficiency[1,2]
	Rice straw	Concentrate	Stylo	Flemingia			
50% RS + 50% C	186.6	216.0	–	–	1.79[a]	30[a]	13.9[a]
50% RS + 50% S	76.3	–	309.5	–	1.07[b]	18[b]	26.2[b]
50% RS + 40% S + 10% F	75.3	–	248.9	63.8	1.22[b]	22[ab]	20.3[ab]

[1]Column means without a common superscript are significantly different ($P < 0.05$).
[2]Feed efficiency = g of feed/g of liveweight gain.

References

AOAC 1975. Official Methods of Analysis (12th ed.). Association of Official Agricultural Chemists. Washington, D.C.

Barry, T.N. and Manley, T.R. 1984. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. 2. Quantitative digestion of carbohydrates and proteins. British Journal of Nutrition, 51: 493–504.

Battad, Z.M. 1991. Yield and quality at different cutting intervals and feeding values of hedge lucerne (*Desmanthus virgatus*) for goats. PhD Thesis (unpublished). UPLB, College, Laguna, Philippines.

Dixon, R.M. 1986. Maximising the rate of fiber digestion in the rumen. In: Dixon, R.M. ed. Ruminant Feeding Systems Utilising Fibrous Agricultural Residues. Canberra, Australia, International Development Program of Australian Universities and Colleges Ltd. (IDP), 243 p.

Fassler, O.M. and Lascano, C.E. 1995. The effect of mixtures of sun-dried tropical shrub legumes on intake and nitrogen balance by sheep. Tropical Grasslands, 29: 92–96.

Goering, H.K. and Van Soest, P.J. 1970. Forage fibre analysis (apparatus, reagents, procedures and some application). Agricultural Research Service, USDA, Handbook No. 379. Washington, DC, USA.

Kearl, L.C. 1982. Nutrient requirements of ruminants in developing countries. International Feedstuff Institute, Utah Agricultural Experiment Station. Utah State University, Utah, USA.

Kumar, R. and D’Mello, J.P.F. 1995. Anti-nutritional factors in forage legumes. In: D’Mello, J.P.F. and Devendra, C. ed. Tropical Legumes in Animal Nutrition. Wallingford, UK, CAB International, 95–133.

Moran, J.B., Satoto, K.B. and Dawson, J.E. 1983. The utilisation of rice straw fed to Zebu cattle and swamp buffalo as influenced by alkali treatment and leucaena supplementation. Australian Journal of Agricultural Research, 34: 73–84.

Poppi, D.P. and Norton, B.W. 1995. Intake of tropical legumes. In: D’Mello, J.P.F. and Devendra, C. ed. Tropical Legumes in Animal Nutrition. Wallingford, UK, CAB International, 173–189.

Forages for Growing under Coconuts in Mindanao, the Philippines

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IN THE Philippines, coconuts tend to be grown in humid and sub-humid areas on soils with moderate to high fertility. Soil pH tends to be in slightly acid, neutral or alkaline. Cattle production under coconuts relies mostly on native vegetation. Considered by many as 'weeds', these natural covers are only able to support a low level of animal production.

Introduced forages which are considered to be adapted to growing under coconuts include the grasses *Brachiaria decumbens* cv. Basilisk, *B. dictyoneura* and *Setaria sphacelata*, the herbaceous legumes *Centrosema pubescens, Arachis pintoi* and *Desmodium heterophyllum*, and the shrub legumes *Desmodium cinerea* (previously known as *Desmodium rensonii*), *Calliandra calothyrsus*, *Leucaena leucocephala* and *Gliricidia sepium* (Reynolds 1995).

Generally, feeding systems for livestock involve grazing or cut-and-carry systems. Not all forage species are suited to both feeding systems, although some are persistent and productive when utilised in both feeding practices. Largely, this is dependent on the type of forage and its growth habit. Erect species like *Pennisetum purpureum* or *L. leucocephala* are adapted to cut-and-carry feeding; while low-growing species like *Arachis pintoi* are tolerant of heavy grazing. Intermediate species like *S. sphacelata* and *C. pubescens* can be used for both feeding systems but require careful management when grazed (Horne and Stür 1999).

Forages are also valuable as cover crops under coconuts. The Philippine Coconut Authority (PCA) has recommended three leguminous species for this purpose: *Pueraria phaseoloides*, *C. pubescens* and *Calopogonium muconoides* (Magat and Cadigal 1976). However, with the availability of new varieties through the Forages for Smallholders Project (FSP), there was an opportunity to screen and select new species under coconuts to give farmers more options to improve their farming systems and incomes.

The objectives of the four experiments reported in this paper were to determine productivity of selected forage species for different feeding systems under coconuts; to identify legumes as cover crops grown under coconuts; and to provide an initial screening of a newly acquired range of forage germplasm.

Experimental site

The four experiments were conducted at the Davao Research Center of the Philippine Coconut Authority at Bago-Oshiro, Davao City, Mindanao, Philippines from 1996 to 1999. All experiments were conducted within a 30-year old plantation with coconuts spaced at 8 m × 8 m with an average light transmission of 60–70%. The experimental area was fenced to prevent accidental grazing. Soils were slightly acidic, fertile and well drained. Annual rainfall was high in 1997 and below average in 1998 (Figure 1). In most years, rainfall is relatively well distributed but there was an exceptionally dry period from December 1997 to April 1998 during the experimental period.

Experiment 1 – Grazed Forage Mixtures

This experiment evaluated different options of forages (grass alone and grass-legume associations) for grazing cattle under coconuts.

Materials and methods

The seven treatments imposed are shown in Table 1. Each plot was laid out in a 6 m × 6 m plot within the 8 m × 8 m square of four standing coconuts. Treatments were replicated three times in a randomised complete block design. Where grasses were grown in association with legumes, the following legume mixture was used: *Arachis pintoi* 'Itacambira' (CIAT

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22160), *Desmodium heterophyllum* CIAT 349 and *Centrosema pubescens* 'Barinas' (CIAT 15160). Where plots included legumes, seed of *Brachiaria* and cuttings of *S. secundatum* and *S. sphacelata* were sown or planted in alternate rows with the legumes. The experiment was established in October 1996, missing plants were replanted and plots were cut back to 10 cm before the first measuring period.

The experimental area was grazed for periods of one week by two cattle, followed by a 45-day growth period. Immediately before each grazing, two 1 m × 1 m quadrats in each plot were harvested at a height of 10 cm for biomass determination.

Results and discussion

Mean yield over the experimental period is presented in Table 1. Only *Brachiaria decumbens* (with and without N) gave a significantly higher dry matter yield than that of the natural vegetation control. Both *Setaria sphacelata* 'Golden Timothy' plus legumes and *Brachiaria decumbens* plus legumes produced an approximately 50% higher yield than the natural vegetation control but the differences were not statistically significant.

Experiment 2 – Cover Crops

Eighteen forage legumes were evaluated for their potential to suppress weeds under coconuts (cover crops).

Materials and methods

The species used are listed in Table 2. Plots were 2 m × 4 m, arranged between rows of coconuts. Treatments were replicated three times in a randomised complete block design. Each species was sown in rows 25 cm apart in November 1996. Attributes were rated 30 days after planting and every 30 days thereafter. The plots were not grazed.

Results and discussion

Mean percentage ground cover increased to an average of c. 90% in November 1997, but after June 1998 started to decrease markedly, and thereafter

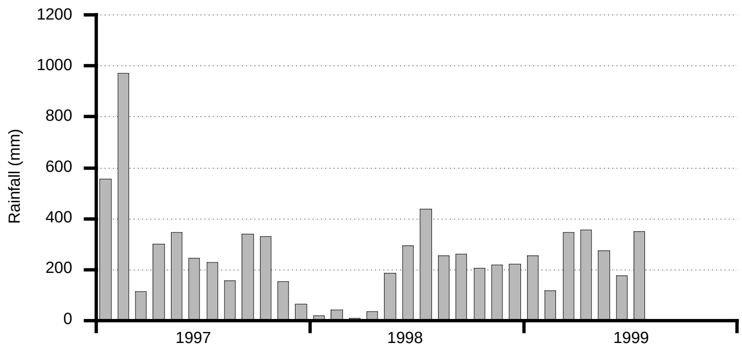

Figure 1. Monthly rainfall (mm) from 1997–1999 at Davao Research Center, Philippines.

Table 1. Mean dry matter on offer (t/ha/year).

Treatment	Accession or cultivar	N or legumes+	Mean yield (kg/ha/year)
1. Brachiaria decumbens	'Basilisk'	–	17.9 ab
2. Brachiaria decumbens	'Basilisk'	+N	24.0 a
3. Brachiaria decumbens	'Basilisk'	legumes	15.4 bc
4. Brachiaria humidicola	'Yanero'	legumes	11.9 c
5. Setaria sphacelata	'Golden Timothy'	legumes	14.8 bc
6. Stenotaphrum secundatum	'Floratam'	legumes	10.1 c
7. Natural vegetation		–	9.8 c
Statistical significance			**
Coefficient of variation (%)			17

+ Nitrogen application of 200 kg/ha/year N applied as urea in 8 split applications. Legume mixture consisted of *Arachis pintoi* 'Itacambira', *Desmodium heterophyllum* CIAT 349 and *Centrosema pubescens* 'Barinas'.

there were no statistically significant differences between accessions (Table 2). *Mucuna pruriens* established the most rapidly but by May 1997, seven accessions had close to 100% ground cover. *Pueraria phaseoloides* CIAT 7182 and 8042 established more rapidly than the local kudzu. The annuals *Centrosema pascuorum* and *Mucuna pruriens* grew well for the first wet season, but did not regenerate the following wet season. *Stylosanthes guianensis* CIAT 184 deteriorated after a slow recovery from the extreme dry season in 1998. *Arachis pintoi* spread fast under favorable conditions, but did not tolerate the competing weeds. If it is to be grown as a cover crop, it requires regular maintenance (or grazing).

Mean percentage leaf increased up to 85% in August 1997, decreasing to 50% in April 1999 (data not presented). For those accessions which survived for the whole experiment, the most leafy were, in order, *P. phaseoloides* local, *C. caeruleum* and *P. phaseoloides* CIAT 7182. The least leafy was *C. pubescens* local, which, on six of eight assessments, was significantly poorer than the most leafy accessions.

Another species comparable in ground cover to kudzu, *C. caeruleum* CIAT 7304, was the least affected during the El Niño months in 1998 (Table 2). In the dry month of January 1998 it had 98% ground cover with 87% leaf (data not presented) while the weeds had dried out (Table 2). This species could serve as an option to replace *C. mucunoides*, which had earlier been recommended by the Philippines Coconut Authority.

Centrosema pubescens had already been tested as a potential cover crop, but another species *C. macrocarpum* CIAT 25522 was noted as being comparable with the former. It was similar in ground cover, but was more leafy, due to its inherently larger leaves than *C. pubescens* CIAT 15160.

Experiment 3 – Cut-and-Carry Grasses

A range of grasses were grown to determine their suitability for use in a cut-and-carry forage system under coconuts. This experiment was intended to serve as demonstration for visiting farmers.

Materials and methods

Each species was laid out in two 8 m rows spaced 0.5 m apart between rows of coconuts. Half of each row was fertilised and the other was unfertilised. The experiment was not replicated and was not grazed. Rows were harvested at 45 day intervals and the cut material weighed fresh. A 50-30-50 kg/ha fertiliser mixture was applied to the fertilised treatments after each cut.

Table 2. Percentage ground cover of cover crops under coconut s at Davao Research Center.

Species	Accession or cv.	Jan–97	May–97	Aug–97	Nov–97	Jan–98	Jun–98	Oct–98	Jan–99	Apr–99
Arachis glabrata	*RFL 3112*	*2 [d]*	*37 [cd]*	*74 [a]*	*77 [b]*	*78*	*89 [abc]*	*80 [ab]*	*65*	*43*
Arachis pintoi	CIAT 22160	77 [a]	100 [a]	73 [a]	90 [ab]	90	90 [abc]	85 [ab]	71	62
Calopogonium caeruleum	CIAT 7304	40 [ab]	97 [a]	96 [a]	99 [a]	98	99 [a]	93 [a]	83	74
Calopogonium mucunoides	CIAT 17856	6 [cd]	77 [abc]	90 [a]	95 [ab]	88	–	–	–	–
Centrosema acutifolium	CIAT 5277	19 [abc]	77 [abc]	88 [a]	87 [ab]	87	92 [abc]	78 [ab]	68	53
Centrosema macrocarpum	CIAT 25522	21[abcd]	73 [abc]	90 [a]	93 [ab]	91	95 [ab]	85 [ab]	75	67
Centrosema ovalifolium	CIAT 13305	2 [d]	40 [cd]	70 [a]	93 [ab]	92	92 [abc]	94 [a]	85	80
Centrosema pascuorum	cv. Cavalcade	33 [abc]	73 [abc]	33 [bc]	77 [b]	–	–	–	–	–
Centrosema pubescens	local	–	27 [d]	23 [c]	86 [ab]	73	87 [abc]	65 [ab]	47	32
Centrosema pubescens	CIAT 15160	43 [ab]	98 [a]	97 [a]	93 [ab]	92	96 [ab]	89 [a]	82	70
Desmanthus virgatus	CPI 40071	7 [bcd]	47 [bcd]	69 [a]	84 [ab]	84	92 [abc]	94 [a]	88	83
Desmodium intortum	cv. Greenleaf	7 [bcd]	57 [abcd]	78 [a]	88 [ab]	87	77 [bc]	47 [b]	–	–
Macroptilium gracile	cv. Maldonado	27 [abc]	80 [abc]	63 [ab]	86 [ab]	85	72 [c]	58 [ab]	45	40
Mucuna pruriens	CIAT 9349	68 [a]	97 [a]	93 [a]	96 [ab]	70	–	–	–	–
Pueraria phasioloides	local	23 [abc]	90 [ab]	85 [a]	98 [ab]	99	98 [a]	97 [a]	94	89
Pueraria phasioloides	CIAT 7182	40 [ab]	100 [a]	96 [a]	99 [a]	99	93 [abc]	94 [a]	78	68
Pueraria phaseoloides	CIAT 8042	40 [ab]	100 [a]	98 [a]	97 [ab]	96	94 [ab]	73 [ab]	53	43
Stylosanthes guianensis	CIAT 184	27 [abc]	100 [a]	95 [a]	96 [ab]	79	88 [abc]	71[ab]	–	–
MEAN		28	76	79	91	87	90	80	72	62
Stat. Sig.		**	**	**	**	ns	**	**	ns	ns
%c.v.		22.1	19.5	14.5	7.6	11.5	7.8	16.7	8.0	10.5

Results and discussion

Averaged over all accessions and harvests, there was a 49% response to fertiliser, but this ranged from 21% to 99% in different harvest periods (Table 3). The local strain of *Pennisetum purpureum* consistently yielded more fresh herbage than other accessions when fertilised, whereas *P. purpureum* cv. Capricorn had the highest overall yield of fresh matter when unfertilised. Other grasses, such as *P. maximum* CIAT 6299, also demonstrated potential feed sources for cattle under coconuts.

The total fresh yields with a 45-day cutting interval do not take into account forage quality. The high yields of the *P. purpureum* varieties were largely associated with a high proportion of stem, and lower yielding but less stemmy varieties could be equally or more valuable as animal feed.

Experiment 4 – Cut-and-Carry Multi-Purpose Tree and Shrub Species

This experiment investigated the adaptation and yield of several tree and shrub legumes under coconuts.

Materials and methods

Accessions grown in the trial are listed in Table 4. Two-week old pre-germinated seedlings of each species were planted in single rows four metres long and three metres apart within rows of coconuts in October 1996. Plants were spaced at 25 cm spacing within the rows. The experiment was replicated three times in a randomised complete block design.

After a 6-month establishment period, five plants were harvested, to a cutting height of 50 cm for separation and all remaining plants in each row were

Table 3. Fresh herbage (kg/m^2) of forage grasses grown for a cut-&-carry system (data are presented for selected harvests only).

Species	Accession or cultivar	Fertiliser	Harvest date					Total
			20–8 1997	12–1 1998	15–7 1998	13–11 1998	19–5 1999	
Brachiaria brisantha	CIAT 6780	+	–	0.8	1.6	4.3	1.1	7.8
		–	–	0.6	1.7	3.4	1.4	7.1
Brachiaria brizantha	CIAT 16827	+	–	2.1	4.9	4.5	1.5	13.0
		–	–	1.0	3.5	1.2	1.1	6.8
Brachiaria brizantha	CIAT 26110	+	1.1	1.4	2.8	3.2	0.8	9.3
		–	1.0	1.0	2.0	4.6	1.0	9.6
Panicum maximum	T-58	+	–	2.0	4.9	3.7	3.1	13.7
		–	–	1.1	3.5	3.4	1.9	9.9
Panicum maximum	CIAT 6299	+	3.2	4.6	5.9	3.5	3.4	20.6
		–	1.2	1.4	5.3	1.4	1.5	10.8
Paspalum atratum	BRA 9610	+	3.2	3.8	3.5	1.2	1.9	13.6
		–	1.9	1.6	3.0	1.9	1.7	10.1
Pennisetum purpureum	local	+	8.6	5.4	5.5	4.8	3.2	27.5
		–	2.8	1.6	2.6	2.4	1.6	11.0
Pennisetum purpureum	cv. Capricorn	+	6.8	3.6	5.8	5.0	3.3	24.5
		–	6.1	3.0	4.4	4.9	3.5	21.9
Pennisetum purpureum	cv. Mott	+	5.4	2.0	0.2	3.8	1.4	12.8
		–	2.9	1.5	0.5	1.0	1.5	7.4
Pennisetum hybrid	‘Florida’	+	4.4	2.6	2.2	2.1	1.9	13.2
		–	2.7	1.6	3.2	2.3	1.0	10.8
Pennisetum hybrid	‘King’	+	4.6	4.0	2.0	2.7	2.1	15.4
		–	2.7	1.6	2.4	3.1	1.1	10.9
Setaria sphacelata	‘Golden Timothy’	+	4.8	2.4	4.2	3.4	3.1	17.9
		–	2.4	1.1	3.3	1.2	1.4	9.4
Setaria sphacelata	var. *splendida*	+	3.5	2.6	2.5	2.5	3.2	14.3
		–	2.5	1.6	2.6	1.8	2.2	10.7
Mean		+	4.6	2.9	3.5	3.4	2.3	15.7
		–	2.4	1.4	2.9	2.5	1.6	10.5
Response to fertiliser (%)			88	99	21	37	43	49

cut back to a similar height and cut material discarded. Similar harvests were taken at 90-day intervals but only selected harvests are presented here. The edible portion (leaves + green stem less than 6 mm diameter) of the five harvested plants was separated from the stem for dry matter yield determination. The samples were oven-dried for 72 hours at 80°C before weighing.

Results and discussion

There were no significant differences among the multi-purpose tree species 30 months after planting (Table 4). This was expected as the species which established more slowly, like the *Leucaena* species caught up with the other trees and shrubs.

In the established and following year, there were large differences in inedible stem production, with local *L. leucocephala* and *L. diversifolia* having lower stem yields than other species. These accessions also had significantly lower leaf yield in August 1998. Although *C. calothysus* produced double the quantity of edible dry matter in June 1999 that the least productive species did, differences were not statistically significant. Other versatile species which are good producers of both edible and inedible stem include *G. sepium* 'Retalhuleu' and *D. cinerea*.

Summary and Conclusion

A wide array of forage species was tested under 30-year old coconuts for different purposes: feeding systems and cover crops for suppressing weeds. These experiments yielded research results and served as a demonstration and source of planting materials for farmers raising their livestock under coconuts.

Fertilised *Brachiaria decumbens* cv. Basilisk yielded 24 t/ha/year of dry matter. This compared to less than 10 t/ha/year of the natural vegetation control. *Setaria sphacelata* with legumes and *Brachiaria decumbens* with legumes produced 50% more dry matter than the natural vegetation control but this difference was statistically not significant. Both *Brachiaria decumbens* and *Setaria sphacelata* appear to be suitable grasses for grazing under coconuts.

The local strain of *Pennisetum purpureum* was confirmed as a suitable species for growing under coconuts when fertilised, although without fertiliser, *P. purpureum* cv. Capricorn gave higher yields. However, *Panicum maximum* CIAT 6299 and T58 reached high herbage yields throughout the growing period of more than two years and are likely to be less stemmy and higher in quality. The tree legume with the highest yield of edible material in the third season was *Calliandra calothyrsus*, althougth at this stage, differences were not statistically significant. The local *L. leucocephala,* and *L. diversifolia,* were markedly poorer than other shrubs and trees tested. Other potential species both for stem and leaf production include *Gliricidia sepium* 'Retalhuleu' and *Desmodium cinerea*.

In the assessment of herbaceous legumes for cover cropping, the annual *Mucuna pruriens* was quickest to establish, but failed to regenerate the second year. Two years after sowing, there were no statistical differences in percentage ground cover, although highest values were obtained from the local strain of *Pueraria phaseoloides. Calopogonium caeruleum* could serve as an alternative covercrop, being particularly impressive during the El Niño months in 1998. *Centrosema pubescens* CIAT 15160 was confirmed as a strong option for cover cropping purposes, as well as *C. macrocarpum* CIAT 25522.

Table 4. Dry matter yield (g/plant) of multi-purpose tree species.

Species	Accession or cultivar	Leaf and edible stem (< 6 mm diameter)			Inedible stem		
		Aug 97	Aug 98	June 99	Aug 97	Aug 98	June 99
Calliandra calothyrsus	'Besakih'	136	124 [a]	478	176 [ab]	113 [a]	357
Desmodium cinerea	ex Davao	72	75 [ab]	327	319 [a]	94 [a]	437
Gliricidia. sepium	local	64	90 [ab]	310	139 [ab]	67 [ab]	226
Gliricidia. sepium	'Belen Rivas'	63	67 [ab]	262	137 [ab]	85 [ab]	288
Gliricidia. sepium	'Monterrico'	46	58 [ab]	257	52 [b]	46 [ab]	222
Gliricidia sepium	'Retalhuleu'	79	81 [ab]	347	138 [ab]	94 [a]	463
Leucaena. leucocephala	local	–	15 [c]	242	–	8 [c]	170
Leucaena. leucocephala	'K636'	–	33 [abc]	350	–	33 [ab]	467
Leucaena diversifolia	ex Davao	–	22 [bc]	230	–	24 [bc]	227
Stat. Significance		ns	**	ns	*	**	ns
c.v. (%)		9.5	13.4	4.7	13.3	11.9	7.3

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References

Horne, P.M. and Stür, W.W. 1999. Developing Forage Technologies with Smallholder Farmers – How to Select the Best Varieties to offer Farmers in Southeast Asia. ACIAR Monograph No 62. Canberra, Australia, 80 p.

Magat, S.S and Cadigal, V.L. 1976. Adaptability and Nutrient Uptake of Some Covercrops/Pasture Legumes in an Inland-Upland Coconut Area in Davao. ARB-PCA Annual Report 1975-76, 27–32.

Reynolds, S.G. 1995. Pasture-Cattle-Coconut Systems. Bangkok, Thailand, FAO-RAPA, 668 p.

Potential New *Brachiaria* Cultivars for the Seasonally Dry Tropics

G. Nakamanee[1] and C. Phaikaew[2]

THE MAJORITY of cattle and buffalo in Thailand are located in the northeast region, where feed shortages during the six-month long dry season are a major concern of farmers.

To ease this problem, Thai research organisations have been developing improved forage systems, with the result that Ruzi grass (*Brachiaria ruziziensis*) has become widespread, primarily because of its high seed yields and ease of establishment. Ruzi is, however, poorly adapted to areas with long dry seasons. *Brachiaria decumbens* cv. Basilisk has been identified as having better dry season growth than Ruzi but its use in Thailand is limited by very low seed yields and poor seed quality.

Materials and Methods

An experiment was started in 1996 at Pakchong Animal Nutrition Research Centre, Nakornratchasima, to evaluate new *Brachiaria* spp. as alternatives to *B. ruziziensis* in areas with a long dry season. The first goal of the experiment was to screen the accessions for seed production potential. Once accessions with promising seed yields had been identified, the second goal was to assess their dry season yield potential.

Thirty one accessions of *Brachiaria* from four species (*B. brizantha, B. decumbens, B. humidicola*, and *B. jubata*) were established together with *B. ruziziensis* and *B. decumbens* cv. Basilisk as controls. The plots measured 1.6 × 1.6 m and were arranged in a randomized complete block design with 3 replications (Experiment 1). In 1998, 18 additional accessions from three species (*B. brizantha, B. decumbens and B. humidicola*) were introduced in an identical parallel experiment (Experiment 2).

Table 1. The most promising new Brachiarias from the original 31 accessions (Experiment 1).

Accession	Relative pure seed yield[1]		Germ (%)	Relative dry matter yield[1]	
	1997[2]	1998[2]	Mean	1997[3]	1999[4]
Brachiaria brizantha					
CIAT 6387	55	35	51	138	190
CIAT 6780	41	50	51	98	183
CIAT16463	26	31	52	115	235
CIAT 16779	47	28	52	90	161
CIAT 16827	52	45	66	45	200
CIAT 16829	48	49	56	88	120
CIAT 16835	100	64	70	88	181
Controls					
B. decumbens cv. Basilisk	3	8	65	163	156
Brachiaria ruziziensis	100	100	76	100	100

[1]Relative yields are expressed as percentages of yields from *B. ruziziensis.*

[2]Pure seed yields of *B. ruzizensis* averaged 9.6 and 25.4 grams per plot in 1997 and 1998.

[3]Dry matter yields for 1997 are from 3 harvests over 114 days in the dry season (total rainfall 303 mm). Yields of *B. ruziziensis* averaged 168 grams per plot.

[4]Dry matter yields for 1999 are from 3 harvests over 133 days at the start of the wet season (total rainfall 542 mm). Yields of *B. ruziziensis* averaged 720 grams per plot.

Pure seed yields were measured in 1997 and 1998. Dry matter yields were measured by harvesting plots over 3–4 months before the seed production seasons in 1997 and 1999.

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Results

Total rainfall in 1997 was only 707 mm (64% of the long-term mean) which adversely affected seed production in that year. Rainfall in the 1998 and 1999 growing seasons was close to average.

Pure seed yields of *B. decumbens* cv. Basilisk were very low. Although many of the 31 accessions produced higher pure seed yields than Basilisk, none produced seed yields as high as *B. ruziziensis*. The germination percentages of seed produced by all accessions were generally lower than those of *B. ruzizensis* (Table 1).

Seven accessions of *B. brizantha* show potential to produce both adequate pure seed yields and good dry season forage yields (Table 1).

Table 2. Promising new *Brachiarias* from the second introduction of 18 accessions.

Accession	Relative pure seed yield[1] in 1998	Germ (%)
Brachiaria brizantha		
CIAT 16327	90	57
CIAT 16322	40	71
Brachiaria decumbens		
CIAT 1873	143	33
CIAT 26318	50	75
CIAT 16212	48	69
CIAT 1737	63	50
Brachiaria humidicola		
CIAT 16315	81	59

[1]Relative pure seed yields are expressed as percentages of pure seed yields from *B. ruziziensis* in 1998 from the first experiment.

Several accessions of *B. decumbens* (CIAT16497, CIAT26112, 'Brazil' and CIAT 26297) and of *B. brizantha* (CIAT16472 and CIAT16464) produced very high dry matter yields relative to *B. ruziziensis* (RDMY) but only small to moderate quantities of seed. These accessions may have promise in countries with a long dry season, where farmers prefer to propagate forages using vegetative planting material.

Although relative dry matter yields are not yet available for the 18 new accessions established in 1998, seven are looking promising based on early pure seed yields, relative to *B. ruziziensis* (Table 2).

Conclusions and Plans

Although few accessions approached the seed production potential of *B. ruziziensis,* a small group of promising accessions are emerging as possible alternatives to *B. ruziziensis* for areas that have a long dry season.

To confirm the potential of these accessions it will be necessary to:

(a) multiply seed of the promising accessions from the two experiments;

(b) use this seed to establish larger plots for measurements of dry matter yields (throughout the year) and pure seed yields;

(c) offer a range of these promising accessions to a small group of cattle farmers (who already grow *B. ruziziensis*) for field evaluation.

Desmodium ovalifolium – a Persistent Multi-Purpose Legume Option for Smallholders in the Humid Tropics

A. Schmidt[1] and R. Schultze-Kraft[1]

THE ROLE of legumes as an essential component of integrated production systems and natural resource management strategies is becoming increasingly important in tropical agriculture. Within this plant family's enormous genetic diversity, many species not only provide food and/or feed, but at the same time can also make a substantial contribution to weed control, soil conservation and soil fertility improvement.

Because of this multi-use potential, legumes are especially important for the sustainability and productivity of smallholder production systems, which are often situated on marginal lands and which are frequently under economic pressure to diversify their production.

Apart from enhancing the system's productivity, good adaptation to prevailing abiotic and biotic conditions, persistence, low demand for labour and low establishment costs are key factors for successful legume adoption.

One of such multipurpose legumes is *Desmodium heterocarpon* (L.) DC. subsp. *ovalifolium* (Prain.) Ohashi, also commonly referred to as *Desmodium ovalifolium*. It originates from Southeast Asia, where it has long been known as a cover crop in plantation agriculture. During the 1980s, it was evaluated in South America for pasture purposes.

Although a commercial cultivar (cv. Itabela) was released in Brazil, adoption has been low because reports from some sites indicated low palatability to grazing cattle, due to high concentrations of anti-nutritional compounds (tannins).

The subspecies is well-adapted to the acid, infertile soils of the humid tropics, has no major pest or disease problems, tolerates shade, forms persistent mixtures with aggressive grasses such as *Brachiaria* spp., has a non-climbing, stoloniferous habit, fixes nitrogen and suppresses weeds.

In a recent BMZ-funded cooperative research project conducted by the University of Hohenheim and the International Center for Tropical Agriculture (CIAT), broadly adapted genotypes of the subspecies with higher nutritional value were identified, which are likely to overcome the low-palatability constraint.

As smallholders are increasingly diversifying their farming systems, including tree-livestock integration and intensification around tree cropping (rubber, fruits) in former grazing land, there are good opportunities for them to benefit from this multi-purpose legume.

Sowing rates to obtain successful establishment are low, and so establishment costs in plantations and pastures would be low. Seed production, improved tree production and complementary cover crop grazing opportunities may further contribute to increased income.

Adapted management strategies for improved utilisation as cover crop and forage, especially aiming at optimisation of nutritive value, are still to be defined.

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New Lucerne (*Medicago sativa*) Cultivars for Livestock and the Environment in China and Australia: a Proposed Project

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LUCERNE (*Medicago sativa*), with a history of cultivation of over 5000 years, is an important perennial forage plant in many countries. It is currently grow over 1.5 to 2 m ha in both China and Australia (Hu Yaogao 1996; Auricht 1999) and there is potential to expand this area significantly.

Lucerne is a nutritious, productive and broadly adapted legume which is grown from cold continental to sub-tropical climates under both dryland and irrigated conditions. The species may be grown on a wide range of soils, from deep sands to heavy clays. However, current lucerne cultivars have limited tolerance to a range of climatic, soil and hydrological stresses and this is restricting their use in both China and Australia. Cultivars with greater drought, salt, acid soil, waterlogging and grazing tolerance are required in both countries. In northern China, cold tolerance is an additional critical limiting factor (Shi and Wu 1998).

The authors are seeking the support of ACIAR for a collaborative research project to overcome a number of these limitations in existing cultivars and to extend lucerne technology.

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Environment

In China, grasslands and cropping areas are becoming degraded from clearing or overgrazing. Grasslands cover a vast 390 million hectares, mainly in the north (20% in Inner Mongolia) and west (20% on the Tibetan Plateau). Overgrazing has resulted in 20% of the grasslands becoming seriously eroded (Liu et al. 1994).

In Australia, dryland salinity already affects 2 million ha of land and causes direct annual production losses estimated at A$130 million. Salt threatens a total area of 15 million ha over the next 50 years (Walker et al. 1999). When combined with sodic and acid soil problems, and considering offsite effects, the total cost has been estimated at nearly A$4 billion pa.

Dryland salinity is the result of rising watertables under cereal farming systems which utilise less of the annual rainfall than the native vegetation they replace. Growing lucerne in rotation with cereals reduces by half the excess water leaking down to the watertable. Continuos lucerne production utilises similar amounts of water to the native vegetation, so restoring the hydrological balance (Walker 1999).

Poor adaptation or performance of current lucerne cultivars in the more extreme environments in China and Australia is restricting their use for forage production and the protection of soils. Stress tolerant lucernes will aid both countries in restoring and preserving fragile environments by enabling lucerne to be grown across wider areas.

Livestock

Demand for livestock products is growing rapidly in China. In 1997, 53.54 m t of meat was produced in China. This represented an 8% increase over the previous year and a 25% increase over 1987. Over the same period, milk production from cows increased by 16% to 6.6 m t with a 5.4% increase between 1996 and 1997 (Anon. 1998; Lu Xinshi 1996).

Clearly the demand for animal products is growing rapidly.

By the year 2000, some 12 m t of livestock protein will be required for the 1.3 billion people in China if they are to meet the average level of protein consumed elsewhere in the world in the 1990s. The Chinese Agriculture Ministry predicts that 100 m t of hay will be needed to supply the protein required to support the required level of animal production. At present, 5 m t of lucerne dry matter is produced each year in China, meeting just 5% of the fodder requirement. Production is clearly being limited by huge fodder shortages.

In colder areas of China, 6% of the livestock die in winter, and survivors lose 30% of their body weight (Nan Zhi Biao, pers. comm. 1999). Adapted, stress tolerant lucernes can help fill this critical feed gap and relieve poverty in poor rural communities.

Lucerne is already grown across 14 provinces in China and naturally occurring wild types can be found in the northern grasslands, showing the species to be adapted to the environments targeted by this project.

Research Program

The research program aims to improve animal production and environmental stabilisation through the development and adoption of new cultivars of lucerne for expanded use in China and Australia. The four key activity areas proposed are listed below, each with a brief description:

1. Germplasm acquisition, storage and documentation

Assemble locally adapted lucerne germplasm plus new potential sources of stress tolerance, then charaterise and multiply seed of this germplasm for further testing.

2. Screening techniques and selection

Develop bioelectric techniques for stress screening and characterise germplasm for critical limiting factors. Bioelectric methods measure ion fluxes and can be used to detect stress in plants. Stresses such as chilling, heat, salinity or drought cause changes to the transport properties of membranes and hence ion transfer (Shabala 1996). This project will adapt and use bioelectric methods for the identification and selection of stress tolerant lucerne plants.

3. Cultivar development

Hybridise selected germplasm. Establish and monitor field trials at 7 sites in China and 2 sites in Australia. Initially, field sites will contain local and introduced cultivars and germplasm where sufficient seed is available. Later trials will contain hybrid lines from this project.

4. Technical training and adoption pathways.

Communicate the results and benefits of the research program to farmers, technicians and scientists in China and Australia in order to encourage uptake of the technologies developed. This aspect is described in further detail in the following section.

Technology Transfer

The transfer and uptake of technology from this project will be encouraged through the following activities:

1. Project meetings or workshops. Bringing together scientists involved in the project, these meetings will be used primarily to plan and communicate research activities. They will also provide opportunities to attract the local media (papers, television and radio) and so extend key messages from the project. Early in the project, the key groups impacted by the development of new technologies will be identified at each site and invited to be involved in a range of project activities.
2. Scientific publications. These will be prepared to extend the results of this project to other scientists. It is anticipated that they will appear:
   - in national journals such as: Grassland of China; Practacultural Science, Grassland and Forage or the Australian Journal of Experimental Agriculture.
   - at conferences such as the International Grasslands Congress or the North American Alfalfa Improvement Conference.
   - in workshop proceedings specific to this project.
3. The preparation of technical extension material aimed at industry and farmers. Such material will take the form of fact sheets, magazine articles and other handouts and will particularly aim at achieving high rates of adoption of project technology by farmers.
4. Development of a Lucerne Production Course. This is planned for use by regional education and extension agencies, targeting farmers and students in regional China.
5. Field days. Organised by local research and extension staff (including local grassland and animal husbandry organisations), these will be held at the research field sites in China and Australia to encourage farmers in the utilisation of lucerne for challenging environments.
6. Two demonstration sites in China are planned for the second half of this project to enable practical

demonstration and training in lucerne production techniques.

7. Consideration will be given to providing small quantities of seed to local farmers to encourage lucerne planting.
8. Reports to policy makers. These will target officers capable of influencing uptake of technologies from this project through policy development.
9. Two short courses will be run for scientists involved in this project. These will be:
   1. Short Course in Stress Screening Methods;
   2. Short Course in Lucerne Breeding Technologies.

Demonstration activities will be linked wherever possible to existing demonstration bases in participating institutions or associated government and private groups. Examples include some of the Chinese national and local 'Key Programs' such as 'Alfalfa Forage Production Demonstration Base and its Processing' at the Zhongger Qi and Aohan Qi in Inner Mongolia.

Adopting a systematic approach to the use of lucerne in the farming systems of the target areas through the course of the project will ensure breeding lines developed will be relevant to the farming system and ensure that outcomes can be readily adopted in the target areas of China and Australia.

References

Anon. 1998. Chinese Facts and Figures, First Edition, Beijing, China, New Star Publishers.

Auricht, G.C. 1999. Lucerne: An Australian Breeding Success Story. In: Langridge, P. et al., ed. 11th Australian Plant Breeding Conference. Proceedings, Adelaide, 19–23 April 1999. Vol. 1: 71–76.

Hu Yaogao 1996. The analysis of alfalfa industry development strategy in China. Pratacultura Science, 13: 44–50.

Liu Qi, Wu Xihong and Bao Lige 1994. Natural Grassland Resources of China and their Characteristics. Proceedings of the International Symposium on Grassland Resources. August 15–20, 1993, Hohhot, China, Beijing, China, Agricultural Scientech Press, 163–169.

Lu Xinshi 1996. Future Collaboration in Animal Sciences. Proceedings of the 2nd China-ACIAR Consultation on Agricultural Research Priorities. Beijing 1996. ACIAR report, Canberra, Australia, 38–41.

Shabala, S.N. 1996. Leaf temperature kinetics measure plant adaptation to extreme high temperatures. Australian Journal of. Plant Physiology, 23: 445–452.

Shi Y. and Wu, R. 1998. The alfalfa germplasm resources, present situation of planting consensus and their outlook of breeding and selection on loess plateau of China. Proceedings of the. 36th North American Alfalfa Improvement Conference, 45.

Walker G., Gilfedder, M. and Williams, J. 1999. Effectiveness of Current Farming Systems in the Control of Dryland Salinity, Canberra, Australia, CSIRO Land and Water.

Utilisation of Native Grasslands in Laos

S. Novaha[1], V. Phengvichith[2] and J.B. Hacker[3]

BEEF cattle are an important export of the Lao PDR and are also the main source of monetary income for most farmers. The Government considers development of the livestock industry to be a priority, and there is particular interest in two eco-geographic regions as a grazing resource – the pek savannas of southern Lao PDR and the province of Xieng Khouang (Figure 1). Xieng Khouang is at a higher altitude than the Pek savannas, is cooler, and is more diverse (Table 1). It includes four distinct ecosystems – the Plain of Jars, the Pine Tree Savannas, the Upland Zone, and the Valley Zone (Hacker et al. 1998). The latter is largely utilised for cropping rather than as a grazing resource.

Table 1. Geography and climate.

Attribute	Pek savannas	Xieng Khouang
Latitude	14–17°N	19–20°N
Altitude	<500 m	>1,000 m
Rainfall	1,890*	1,360$^{\#}$
No. of dry months (<50 mm)	6*	5$^{\#}$
Mean maximum temperature of hottest month	37°C*	29°C$^{\#}$
Mean minimum temperature of coolest month	16°C*	1°C$^{\#}$

*Champasak
$^{\#}$ Phonsavanh

The Pek Savannas

The pek savannas are an area of dipterocarp woodlands with an understorey largely dominated by the dwarf bamboos *Vietnamosasa ciliata* and *V. pusilla*. They occur from the northern borders of Savannakhet Province (16°30'N) south to the Cambodian border and also extend into Thailand, Cambodia and Vietnam. At higher altitudes (500 m), they occur in pine tree woodlands (mostly *Pinus merkusii*). Soils are sandy with a pH of 5.0–7.0. In remote areas, *Vietnamosasa* spp. comprise more than 95% of the herbaceous vegetation (Figure 2); in less remote areas, where it appears there has been overgrazing, they have been replaced with unpalatable shrubs. Where *Vietnamosasa* spp. are dominant, the few other grass species which occur in the herbaceous layer are tall-growing species such as *Heteropogon triticeus* and *Sorghum nitidum*. *Vietnamosasa* spp. has limited value as a grazing resource, only being palatable for a few months during the growing season. They are restricted to wooded, lightly shaded areas and when trees are removed, the productivity of the *Vietnamosasa* spp. decreases. Further details of the grass flora of pek savannas are published in Hacker et al. (1996).

Recommendations

Increased animal production could best be achieved with limited, intensively managed areas of improved forages, and utilising the pek savannas only during the growing season.

Xieng Khouang

The Plain of Jars and the Pine Tree Zone

The Plain of Jars is a level plain more or less surrounded by low hills, which are either treeless or with areas of Pine Tree Zone (*Pinus merkusii* and *P. kesiya*). Surface soils (top 10 cm) in these two zones are acidic and infertile, with high levels of aluminium saturation and low phosphorus concentrations (Table 2). They apparently differ in that the soils of the Plain have a deep, surficial layer of alluvium whereas those of the Pine Tree Zone have shallow A horizons over

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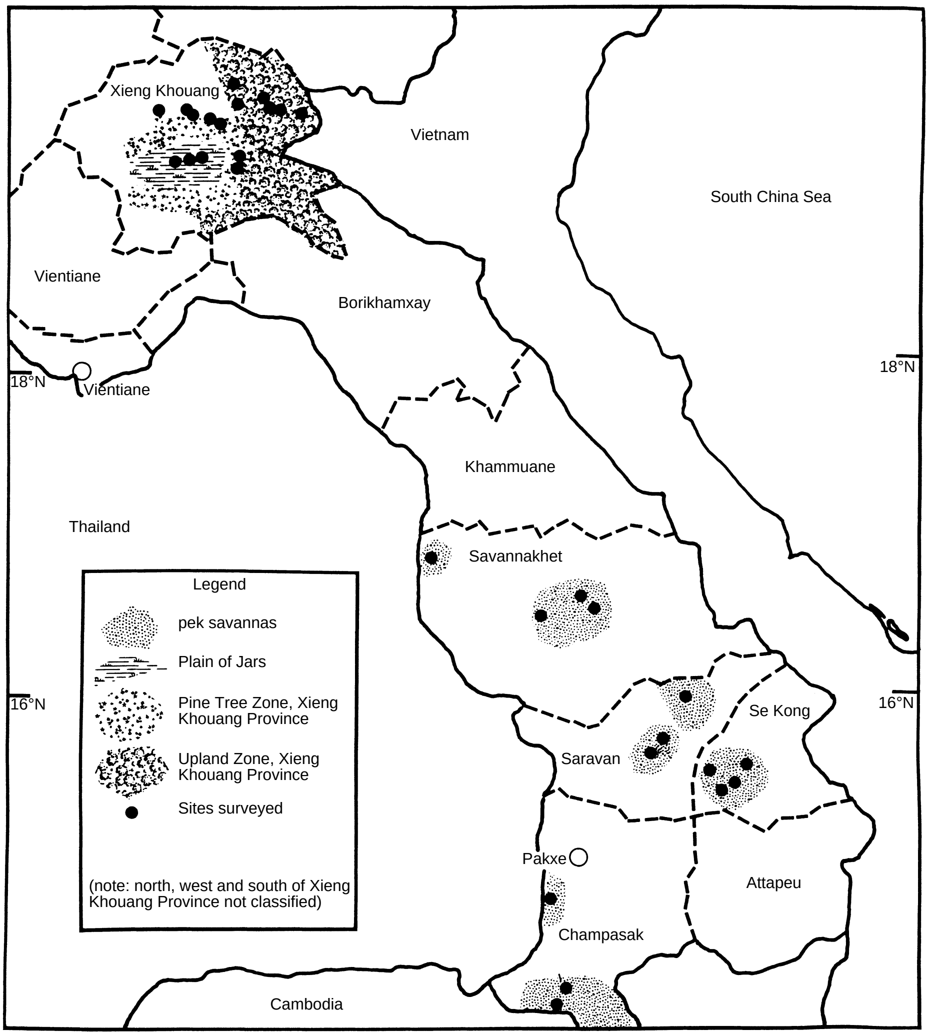

Figure 1. Central and southern Lao PDR, showing approximate areas of pek savannas, the Plain of Jars, parts of the Pine Tree and Upland Zones in Xieng Khouang Province, and sites surveyed.

Table 2. Soils of Xieng Khouang.

Attribute	Plain of Jars (3 sites)	Pine Tree Zone (5 sites)	Upland Zone (8 sites)
pH (1:5 water)	5.4 (4.8–5.0)	4.9 (4.7–5.2)	5.4 (4.7–7.7)
NO_3 (mg/kg)	0.6 (0.2–1.3)	3.0 (0.4–10.8)	14.9 (0.4–58.5)
S (mg/kg)	7 (5–9)	6 (4–9)	9 (2–13)
P (BSES) (mg/kg)	6 (5–7)	6 (4–8)	15 (7–54)
P (Colwell) (mg/kg)	2 (2–3)	2 (1–2)	7 (3–15)
K (meq/100 g)	0.1 (0.1–0.2)	0.2 (0.1–0.4)	0.4 (0.2–0.7)
Ca (meq/100 g)	0.4 (0.3–0.5)	0.8 (0.3–1.8)	6.2 (0.5–22.4)
Mg (meq/100 g)	0.1 (0.1–0.2)	0.4 (0.2–0.9)	1.0 (0.2–2.4)
Al (meq/100 g)	2.4 (1.9–3.2)	2.3 (1.7–2.8)	1.7 (0–3.8)
Na (meq/100 g)	0.02 (0.01–0.04)	0.03 (0.03–0.04)	0.02 (0.01–0.03)
CEC (meq/100 g)	3.1 (2.4–4.2)	3.9 (2.7–5.5)	9.4 (4.1–23.4)
Al saturation (%)	77 (74–79)	62 (43–81)	34 (0–79)

Figure 2. Pek savannas in good condition.

Figure 3. The Plain of Jars, with dominant *Themeda triandra*.

Figure 4. Uplands of eastern Xieng Khouang are utilised for ‘slash and burn’ agriculture.

a clay B horizon, and are formed on schists, sandstones or igneous rocks (Hacker et al. 1998). *Themeda triandra* is often dominant both on the Plain and in the Pine Tree Zone (Figure 3). *Eulalia* spp., *Andropogon chinensis* and *Hyparrhenia* spp. are frequently evident in the Pine Tree Zone where grazing has not been heavy. Areas on the Plain of Jars are often severely overgrazed. In some situations, overgrazing can result in increasing dominance of unpalatable species such as *Cymbopogon nardus*. Further details of the grass flora of Xieng Khouang are published in Hacker et al. (1998).

Animal production from these areas is more limited by soil fertility than species composition (Gibson 1995, 1997), as many of the dominant species, including *Themeda triandra*, are palatable to livestock. Broad scale application of phosphorus fertiliser is unlikely to be economic.

Recommendations

A moderate grazing pressure should be maintained on native grasslands, and limited areas sown to acid-tolerant grasses (*Brachiaria* spp.) and legumes tolerant of low soil phosphorus (e.g. *Stylosanthes guianensis*). Phosphorus would be required, either applied directly to the sown pastures or as a direct supplement to the cattle.

The Upland Zone of Xieng Khouang

This zone is very variable (Table 2; Figure 4), and would naturally have been forested. Underlying rock is frequently schist or limestone, giving rise to neutral-acidic or alkaline soils respectively. In many cleared areas, *Imperata* is dominant, but poor grazing management can result in invasion of unpalatable shrubs. Upland rice, maize and other crops are grown although cattle are a traditional source of income in this zone. In some areas, there are high concentrations of cattle which have to walk considerable distances daily to areas of grazing.

Recommendations

Increasing pressure on the 'slash and burn' management system requires build-up of fertility between cropping periods. This could be achieved with sown pastures, including *Panicum maximum*, *Setaria sphacelata* and *Desmodium intortum*.

Conclusions

There is a need to control grazing on Lao grasslands in order to conserve the natural resource. Increased animal production could best be achieved by planting limited areas of adapted, high-quality grasses and legumes close to settlements, for use in supplementary feeding and as a dry-season feed. Provision of phosphorus to livestock, either directly or through the forage, is required where this element limits animal production on the Plain of Jars.

References

Gibson, T. 1995. Livestock component of the Lao/UNDCP/IFAD Xieng Khouang Highland Development Program. Final Report to UNDCP.

Gibson, T. 1997. The Plain of Jars: an example of phosphorus deficiency for forages and livestock. SEAFRAD News, 4, 2.

Hacker, J.B., Simon, B.K. and Phengvichith, V. 1996. The pek savannas of the Lao People's Democratic Republic — ecology and floristics. CSIRO Tropical Crops and Pastures Genetic Resources Communication No. 23.

Hacker, J.B., Phimphachanhvongsod, V., Novaha, S., Kordnavong, P., Veldkamp, J. and Simon, B.K. 1998. A guide to the grasses of Xieng Khouang Province, Lao PDR and some notes on ecology of grazing lands in the Province. CSIRO Tropical Agriculture Genetic Resources Communication No. 28.

Pilot Seed Production Studies of *Stylosanthes guianensis* CIAT 184 in the Northern Philippines

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THE *Stylosanthes guianensis* cultivar CIAT 184 (Stylo 184) is widely adapted throughout the humid tropics of Southeast Asia and has proved to be a useful forage for livestock. In common with most other forage legumes, it needs to be propagated from seed. As smallholder farmers need ready access to a supply of seed, it is desirable for seed production areas to be within easy reach of farming communities. This paper reports pilot studies on seed production in northern Luzon, the Philippines.

A seed production trial was conducted in the Province of Isabela in the Cagayan Valley region which lies between three mountain ranges. On the west are the Cordillera Mountains, while in the southern part is Caraballo and to the east are the Sierra Madre ranges. It is at about 18° latitude and 122° longitude.

Ninety-five percent of the farmers are upland farmers and 65% of these have had less than six years of formal education. Fewer than 10% of the farmers have graduated from high school. The main sources of information for these farmers are transistorized radios and government extension technicians. The average number of children is 3.85 per family and the average land holding is 1.5 ha. Likewise, the average animal holding per household is 1.0 for carabao, 0.9 cattle and 0.35 goats.

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Site description

The selected site for the pilot production study was an undulating area with 15–18% slope. The soil was classified as Rugao clay with a pH of 4.8. It has 10 ppm of N, 3 ppm of P (total), and 11 ppm of K (total). The average annual rainfall is 1764 mm. The onset of the rainy season is in May and it continues until November or December; the rest of the year is dry.

Establishment, care and management of the seed crop

Three areas were established for seed production (Table 1). The first was a pilot area of 0.1 ha, sown in 1995; larger areas were subsequently sown in 1996 and 1997. Areas were thoroughly prepared by ploughing twice using a disc plough at one-week intervals and harrowing after each ploughing. The furrows were established 50 cm apart using an animal-drawn plough. The seeds were drilled into the furrows at a depth of 0.5 to 1 cm to ensure good seed-soil contact, 5–10 seeds per hill and 25 to 30 cm between hills.

One month after planting, the area was weeded. Spot weeding was carried out until the crops were fully established. Just after the first weeding, the areas were fertilised at the rate of 70 kg P_2O_5 and 200 kg K_20 per hectare.

The crops were defoliated at a height of 50 cm in September to induce branching and increase flowering. Onset of flowering was observed from late October to early November of each year.

Table 1. Seed yield of *Stylosanthes guianensis* CIAT 184 in the Cagayan Valley, the Philippines (1996–1997).

Site	Area (ha)	Date sown	Seed yield (kg/ha)		
			1996	1997	1998
Original area	0.1	1 June 1995	205	257	121
KLDA forage seed production area	1.8	6 August 1996		193	19
KLDP extension area	2.0	10 June 1997		150	10

Seed harvesting

Seed was harvested in December to January each year. Harvesting was done by manually clipping the herbage with seed and drying it on a cement pavement. Three to four days later the cut material was beaten with a stick to detach the seeds and the seed heads. The seed heads and seeds were then swept off the floor and the seeds cleaned by winnowing. A second seed crop was harvested in March to early April and treated similarly.

Seed yields

Seed yields are presented in Table 1. In 1996 and 1997, seed yield from the three sites averaged 201 kg/ha of cleaned seed. The low yields in 1998 were very low due to climatic effects associated with a strong El Niño event early in the year. Excluding the unusual conditions of 1998, seed yields were good and sufficient seed was produced for distribution to smallholder farmers in the province.

The Shrub *Cratylia argentea* as a Dry Season Feeding Alternative in Costa Rica

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*C*RATYLIA is a neotropical genus that occurs naturally south of the Amazon river through the area east of the Andes in Brazil, Perú, Bolivia and Argentina. *C. argentea* (syn. *C. floribunda, Dioclea floribunda*) is one of five species presently identified in the genus and the most widespread in South America (Queiroz and Coradin 1995).

It is a shrub that branches from the base of the stem and reaches 1.5 to 3.0 m in height. It is well adapted to subhumid climates with a 5–6 month dry season and infertile acid soils with high aluminum content in tropical areas below 1200 masl. However, this shrub responds to better conditions and yields of edible tissues (leaves and young stems) can reach over 20 t/ha/yr dry matter in humid environments on soils of medium to high fertility. It is currently used as a protein complement to sugar cane or king grass for supplementing lactating dairy cows during the dry season (Argel and Lascano 1998).

Response to Cutting

C. argentea regrows well after cutting even during the dry season. It can first be cut four months after planting, without affecting subsequent persistence. Yield is increased to a plant density of at least 20 000 plants/ha, which is a plant spacing of 1 m × 0.5 m (Table 1). From 30%–40% of the total growth occurred during the dry season, which lasted from 5–6 months during the experimental period of 2.5 years.

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Table 1. Effect of plant density and age at first cut on DM yields of *C. argentea* (CIAT 18516) cut every 60 days at 70 cm height, Costa Rica (P. Argel, unpublished data).

Density	Plant age at first cut (months)			Mean	Yield estimate
	4	6	8		
(plants/ha)		(kg/plant)			(kg/ha)
20 000	0.16	0.15	0.24	0.19 a*	3700 a
10 000	0.28	0.25	0.23	0.25 b	2500 b
6667	0.34	0.36	0.36	0.35 c	2300 c
Means	0.26 a	0.25 a	0.27 a		

$^*P < 0.05$.

A cutting trial in progress shows that a 30% higher yield can be obtained by cutting at a height of 90 cm than by cutting at 60 cm height. Further, regrowth (leaves + fine stem) at 60 days has a crude protein content of 20% vs 16% for regrowth at 90 days (M. Lobo, unpublished data).

Cratylia as a Protein Supplement for Lactating Cows

Experimental feeding trials at CIAT in Colombia demonstrated that *C. argentea* could be used as a protein supplement for low quality grasses in the dry season (Wilson and Lascano 1997). However, the best response was obtained when the *C. argentea* was fed with a high energy supplement such as sugarcane to cows of medium to high genetic potential for milk production grazing low quality grasses (Argel and Lascano 1998).

In sites with a 5–6 month dry season in Costa Rica, there is a need to supplement cows with concentrates to maintain acceptable levels of milk production. Concentrates are becoming a very expensive input as real prices received for milk are decreasing. It has now been demonstrated on experiment stations and on-farm that *C. argentea* fed fresh or as silage with sugar cane or king grass can replace concentrates at a much reduced cost for the farmer.

The initial experimentation was carried at the Livestock College for Central America, (ECAG), Atenas, Costa Rica. This is located at 460 masl, has annual mean temperature of 23.7°C, and mean precipitation of 1600 mm. Six mature Jersey cows within 50 days postpartum were randomly assigned to three treatments and then rotated through the other treatments using a cross-over Latin square design. Each treatment period comprised 12 days, 7 for adaptation and 5 for measurement. A low amount of concentrate was fed with the *Cratylia* treatments as cows were accustomed to receiving some concentrate and this kept them quiet during feeding and milking.

The treatments were:

T1 = sugarcane (1% BW) + rice polishings (0.5% BW) + concentrate (1.48% BW) + urea (0.02% BW).

T2 = sugarcane (1.3% BW) + concentrate (0.5% BW) + freshly cut *Cratylia argentea* (1.2% BW).

T3 = sugarcane (1.1% BW) + concentrate (0.5% BW) + silage of *Cratylia argentea* (2.4% BW).

Nutritional characteristics of supplement:

Sugar cane: % CP, 3.0 Mcal ME.

Concentrate: 14% CP, 2.3 Mcal ME (mixture of corn and soybean).

Rice polishings: 12% CP, 3.0 Mcal ME.

Fresh *Cratylia*: 20% CP, 1.8 Mcal ME (from 90 day regrowth cut at 30 cm).

Cratylia silage: 16.4%CP, 1.9 Mcal ME (from 180 day regrowth cut at 30 cm).

There was no significant differences ($P < 0.05$) in DM intake, milk yield or total solids between the Jersey cows fed with silage and fresh *C. argentea* and those fed on a full concentrate diet during a dry period. The full concentrate diet had a higher amount of milk protein ($P < 0.01$) while the silage increased the milk fat ($P < 0.06$). The lowest cost supplement was the one based on freshly cut *Cratylia*. The high cost of the diet containing silage made from *Cratylia* was due to the high labour cost on the station of harvesting and separating edible portions of 6-month old *Cratylia* regrowth.

Similar trials have been repeated on small farms in the Central Pacific coast area of Costa Rica. We report one trial on a farm where *Cratylia* was fed fresh or as silage conserved during the rainy season and where the main concentrate fed is dried chicken manure.

The trial was conducted in a small farm located in Barrancas at an altitude of 280 masl, annual mean temperature of 28°C, mean precipitation of 2500 mm, and with a 5 months dry season. Six crossbred Swiss Brown × Brahman cows in the third month of lactation were randomly assigned to the three treatments and then rotated through the other treatments using a a cross-over Latin square design. Each treatment period comprised 10 days, 7 for adaptation and 3 for measurement. A low amount of rice polishing was fed to all cows to ensure that they were quiet during milking.

Treatments:

T1 = 12 kg sugarcane + 6 kg *C. argentea* silage + 0.6 kg rice polishings.

T2 = 12 kg sugarcane + 6 kg *C. argentea* fed fresh + 0.6 kg rice polishings.

T3 = 12 kg sugarcane + 3 kg chicken manure + 0.6 kg rice polishings.

Nutritional characteristics of feed:

Sugarcane: 2.1% CP, 3.0 Mcal ME

Chicken manure: 19.5% CP (ME not measured).

Rice polishings: 12% CP, 2.9 Mcal ME.

C. argentea fresh: 20% CP, 1.8 Mcal ME.

C. argentea silage: 16.5% CP 1.9 Mcal ME (pH 4.5, 36% DM.).

Milk yields in all treatments were similar though slightly higher in the treatment where *Cratylia* was fed fresh (Table 3). Milk fat and total solids were higher in the treatments with *Cratylia*. The cost of supplementation was lower with *Cratylia* with the result of a higher cost to benefit ratio for the farmer. Also the costs of using *Cratylia* were much cheaper than those estimated for the research station. Farmers cut all material from 3–4 month regrowth when making silage and do not separate them into leaves and stems.

Our results show that there is a beneficial effect of using *Cratylia* as an on-farm protein supplement. Furthermore farmers have contributed to the development of the technology in initiating the conservation of *Cratylia* as silage and using it fresh to feed other farm animals like pigs and horses. Three years after introduction of *Cratylia* to pilot farms, there is an increasing interest by other farmers in the area. This is shown by the distribution in 1999 of 79 kg of experimental seed by the Seed Unit of CIAT in Costa Rica, plus seed sold by pioneer farmers to their neighbours.

Management

C. argentea produces abundant seed with no evidence of either physical (hard seed coat) or physiological dormancy. Viability is high but can diminish rapidly when stored under humid conditions due to seed deterioration and fungal attack. It is best propagated using non-scarified seed and must be sown at less than 2 cm depth. It responds to rhizobia inoculum with CIAT strains 3561 and 3564 (Argel and Lascano 1998).

It is a robust shrub and coppices freely when cut. It recovers well from accidental fires. The youngest leaves are less palatable than older leaves. Intake is increased when *Cratylia* is cut the day prior to feeding and allowed to wilt before feeding. It is acceptable to cattle, horses, pigs, sheep and goats.

In the dry pacific coast of Central America, natural or improved pastures provide sufficient feed of reasonable quality during the rainy season. Feeding trials show no response to *Cratylia* unless it is fed as 100% in the supplement. Farmers themselves do not see the need to use *Cratylia* as a supplement during the rainy season and the idea and first experiments with making and feeding silage were carried out by them. It is obvious after the first few trials that *Cratylia* fed as silage does not have the same value as freshly cut material.

One of the reasons is that it is generally cut at a later stage of regrowth than when fed fresh and so the material ensiled is of lower quality than material cut earlier and fed fresh. Also there is probably some loss in feeding value during the ensiling process. Nevertheless, there is an advantage in farmers producing silage as it decreases the area of *Cratylia* that needs to be managed as a protein bank. Research is underway to study the effect of adding different proportions of molasses, and different sources of energy such as sugar cane and maize, on quality *Cratylia* silage.

It has been observed that dense strips or banks of *Cratylia* can be grazed continuously by cattle without harming the plant. The growing tips tend to be avoided and the good coppicing ability ensures rapid recovery from trampling or grazing pressure. Direct animal intake of immature *Cratylia* forage is low (Raaflaub and Lascano 1995), and for this reason it would seem to be an ideal plant for strip grazing, given that the plant would be preferentially grazed when mature and when the companion grass is of low quality, as is the case in the dry season.

The current research emphasis is to evaluate the contribution of direct grazing of *Cratylia* on milk production when sown in strips in association with a grass. It could also be sown in contour strips in permanent pastures to provide supplementary feed when needed.

Limitations

- Lines of *C. argentea* studied so far (CIAT 18516 and CIAT 18668) do not adapt well to cool environments (over 1200 masl in the tropics).
- *C. argentea* establishes slowly, although faster than other shrub legumes like *Leucaena leucocephala*. Thus, production is low during the first year.

Table 2. Dry matter intake and milk production of Jersey cows fed different diets during the dry season in Costa Rica (F. Romero and J. Gonzalez, unpublished data).

Treatments	DM intake	Milk yield	Fat	Protein	Solids	*Cost of supplement	Benefit cost ratio
	(kg/cow)	(kg/cow/d)	%	%	%	($/kg DM)	
T1. Concentrate	10.8	11.1	3.5	3.4	12.4	0.20	1.33
T2. Fresh *C. argentea*	10.7	10.9	3.7	3.2	12.5	0.16	1.68
T3. Silage of *C. argentea*	10.4	10.7	3.8	3.2	12.5	0.43	0.62
Sig. difference	ns	ns	$P < 0.06$	$P < 0.01$	ns		

*Supplement includes the cost of all ingredients in the supplement except sugarcane.

Table 3. Average milk yield of dual-purpose cows supplemented with *Cratylia argentea* either fresh or as silage and with chicken manure (M. Lobo and V. Acuna, unpublished data).

Treatments	Milk yield	Total solids	Fat	Cost of supplement	Benefit cost ratio
	(kg/cow/d)	(%)	(%)	($/kg DM)	
T1. *Cratylia* as silage	5.1 b	12.3	3.6	0.17	1.58
T2. Fresh *Cratylia*	5.5 a	12.2	3.4	0.11	2.37
T3. Chicken manure	5.3 a b	11.7	3.0	0.22	1.14

Summary and Conclusions

Cratylia argentea provides an interesting example in time path for identification and evaluation of a new species. Seed was collected in Brazil in 1980 and again in 1984, then evaluated in the RIEPT network during the late 1980s. It showed promise not only in several sites in Latin America (Isla in Mexico, La Ceiba in Honduras, and several sites in Costa Rica, Colombia and Brazil) but also in West Africa (CIAT 1995).

However, it was not until scientists realized a need for shrub legumes tolerant to acid infertile soils for small farm use in hillside agriculture that there was a major effort to evaluate the shrub more intensively, starting in 1996. It has been shown since that it is indeed widely adapted and at this stage appears to have most promise as a commercial species in Central America, rather than in the Cerrados where it originated.

Management does not appear to be a problem for small farmers. It establishes readily from seed, though production is low during the first year. Regrowth is vigorous after cutting. Yield increases as the plant matures (up to 0.5 kg of DM/plant every 3 months up to a plant age of 5 years, plants at 1.0 × 1.0 m spacing).

The shrub produces high yields of good quality forage (19%–26% CP and 40%–55% IVDMD, depending of plant maturity); a high proportion of this yield is produced during the dry season. For this reason, *C. argentea* is a shrub with high potential as a protein supplement for high energy forages like sugar cane or king grass in cut and carry systems.

Dual-purpose or dairy cows grazing protein-deficient grasses during the dry season and supplemented with sugar cane and *C. argentea*, have produced similar milk yields to animals fed with more expensive concentrates, giving greater economic returns to farmers.

References

Argel. P.J. and Lascano, C.E. 1998. *Cratylia argentea* (Desvaux) O. Kuntze: Una nueva leguminosa arbustiva para suelos ácidos en zonas subhúmedas tropicales. Pasturas Tropicales, 20, 37–43.

CIAT 1995. West and Central African animal feed research project ‘Adaptation of Forages in West Africa’. Working Document No.145, Cali, Colombia, CIAT.

Queiroz, L.P. and Coradin, L. 1995. Biogeografia de *Cratylia* e Areas Prioritárias par Coleta. In: Pizarro, E.A. and Coradin, L. Potencial de Género *Cratylia* como Leguminosa Forrajera. Memorias del taller de Trabajo sobre *Cratylia* realizado el 19 y 20 de julio de 1995, Brasilia, DF, Brazil. Working Document No. 158, Cali, Colombia, CIAT, 1–28.

Raaflaub, M. and Lascano C.E. 1995. The effect of wilting and drying on intake and acceptability by sheep of the shrub legume *Cratylia argentea*. Tropical Grasslands, 29, 97–101.

Proposed Studies on the Development of Ruminants in the Red Soil Areas in South China

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IN RECENT years, soil erosion has become a serious problem in the southern part of China, as farmers open up the wasteland for fruit trees and other short season crops on sloping and hilly land, without considering the consequences. Although the government has suggested some measures to reduce soil loss and water erosion, such as growing grasses, it is difficult for farmers to adopt these practices. This is because pressure to produce food is increasing and the farmer cannot make a profit simply from growing grass. In 1998, the Chinese government declared that the development of ruminants would be one of the more important tasks in agricultural development (Huang and Liu 1999). Therefore, combining growing of grass as a means of controlling erosion and as a feed for ruminants may be a good solution for addressing China's growing population pressure as well as combating soil loss.

Research Objectives

This project will develop nutritional technologies for profitable and sustainable beef production from forages in the southern part of China, most of which is hilly and covered by acidic red soils. Our particular focus will be the development of beef production systems that match nutritional inputs with outputs of beef to market specifications, while maintaining long-term productivity of the forage base.

A system will be developed for smallholders which integrates beef production from forages into the whole farm enterprise (crops, forages to control soil erosion and to feed livestock). Annual feed budgets will be developed to allow numbers of productive livestock to be matched with available nutrients from forage. These budgets will incorporate fresh forage, harvested in a cut and carry system, during spring, summer and autumn, and conserved forage fed during the harsh winter when forage growth is not sufficient to sustain cattle. An important objective of the study will be the determination of the nutritive value of the conserved forage. Measurements will be made to ascertain whether conserved forage is of sufficient quality to allow acceptable growth rate during winter or whether supplements to stimulate forage intake and/or additional energy in the form of agricultural by-products need to be added to the diet.

A further objective will be training Chinese scientific and extension staff in cattle husbandry and management. Ruminant production is currently not a core strength of Chinese scientific institutions in the red soil region so it will be important to ensure that key Chinese staff acquire the appropriate skills.

Research Methods

The major experimental site in China will be an established 10 ha orchard near the campus of the Jiangxi Agricultural University. The dominant grass species in the inter-rows between fruit trees is currently *Paspalum notatum* which is effective for the control of soil erosion (Yin et al. 1996; Ji et al. 1999). An animal building to house up to 20 cattle in individual pens and an effluent pit/methane generator will be constructed. A diagrammatic representation of the ecologically sustainable ruminant production system envisaged is shown in Figure 1.

Steers will be purchased at 150 to 200 kg liveweight soon after weaning and be fed in a cut and carry system until they reach market weight at 500–550 kg liveweight. The fodder provided will be harvested from a known area of orchard so the contribution per unit area of land to cattle growth can be calculated. Nutritional treatments will be chosen to

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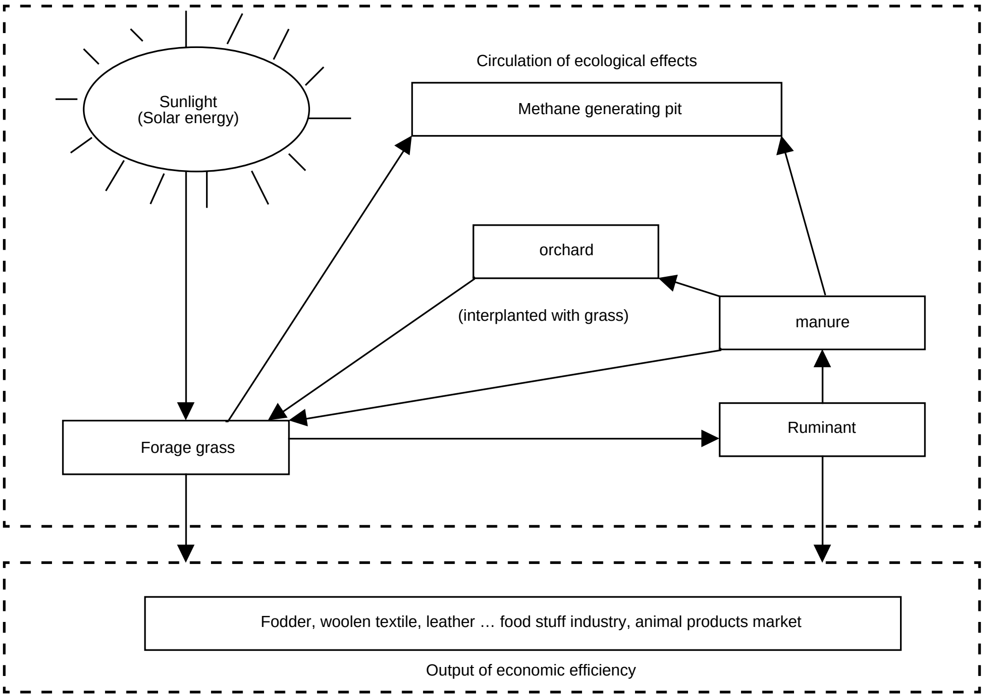

Figure 1. Ecological principle of the project.

provide an annual feed supply which maximizes the use of forages. Various combinations of grass and legume fresh forages will be fed when they are available in summer and spring, and conserved forages, straws and agricultural by-products for the remainder of the year. The forage species and varieties that were identified as potentially useful by the previous ACIAR projects (Wen Shilin et al. 2000) and those species that have been identified by scientists at Jiangxi will be evaluated using standard chemical in vitro and in vivo techniques in order to determine their nutritive value, either alone or in combination with other forages. The effect of cultivation techniques and fertiliser requirements to maximise yield of high quality forage will be determined.

Forages will be conserved as silage or hay, and time of harvest in relation to the nutritive value of the conserved product will be measured. Changes in the physical structure and chemical characteristics of the soil under the various forage swards will be documented and water holding capacity and degree of erosion measured.

The research results will be extended to the farmers through Jiangxi Agricultural University, the extension station of animal husbandry technology of Jiangxi province and the science and technology committee of Jiangxi province (Figure 2).

Expected Outputs

The major output will be a beef production system for the red soils that profitably converts forages used to control soil erosion into saleable animal product. Another output will be the capacity to transfer the technology to smallholder farmers. This would be achieved through the extension networks already existing in the region.

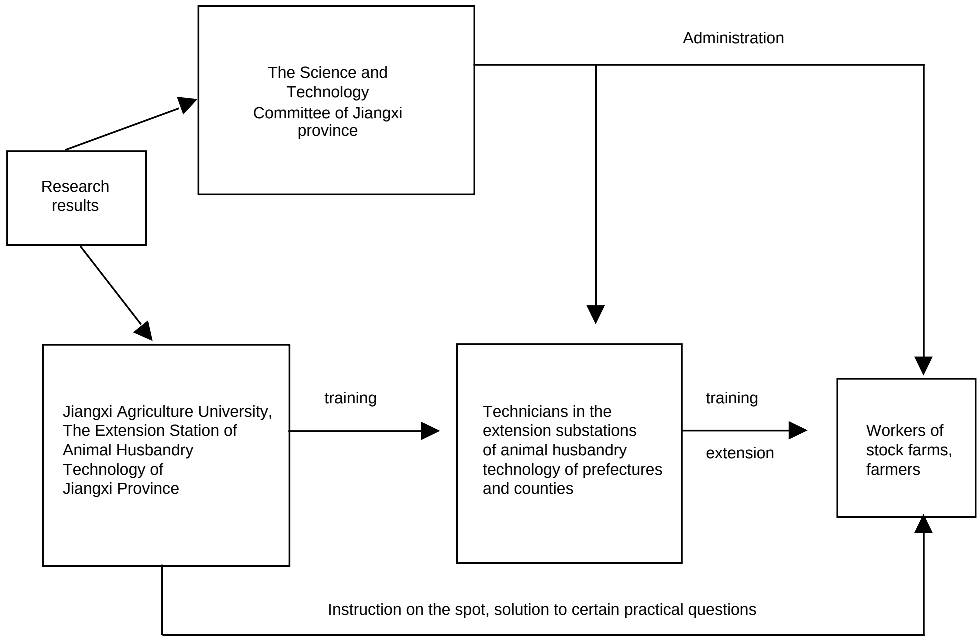

Figure 2. Extension system of the project.

References

Huang, G.Q. and Liu, Y.B. 1999. On the innovation of China's agricultural science and technology. Acta Agriculturae Universitatis Jiangxiensis, 21, 2: 205–310.

Ji, M.C., Dong, W.D. and Liu, S.Y. 1999. A preliminary study on the application of bahia grass in soil conservation and slopeland agriculture. Acta Agriculturae Universitatis Jiangxiensis, 21, 2: 226–228.

Yin, S.H., Bao, J.Y. and Li, W.J. 1996. Herbage yield properties and nutritive value of bahia grass. Grassland of China, 5: 32–35.

Wen Shilin, D. MacLeod, J. Scott, Xu Minggang and Huang Pingna. 2000. Forage research on the red soils of South Central China. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Smallholders: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Forage Research on the Red Soils of South Central China

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THE most difficult challenge facing China today is that of feeding an expanding population (1.2 billion) with a limited supply of arable land. The enormity of this problem has focused national attention on the redevelopment of wastelands for agricultural use. Of particular concern, because of the large areas of barren land it encompasses, is the red soils region of southern China.

There are 0.48 million km^2 of eroded wasteland (18% of the total region) in the red soils region of southern China. This wasteland has resulted from inappropriate land utilisation and excessive deforestation, particularly in the past 40 years. Vegetation is now sparse and soil erosion severe.

In recent years, the Chinese government has promoted the development of these degraded lands. Some of wasteland has recently been developed as fruits plantations, particularly citrus. However, the soils remain exposed to continuing erosion as the fruits trees, when young, are not big enough to cover the soil.

It is becoming more and more difficult to meet peoples requirements for animal products in the red soils region, where pigs are traditionally fed on a grain diet. Moreover, consumption of meat is increasing, as living standards improve. Reducing Chinas dependence on grain-fed animals for meat is a policy objective of the government. Changing dietary preferences associated with rising consumer incomes are also encouraging increased interest in forage and ruminants *f* particularly cattle production.

Planting forages would contribute to controlling soil erosion, rebuilding soil fertility, and providing feed for ruminant animals. The potential of developing ruminant production by planting forages on the wasteland and as ground cover in new fruit plantations has been well recognised by Chinese scientists, central and provincial government, and local farmers.

The studies on forage development started in 1982 at Red Soil Research Station, Chinese Academy of Agricultural Sciences, in Hunan Province. Chinese and Australian scientists have cooperated to develop forages for the red soils region for more than ten years. A number of promising forage species were selected and management procedures developed in three ACIAR-funded projects (8925, Forage Development on Red Soils; 9303, Forage Management on Red Soils; 96172; Selecting *Chamaecrista rotundifolia* for soil stabilisation and forage).

Selecting Suitable Forages

The obstacles to selecting suitable forages for this region are as follow:

- Extreme thermal condition (temperature: max. 40°C, min. −7°C). Forage persistence is a big problem, particularly legumes.
- Low soil pH (pH = 4.4, 1:5 H_2O), aluminium toxicity, multiple mineral deficiencies, including phosphorus (<1 μg/g soil, Olsen), magnesium, calcium, nitrogen and micronutrients.
- Drought in summer and autumn.
- Severe weed competition.

In the search for forages suited to the red soil region — and therefore tolerant of cold winters, hot summers, drought in summer and autumn, and soil infertility — more than 300 accessions were evaluated for productivity and persistence. Fewer than 10% of these turned out to have potential for forage development. Many of the cool season species died out over summer and did not regenerate.

According to vegetative and reproductive characteristics, using Pattern Analyses for group classification, 31 grasses, 19 legumes, 14 cereals and some others were found promising. The most promising cool season species were the grasses Porto cocksfoot

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(*Dactylis glomerata*), *Phalaris aquatica* and *Triticale* cv. Madonna (cereal), and the legumes Haifa white clover (*Trifolium repens*), *Lotus pedunculatus* cv. Maku. Among warm season species, *Hemarthria compressa*, Premier finger grass (*Digitaria eriantha* cv. Premier), *Setaria sphacelata* cv. Solander, *Paspalum wettsteinii*, and the legumes lotononis (*Lotononis bainesii*), Wynn cassia (*Chamaecrista rotundifolia* cv. Wynn) and *Lespedeza bicolor* performed best.

Establishing Suitable Forages

In the trials, forages were sowed at a range of dates between March (spring) and November (autumn). Spring sowings proved best for warm season species, enabling them to establish before winter; the optimum sowing time was from the end of March to end of April in Hunan.

In contrast, the cool season species only persisted when sown in autumn, due to the inability of young plants to withstand high summer temperatures and drought, October was the best sowing time. Mulch significantly promoted legume establishment; however, the effect was negative for the grass.

The results of sowing rates and methods showed that the density and yields of Premier finger grass increased markedly with increasing sowing rate (Figures 1 and 2). Sowing in rows simulated the first phase of pasture establishment and produced higher forage yields than broadcasting seed, when sowing rate was less than 20kg/ha.

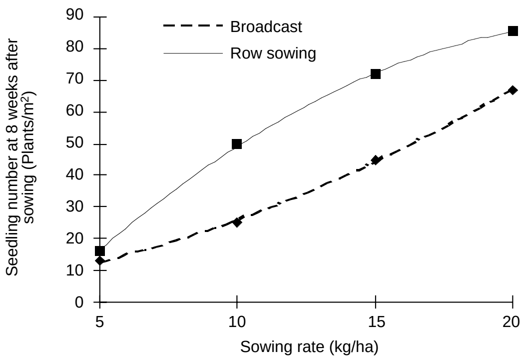

Figure 1. The effects of sowing rates and methods on emergence of Premier finger grass.

Phosphorus was the most limiting nutrient, having to be applied at a rate of at least 20 kg/ha to obtain reasonable initial growth. The result of trials in Hunan led to the recommendation that a reasonable basal application should be 50kg N, 40kg P and 50 kg K per hectare in a high-input forage system, when establishing pasture on wasteland.

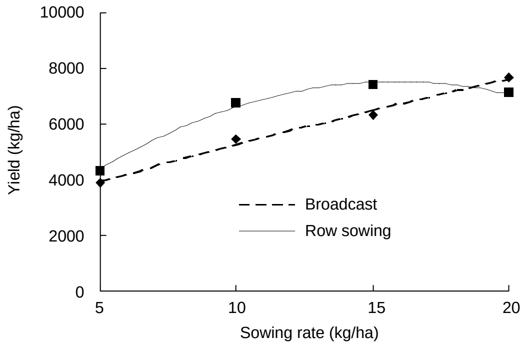

Figure 2. The effects of sowing rates and methods on yield of Premier finger grass.

Most warm-season forages showed good tolerance of soil acidity; however most cool-season species benefited from liming to raise the pH to 5.6. Wynn cassia showed the greatest tolerance of acidity, with pot trials suggesting that liming actually decreased its yield.

Management of Forages

Having found that a range of grasses and legumes could be grown on the red soils if sufficient fertiliser was added and they were sown at appropriate times, the next challenge was learning how to manage the adapted forages so they persist and remain productive.

Four forages, *Digitaria eriantha* cv. Premier, *Chamaecrista rotundifolia* cv. Wynn, *Dactylis glomerata* cv. Porto, and *Trifolium repens* cv. Haifa were grown singly or in grass/legume mixtures and cut at different heights for three years. Premier persisted and yielded well, providing a large quantity forage from May to August. Porto yields were lower and declined in the third year, but it provided a small quantity of forage in winter. Wynn had high vegetative yields during the first year, but it failed to set seed at either 15 or 25 cutting height, and plants did not survive through the winter. Hence, Wynn failed to persist after year one. Haifa grew poorly. The yield of Haifa was the lowest. Combinations containing Premier yielded higher than all others. Mild cutting increased Premier and Wynn yield, but decreased Haifa yield. Porto yields were not affected by cutting height (Figure 3). Mild cutting had some beneficial effect on preventing weed invasion. Severe cutting suppressed the growth of grasses, reducing the persistence of Porto.

In another trial carried out in Qiyang, Hunan province, lotononis combined well with a wide range of grasses. Combinations of lotononis with Premier finger grass, *Hemarthria compressa* or Solander setaria always gave higher yields than when these grasses were grown in mono-culture. The highest yields occurred with a single row of lotononis alternating with a single grass row, except for the lotononis /*Hemarthria compressa* combination, in which the highest yields were from a single legume row and two rows of grass (Table 1).

Table 1. The yields of different combinations of lotononis with grasses in 1998 (kg/ha).

Combinations	Grass	Legume	Total yield
Lotononis (L)		6251	6251
Premier finger grass (P)	5945		5945
1 row L, 2 rows P	8181	867	9048
1 row L, 1 rows P	8545	2236	10781
2 row L, 1 rows P	4637	2971	7607
Hemarthria compressa (H)	4562		4562
1 row L, 2 rows H	3779	3919	7698
1 row L, 1 rows H	3142	3773	915
2 row L, 1 rows H	1495	4035	5530
Setaria cv. Solander (S)	3541		3541
1 row L, 2 rows S	2047	3439	5486
1 row L, 1 rows S	1517	4833	6350
2 row L, 1 rows S	1927	4143	6070

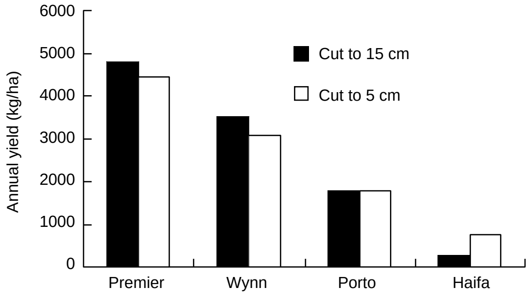

Figure 3. The effect of different cutting heights on the yields of four forage species.

The Effect of Forage on Controlling Soil Erosion

Twelve runoff plots were constructed at Menggongshan in Hunan Province to evaluate the impacts of incorporation of forage with upland cropping systems and engineering measures on erosion control. Forages were generally grown in strips alongside crops; the proportion of the area occupied by forages ranged from 25% to 100%. Terraces were constructed in

Table 2. Soil fertility status at 6 years after planting forages.

Treat.	O.M. (%)	Total N (%)	NH_4^+-N (ppm)	Available P (ppm)	Available K (ppm)	$1/2Ca^{2+}$ (cmol/kg)	$1/2Mg^{2+}$ (cmol/kg)	$1/3Al^{3+}$ (cmol/kg)
Wasteland	1.42	0.079	62.8	2.4	49.3	0.53	0.14	4.11
Grass sward	1.56	0.068	60.1	4.4	55.5	1.82	0.17	4.13
Legume sward	1.69	0.091	82.3	4.7	76.8	2.30	0.23	3.48

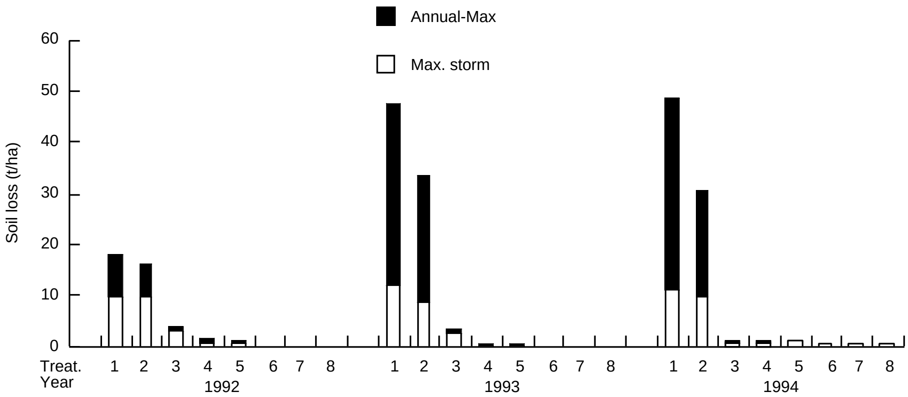

Figure 4. The effects of treatments and maximum storm on soil loss (Tr. 1: Control (bare plot); Tr. 2: Natural vegetation; Tr. 3: 100% forage; Tr. 4: 50% crop and 50% forage; Tr. 5: 75% crop and 25% forage; Tr. 6: Terraces + Crop; Tr. 7: Terraces + Crop + Forage; Tr. 8: Terraces + Crop + Forage + pits).

three of the cropped plots. The results from three years study showed that forages and terraces had very significant effects on controlling runoff and reducing soil loss.

The annual soil loss from bare plots was measured at 48.5 t/ha in 1994, a very high figure. The treatments with 25 to 100% forages strips reduced soil loss to 0.8 t/ha which was only 0.4 t/ha more than where terraces had been constructed (Figure 4). The soil loss mainly resulted from heavy storms which occurred frequently in April, May and June. Forages grow well in this period, hence reducing the effect of storms on erosion. Inter-cropping forages could reduce soil and water loss before crops are sown and after harvest. Forages also benefit by intercepting nutrients lost from crop strips.

The research showed that, on a slope of 1 in 7, forages could replace expensive terraces. In the areas where fruit trees are grown on steeper slopes requiring terracing, planting of forages would protect terrace faces and the soils between trees before they achieve canopy closure. The legume lotononis has proved highly suitable for this purpose because, with its prostrate creeping habit, it stabilises the soil and does not interfere with tree growth. In addition, being a legume, it adds nitrogen to the soil.

The Effects of Forages on Restoring Soil Fertility

Soil fertility in wastelands, grass swards and legume swards has been monitored for six years. The results showed that levels of soil organic matter (OM), total N, NH_4^+-N, available P and K, and Ca^{2+} and Mg^{2+} in legume swards were significantly higher than in wasteland. Soil under grass swards was also higher in OM, P, K and Ca^{2+} than wasteland soils (Table 2). Planting legumes could increase the content of exchangeable Ca^{2+} and Mg^{2+}, and decrease the content of exchangeable Al^{3+}, thus decreasing aluminium toxicity.

Astragalus sinicus L. in Rice Farming Systems of Southern China

Wen Shilin[1], Xu Minggang[1] and Qin Daozhu[1]

RICE is the main crop in southern China. There are more than 20 million ha of paddy fields in this region, and one of the main cropping systems is two crops of rice followed by *Astragalus sinicus* L. (astragalus) In this system, early rice is transplanted in the second half of April, and harvested in the second half of July. The late rice crop is then transplanted and harvested in the second half of October. Astragalus is oversown in the second half of September, and ploughed in early April. There has been a long history of planting astragalus on paddy field in southern China. More than 8 million ha of paddy fields were sown with the species in the 1970s. It is used mainly as a green manure, and is the main green manure crop in China.

In recent years, Chinese farmers have come to recognise its value as a feed with improving techniques of conservation.

Agronomic Characteristics

Astragalus sinicus L. is a semi-erect, annual or biennial legume with hollow stems 30–100 cm long (Figure 1). The roots concentrate in the upper 15 cm of the soil profile, and are well nodulated. Astragalus is grown mainly around the Yangtse River, from 24°N to 35°N. It prefers cool weather and well-drained soil.

Seedlings can emerge at a temperature of 4–5°C. It makes its most vigorous growth in spring (March and April), growing best at temperatures of between 15°C and 20°C. The seedlings are frosted when minimum temperature falls below −7°C. The optimum soil moisture for growth is 60–75% of field capacity, and if it falls below 40%, growth is depressed. It is tolerant of mild waterlogging, but grows poorly or dies if waterlogging is prolonged. Astragalus is unable to nodulate with indigenous rhizobia and needs to be inoculated if it has not been sown on the soil before. Its yields are quite high, with fresh yield of 30 000–45 000 kg/ha. Seed production is 600–750 kg/ha.

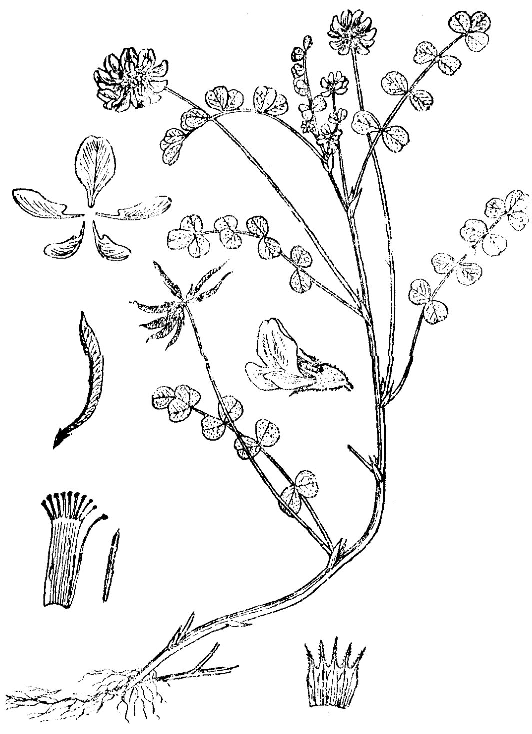

Figure 1. The morphology of *Astragalus sinicus*.

Establishment and Management

Astragalus is very easy to establish and manage. The recommended procedure is to:

- ditch the paddy field to drain water before sowing, to improve emergence and growth;

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- soak seeds in warm water for 24 hours;
- inoculate with rhizobium if sowing on the field for the first time;
- sowing rate 30–45 kg/ha;
- broadcast directly into late rice field in the second half of September, 3–4 weeks before the late rice harvest;
- plough in or harvest for feed in early to mid-April, 2 weeks before transplanting rice.

Table 1. The nutrient contents of *Astragalus sinicus* (%, dry matter) (Lin et al. 1994).

N	P	K	C
3.80	0.32	3.13	38.06

Astragalus as a Green Manure

Astragalus has been used mainly as a green manure due to its high capacity for fixing N (75–120 kg/ha per annum) and high nutrient content in the plant (Table 1). It has contributed to increasing rice yield and decreasing fertilisers input for many years in China. A 30 000 kg/ha crop of astragalus has a similarly beneficial effect on yields of a following rice crop to 260 kg/ha of urea, and also has a significant residual effect (Table 2).

However, despite the proven beneficial effects of astragalus as a green manure crop, areas have been decreasing since the 1980s, with increasing application of chemical fertilisers.

Table 2. The effect of *Astragalus sinicus* on rice yield (kg/ha) (Lin et al. 1994).

Treatment	Application rate(kg/ha)	Early rice	Late Rice[1]	Total yield
Control	Without N	4950	4365	9315
Urea	260	6270	4485	10755
Astragalus	30 000	6240	4980	11220

[1]No fertiliser was applied to the late rice crop

Astragalus as a Feed for Livestock

Astragalus is an excellent feed, with high nutritive value, high crude protein content and low crude fibre content (Table 3). Many animals such as cattle, pigs, horses, goats and rabbits like to eat it. The economical return of astragalus as a feed are 1.5 times that of utilising it as a green manure (Table 4). The area of astragalus is now rising again due to its use as a feedstuff and the extension of silage technique in recent years.

Table 4. The economical benefit of *Astragalus sinicus* as a feedstuff compared with as a green manure (Yuan/ha) (Chen 1993).

Treatment	Input	Output	Income
Rice-rice — astragalus (as green manure)	2162	7751	5589
Rice-rice — astragalus (feeding pigs)	2717	11199	8482

The Problems

There are several problems in the Astragalus Farming System:

1. Early rice seedlings after transplanting grow slowly due to high contents of deoxidized materials and organic acids when the preceding astragalus has grown too vigorously.
2. Early rice is too green in the late growth stage, resulting in insect and disease damage, when preceding astragalus crops exceeding 30 000 kg/ha fresh matter are ploughed in.
3. It is difficult to plough in astragalus when yields are high.
4. Astragalus produces most of its biomass in March and April and it must be harvested before the early rice is transplanted if it is to be used as a feedstuff. However, this is the rainy season in southern China, and conservation for use as a feed is a big problem.

Table 3. The nutritive composition of *Astragalus sinicus* at different growth stage (% dry matter) (Li 1987).

Growth stage	Crude protein	Crude fibre	Ether extract	Nitrogen free extract	Ash
Budding	28.1	11.7	3.8	39.8	7.1
First flower	25.8	11.8	4.6	41.0	7.1
Full flowering	22.3	19.5	4.8	33.5	7.8
Pods	19.4	20.2	5.0	38.3	8.0

The Solutions

Problems 13 can be solved by reducing the amount of astragalus ploughed in, by harvesting the herbage, and using it as a feedstuff. The underground part still has enough N to meet the requirement of rice growth.

Silage is the best method for astragalus conservation. If astragalus is harvested at full flowering, chaff or a protecting agent added, and moisture content controlled to 5565%, the lactic acid bacteria fermentation process could be completed in 30 days. The silage can then be kept for two months or more, and is relished by pigs and cattle (Wang 1998).

References

Chen, L.Z. 1993. The comprehensive benefit of green manure using as feedstuff and manure. Soils and Fertilisers, 3: 2831.

Li, J.M. 1987. Register of Chinese Herbage Plant Cultivars. Agricultural Press, Beijing.

Lin, B., Li, J.K and Huang, Z.Y. 1994. Fertilisers in China. Shanghai Scientific Press, Shanghai.

Wang, B.L. 1998. The silage techniques of *Astragalus sinicus* L. In: Xu, M.G., Zhang, J.Q. and Wen, S.L. ed. Forage Cultivation and Utilisation in Hilly Red Soil Regions of Southern China. Chinese Press of Agricultural Science and Technology, Beijing, 159–161.

Studies on Herbage Yield Characteristics, Nutritive Value, and Soil-and-Water Conservation of Bahiagrass (*Paspalum notatum* Flugge)

Ji Mengcheng[1] and Shi Qinghua[1]

BAHIAGRASS (*Paspalum notatum* Flugge) is a sown forage species native to South America. It has been used and studied extensively in America since 1920 (Scott 1920; Burton 1940, 1943). More recently, there have been many reports on the herbage yield of bahiagrass, especially in Japan (Hirata 1998). Bahiagrass was introduced into Jiangxi Province, China, in 1989 and has been planted in more than 90% of the counties, with a total area of 6700 ha (Ji et al. 1999).

Experimental Studies in Jianxi

Herbage yield of bahiagrass

Dry matter accumulation increased with the progress of growth stages (Table 1). Bahiagrass yielded 9500 kg/ha dry matter at the stage of seed maturity. During the growth stages, the daily dry matter accumulation was faster in the stages from tillering to internode elongation and from flowering to seed maturing with 115 and 134 kg/ha/day, respectively. The daily dry matter accumulation was the least during the stage from heading to flowering, 10 kg/ha/day. There was still a relative long regenerative growth after seed maturation stage.

Dynamics of herbage yield was determined by cutting bahiagrass at monthly intervals, and two levels of fertiliser application, applied after each cut (Table 2). There were apparent differences in herbage yield between high and low fertiliser applications. In the Nanchang area, where the experiment was carried out, the growth of bahiagrass was faster from June 5 to August 4. The daily dry matter accumulation reached 15 kg/ha/day.

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Nutrient elements of bahiagrass and its nourishing effects on goats

The main nutrient elements of bahiagrass are shown in Table 3. Crude protein percentage peaked at tillering, with 14.2% crude protein and then declined to the lowest point at seed maturity with 5.1%. It then increased to 7.8% at the regenerative growth stage. The changes in crude fibre in relation to growth stage were opposite to the trends in crude protein.

Mountain goats were fed dry bahiagrass with digestible dry matter, digestible protein, fibre, and digestible energy of 507.8 g/kg, 46.8 g/kg, 170.8 g/kg and 10.03 Mj/kg, respectively. The nourishing effects on goats were significant and the average daily weight increase reached 83.5 g during the feeding experiment stage.

The effects of bahiagrass on soil-and-water conservation and its improvement on soil

The effects of planting bahiagrass in red soil as a covering crop in peach orchard on soil-and-water conservation and its effectiveness on soil improvement were compared with seven other soil-and-water conservation treatments (Figure 1; Table 4). It was found that planting bahiagrass significantly reduced the soil erosion. In certain treatments, the soil erosion was close to or even zero.

After three years of planting bahiagrass, the characteristics of soil physical and chemical were determined. The results indicated that planting bahiagrass significantly increased soil organic matter, total nitrogen, effective potassium, etc. while soil capacity and density were decreased.

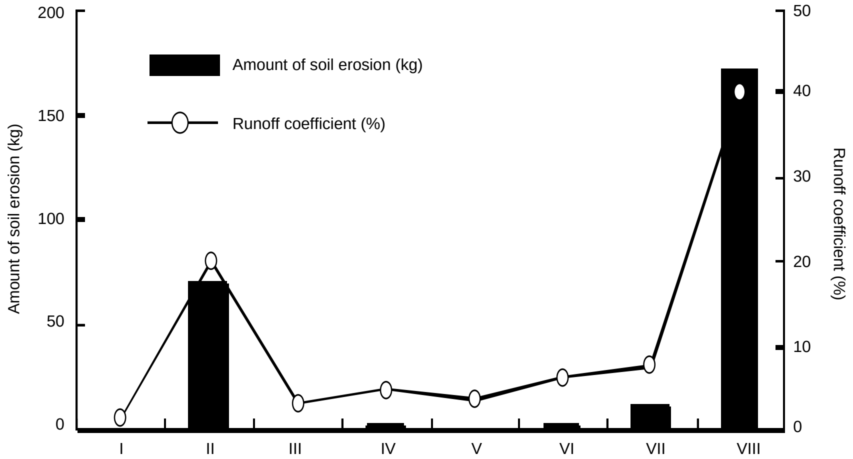

Figure 1. The effects of planting bahiagrass on red soil as a covering crop in peach orchard on soil-and-water conservation and on soil improvement were compared with seven other soil-and-water conservation treatments. Treatments were: I, level bench terrace planted bahiagrass on the slope; II, level bench terrace without planting bahiagrass on the slope (bared slopes); III, fully covered with bahiagrass; IV, strips of bahiagrass and soybeans planted between rows of peach trees; V, strip-covering with bahiagrass between rows of peach trees; VI, fully covered with centipede grass [*Eremochloa ophiuroides* (Munro) Hack.]; VII, strips of vetiver [*Vetiveria zizanioides* (L.) Nash] and peanuts planted between rows of peach trees; and VIII, bared cultivated plot as check.

Table 1. Total (tonnes/ha) and daily (kg/ha/day) dry matter yield of bahiagrass at different growth stages.

Stage of growth	Tillering	Internode elongation	Heading	Flowering	Maturing	Regenerating
Date	9 May	4 June	15 June	24 June	27 July	21 October
Total	1.26	4.25	4.90	4.99	9.55	11.72
Daily	42	115	64	10	134	25

Table 2. Dynamics of dry herbage yield (tonnes/ha) of bahiagrass cut at monthly intervals and with different levels of nitrogen application.

N applied (kg/ha)	5 May	4 June	4 July	4 August	4 September	4 October	4 November	Total
20.7	1.28	2.26	4.19	3.07	1.61	1.10	0.64	14.16
41.4	1.26	3.13	5.47	4.10	2.24	1.75	1.09	19.03

Table 3. Nutrient elements (%) of bahiagrass.

Growth stage	Date	Crude protein	Crude fat	Crude fibre	Non-N extract	Ash	Ca	P
Tillering	9 May	14.2	6.7	28.4	37.6	8.7	0.71	0.27
Elongation	4 June	10.4	1.2	29.8	42.1	8.9	0.96	0.23
Heading	15 June	9.0	1.9	31.2	49.4	7.1	0.92	0.21
Flowering	24 June	6.8	1.8	32.5	49.5	7.9	0.90	0.18
Maturing	27 July	5.1	2.0	33.5	49.9	7.9	0.98	0.14
Regenerating	21 October	7.8	4.4	31.5	39.4	9.9	1.28	0.25

Table 4. The effect of planting bahiagrass on soil physical and chemical characteristics 3 years after planting.

Treatment	Organic matter (g/kg)	Total nitrogen (g/kg)	Effective P (mg/kg)	pH	Soil porosity (%)	Total porosity (%)	Soil bulk density
Grass	1.7	0.87	5.76	5.5	48.2	54.1	1.23
No grass	7.0	0.50	2.11	5.2	45.3	47.2	1.44

Discussion

Planting bahiagrass in Jiangxi Province has many advantages. Bahiagrass adapts well to the soils and climate, has a high herbage yield and is a nutritious feed for ruminants. When planted under orchards, on red soils on sloping land, bahiagrass has beneficial effects in terms of soil-and-water conservation and on the improvement of soil characteristics.

There are extensive sloping lands with red soils in Jiangxi Province, and the current developmental model for small farmers is mainly to plant economic trees such as orchards.

For the research and extension of bahiagrass for the past 10 years, it is clearly demonstrated that the use of 'fruit tree-bahiagrass-ruminant' is a production model suitable for small farmers to develop sloping land agriculture and to improve their living conditions.

References

Burton, G.W. 1940. The establishment of bahia grass (*Paspalum notatum*). Journal of the American Society of Agronomy, 32: 545–549.

Burton, G.W. 1943. Factors influencing seed setting in several southern grasses. Journal of the American Society of Agronomy, 35: 465–474.

Hirata, M. 1998. Dynamics of the horizontal distribution of herbage mass in a bahiagrass (*Paspalum notatum* Flugge) pasture grazed by cattle: Stability of spatial pattern of herbage mass. Grassland Science, 44: 169–172.

Ji, M.C., Dong, W.D., Xie, G.W., Li, D.R. and Liu, S.Y. 1999. A preliminary study on the application of bahiagrass in soil conservation and slopeland agriculture. Acta Agri. Univ. Jiangxiensis, 21: 226–228. (Chinese with English abstract).

Scott, J.M. 1920. Bahia grass. Journal of the American Society of Agronomy, 12: 112–113.

Potential of *Chamaecrista* spp. in southern China

Ying Zhaoyang[1], Wen Shilin[2] and J.B. Hacker[3]

THE Red Soils Region of central, southern China covers a belt c. 1500 km long and 800 km wide, including most of the provinces of Zheijang, Fujian, Jianxi and Hunan, and parts of Anhui and Guangxi (Horne 1991). The total area is about 1.64 million km^2, of which 65% is mountainous land. Soils are acidic, summers are hot and winters are cold (Figure 1).

Much of the area is deforested and seriously degraded, and there is interest in the region in developing a livestock industry. Studies by University of New England researchers identified several grasses adapted to the region, but few legumes. The most promising was *Chamaecrista rotundifolia* cv. Wynn, Wynn cassia (Zhang et al. 1991; Wen Shilin et al. 2000).

Wynn cassia is currently used as a ground cover in orchards, and as a feed for livestock, including rabbits and pigs. However, Wynn cassia does not perennate, is slow to establish, self-sown seed germinates late and it is only moderately palatable to livestock. A collection of 40 accessions was evaluated at Qiyang, Hunan Province, and Jianyang, Fujian Province, with the aim of selecting genotypes superior to cv. Wynn with regard to winter survival and seedling regeneration the following spring.

Materials and Methods

The accessions tested covered the natural geographic range of *C. rotundifolia*, from 20°45′N to 28°53′S (Pengelly et al. 1997) and included 34 accessions and cv. Wynn. In selecting accessions for evaluation, high latitude accessions were prioritised. Also included were three accessions of *C. serpens*, two of *C. nictitans* and one of *C. pilosa*.

At each site, plots were fertilised and limed according to University of New England recommendations. Seed was inoculated and sown into a cultivated seedbed on 1 May 1997 (Qiyang) and 25 April 1997 (Jianyang). Plots were 1.5 × 1.5 m and rows 20 cm apart; there were three replicates at each site. Seedlings were thinned to a spacing within rows of c. 15 cm. Plots were cut back in November.

Yield was rated at fortnightly intervals on a 1–5 scale over the growing season and scores averaged to provide an overall performance score. Flowering was recorded as number of days after 1 June that the first flower appeared. Plant survival in spring 1998 was noted as a percentage. Seedling regeneration was assessed at weekly intervals from 2 April to 24 May 1998, in an area of 0.5 m^2 in each plot.

Results

Survival over winter

No cv. Wynn plants survived over winter at either site. Eight accessions of *C. rotundifolia* and one of *C. nictitans* had some plants surviving over winter at Jianyang, and five (including *C. nictitans*) had >50% survival (Figure 2).

All accessions with surviving plants originated from latitudes south of 23°S and no northern high-latitude accessions survived over winter at either site. The only accession to survive over winter at Qiyang (30% survival) had 35% survival at Jianyang. This accession was from 29°S and was the highest latitude accession tested. The poorer survival at Qiyang was associated with lower winter temperatures (Figure 1).

Seedling regeneration

Seedling regeneration in spring was closely (negatively) correlated with days to flowering the previous summer at Qiyang (Figure 3), but there was no such relationship at Jianyang. The reason for the

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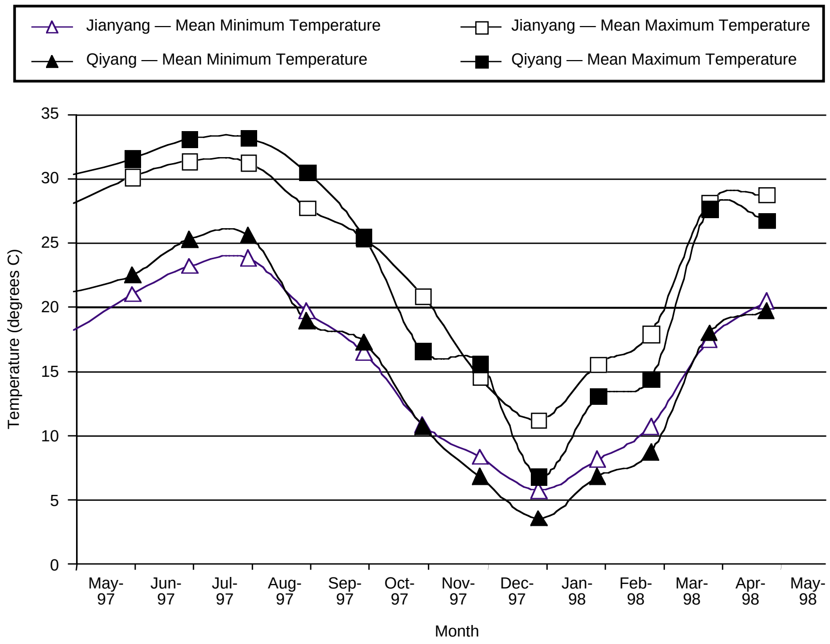

Figure 1. Mean minimum and maximum temperatures near the experimental sites.

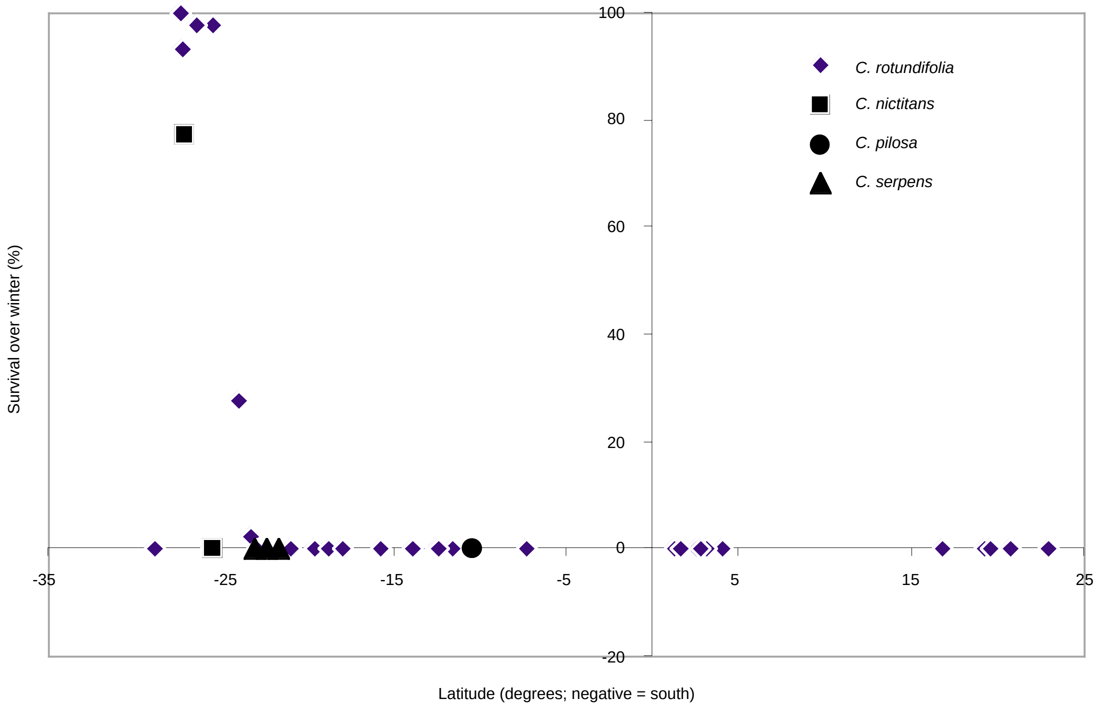

Figure 2. Relation between winter survival at Jianyang and latitude of provenance.

difference between the two sites is not understood. There was excellent establishment and growth at Jianyang the previous year, the soil conditions were apparently superior to those at Qiyang, and there was good spring rainfall. The only two accessions with high seedling numbers at Jianyang were the two *C. nictitans* entries, with 496 and 2321 seedlings/0.5 m^2 (cf. cv. Wynn with 30 and the best *C. rotundifolia* with 105 seedlings/0.5 m^2).

Early-flowering accessions were generally from higher latitudes and developed a lower canopy height (data not presented) than accessions from low latitudes.

Yield of accessions which survived over winter

Four accessions of *C. rotundifolia* and 1 of *C. nictitans* had >50% survival over winter at Jianyang. On average, the four *C. rotundifolia* accessions had lower mean yield ratings averaged over the previous May–December, had lower canopies and were earlier flowering than cv. Wynn (Table 1). They had a similar number of seedlings to cv. Wynn the following spring (but 70% more seedlings at Qiyang).

The surviving *C. nictitans* accession was notable for its tall growth and abundant seedlings the following spring (Table 1).

Conclusions

Several accessions of *Chamaecrista rotundifolia* were identified which survived over winter at Jianyang, south China and one of these also had a high percentage survival at a cooler site, Qiyang. They all originated from high southern latitudes in

Table 1. Some attributes of *Chamaecrista* species which had >50% survival over winter at Jianyang.

	Mean yield ratings May–Dec. (1–5 scale)	Max canopy height (cm)	First flower (days after 1 June)	Seedlings following spring (no/0.5 m^2)
4 *C. rotundifolia* with >50% survival	2.1	43	14.5	30
1 *C. nictitans* with >50% survival	3.0	112	62.3	496
cv. Wynn	3.4	49	21.7	30
Overall mean	3.3	76	40.4	—

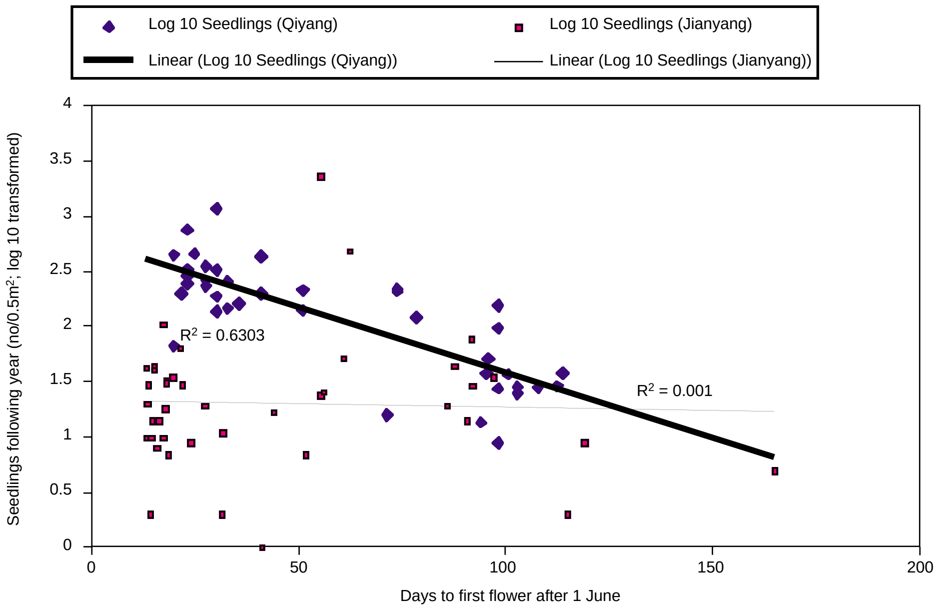

Figure 3. Relation between days to flowering and number of seedlings the following spring at Jianyang and Qiyang.

South America. On average, these accessions were lower yielding than cv. Wynn and flowered earlier. An accession of *C. nictitans* also survived over winter. This accession was later-flowering but re-established well from seed the following spring.

Early flowering accessions at Qiyang germinated and emerged more prolifically the following spring than late-flowering accessions. At Jianyang, emergence the following spring was poor, except for *C. nictitans*.

The trials have identified accessions with potential for the region, but further trials should be conducted to assess extent of adaptation.

Acknowledgment

We are grateful to the Australian Centre for International Agricultural Research for funding this research.

References

Horne, P.M. 1991. A simple agro-climatic model for forage production on the red soils of south central China. In: Horne, P.M., MacLeod, D.A. and Scott, J.M., ed. Forages on Red Soils in China. Proceedings of a Workshop, Lengshuitan, Hunan Province, Peoples' Republic of China, ACIAR Proceedings No. 38, Canberra, ACIAR, 22–28.

Pengelly, B.C., Maass, B.L., Thomas, B.D. and Hacker, J.B. 1997. Origin of the world's collection of the tropical forage legume *Chamaecrista rotundifolia*. Proceedings of the 18th International Grassland Congress, 125–126.

Zhang, J., Wen, S., Horne, P., Scott, J. and Blair, G. 1991. Introduction and establishment of forages on the red soils of south central China. In: Horne, P.M., MacLeod, D.A. and Scott, J.M., ed. Forages on Red Soils in China. Proceedings of a workshop, Lengshuitan, Hunan Province, Peoples' Republic of China, ACIAR Proceedings No. 38, Canberra, ACIAR, 125–128.

Poster Paper

Ridge Tillage System Enhances Corn Productivity, Profitability and Sustainability

A.R. Mercado, Jr[1], D.P. Garrity[2], C. Pailagao[1], B. Thapa[3] and D. Badino[4]

CORN is the dominant crop in northern and central Mindanao, where it accounts more than 40% of the total farm area, and throughout the Philippines. It is the staple food for most upland farmers. In Claveria, 70% of the total population consumes corn grits as their staple food (Mandac et al. 1987). However, the bulk of the corn produced in this region is exported to Cebu and Manila, to meet the growing needs of the feed millers as raw materials to feed the expanding needs in poultry, piggery, and fishpond industries. As the population pressure increases, there has been a corresponding need to increase corn production to feed the rapidly growing population and the expanding animal and fish industries.

The search for options to meet these growing needs, such as expansion of the corn growing areas, use of improved technology to improve productivity, and intensification of cropping to increase total annual productivity, are indeed necessary. The expansion of corn growing areas has been pushed toward unfavourable sloping lands, and to the forest margins or to clearing more forests. Besides, lots of prime agricultural lands have been converted to non-agricultural uses to give way to urbanisation. In fact, 18 million Filipinos eke out a living on slopes above 30% or on upper watersheds. Inappropriate farming practices in these fragile areas contributed significantly to the degradation of the resource base, such as severe soil erosion, loss of bio-diversity and sedimentation of rivers, creeks, coastal areas and farmlands.

The use of improved technology to increase productivity is a necessity. Soil erosion has been a major problem in improving and sustaining corn productivity. In sloping areas where no soil conservation has been practiced, annual corn yields have declined by as much 300 to 700 kilograms per hectare (Fujisaka 1989) Crop intensification has been challenged by weed management as the conventional land preparation requires six to 10 weeks turnaround time between crops, limiting production to two crops per year. In areas with a shorter rainy season, the second crop is exposed to moisture deficit towards the end of the growing season, resulting in low grain yield.

Land management systems that will improve and sustain corn productivity, while intensifying cropping to increase total annual productivity and at the same time reduce production costs to enhance profitability are indeed a very difficult combination of objectives. The ridge tillage system (Buchele 1954), a conservation farming practice developed in the mid-western United States, with simple modifications to fit the local environment, was considered to be a possible option. This tillage system uses herbicide as a method of land preparation to reduce turnaround time between crops and reduce land preparation costs. The ridges formed reduce lateral surface flow of water, creating micro-impoundments, thus increasing infiltration and reducing soil erosion. The ridge tillage system requires limited land disturbance by tillage, resulting in a significant reduction in soil erosion induced by tillage.

The objective of this study was to evaluate alternative land management systems using contoured barriers of ridge tillage system and natural vegetative filter strips (NVS) to enhance corn productivity, profitability and sustainability in sloping uplands. This study focuses on evaluating the effects of these land management systems on soil erosion, crop yield, weeds, hydrological properties and economic benefit under sloping acid upland environments.

Materials and Methods

Four alternative land management systems were evaluated in two upland sites in Northern and Central

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Mindanao namely: Claveria, Misamis Oriental, and Lantapan, Bukidnon.

In Claveria, the two experimental fields were located in Barangays Ani-e and Patrocenio, with slopes of 22% and 18%, respectively. The soil in the Ani-e site is a very fine, kaolinitic, isohyperthermic, lithic hapludox, and at the Patrocenio site, the soil is a very fine, kaolinitic, isohyperthermic, rhodic hapludox. Elevation at both sites is about 500 m above sea level. The two sites are located about two kilometres apart.

The land management systems compared were:

T1 Contour ploughing (CP)–farmers' practice (control). Ploughing, harrowing, furrowing and interrow cultivations were done along the contour using a conventional single mouldboard plough. Land preparation includes 2–3 ploughings and harrowing between ploughings.

T2 Ridge tillage (RT)–contour barriers formed by ridge tillage. Ploughing, harrowing, furrowing and interrow cultivations as in T1 for the first crop, but during the hilling-up operation (30 days after emergence) a double mouldboard plough was used to create 20 cm high ridges. After formation, these ridges were maintained permanently except for minor disturbances during seeding while furrowing for the succeeding crop. Prior to the subsequent crop, the corn stalks were slashed into 3–4 pieces. After slashing herbicide was used to control weeds before seeding, which was carried out 5–7 days after harvesting the preceding crop.

T3 Natural vegetative filter strips (NVS)–contour barriers formed by NVS. Fifty cm wide grass strips, usually of natural vegetation, were laid out along contour lines using an A-frame and spaced at 1.5 m vertical interval (approximately 8–10 m apart, depending on the slope of the plot). Grass growing on the strips was cut 2–3 cm above ground level at 45 days intervals and the cut material applied uniformly to the alleyway as mulch or ploughed under during land preparation.

T4 NVS + RT–combination of contoured barriers using natural vegetative strips and ridge tillage.

Each treatment (plot) was 50 m long (top to bottom), and 12 m wide. The four treatments were arranged in a randomised complete block (RCB) design with three replications in each site, thus making a total of six replications.

At the start of the experiment in July 1992, lime (3 tonnes/ha) was applied uniformly to correct soil acidity. Furrows were constructed 60 cm apart, using a single mouldboard plough. Phosphorus (30 kg/ha), potassium (30 kg/ha) fertilisers and Furadan 3G (18 kg/ha) were applied as basal nutrients in the furrows. Pioneer hybrid (3072) corn was seeded at 25–30 cm apart within the row. Nitrogen fertiliser (urea) at the rate of 80 kg/ha was applied in two equal two splits, 15 days after emergence (DAE) and 30 DAE during off-barring and hilling-up, respectively. During hilling-up (30 DAE), a single mouldboard plough was used for T1 and T3, and double mouldboard plough for T2 and T4. Generally, the first crop was planted in May and harvested in August. The second crop followed in September or October and was harvested in December or January. For ridge tillage treatments (T2 and T4), turnaround time between cropping was shorter, thus accommodating more crops each year. These cropping cycles were practised until the termination of the experiment in 1995.

To monitor soil loss, a sediment collection trench (50 cm deep, 50 cm wide, 6 m long), lined with bamboo splits, was laid out at the bottom of each plot. Galvanised iron sheets, 20 cm wide and 2.4 m long, were used to outline the erosion plot (6 m × 50 m) and to prevent water and sediments from coming on or leaving the plot. The soil sediment (bed load) remaining in the trench was collected and weighed twice each month, and a sub-sample of 500 g was oven dried and weighed. The dry bed load was then calculated on a per hectare basis.

Infiltration rate was determined using a single ring infiltrometer (20 cm inside diameter and 25 cm high) (Van Es et al. 1991; Cassel et al. 1994). The ring was inserted 12 cm into the soil. The soil surface inside the ring was covered with a double layer cheesecloth. One litre of water (3.2 cm) was added into the ring and a constant head device (Thapa 1991) was used to determine the steady state of infiltration rate. The average infiltration rate for different geomorphic surfaces and soil management systems was calculated. Soil erosion, crop grain and total dry matter yield and other agronomic characters, and weed weights were collected and analysed using SAS procedures.

In Lantapan, a similar experiment was conducted in the foothills of the Mt. Kitanglad National Park in collaboration with SANREM CRSP. Three treatments were compared:

T1 – contour ploughing (CP) – farmers' practice, referred to as control;

T2 – Ridge tillage (RT) – contour barriers formed by ridge tillage;

T3 – natural vegetative filter strips (NVS) – contour barriers formed by NVS.

These 3 treatments were laid out in 5 farms, which served as replicates. Each treatment was laid out in a 12 m × 48 m plot. A soil collection trench lined with bamboo splits (similar to Claveria) was installed at the bottom of each plot to quantify soil loss. Data on grain yield, total dry matter yield and other agronomic characters, weed weights, and soil erosion were taken and analysed using SAS procedures.

Results and Discussion

Annual soil loss

Annual soil loss at the Claveria site over the period 1993–1995 is presented in Table 1. At the Patrocenio site, soil loss was much lower than at Ani-e, averaging 2.85 tonnes/ha/yr. This was due to shallower slope (18%) than at the Ani-e site (24%). The control treatment (T1) showed a significantly higher annual soil loss than the other land management systems. The ridge tillage system reduced soil loss by 49%, while NVS reduced soil loss by 97%. Combining RT and NVS reduced soil loss by 96%.

At the Ani-e site, the ridge tillage system reduced soil by 58%, while NVS reduced soil loss by 91%. By combining NVS and ridge tillage, soil loss was reduced further to 95% of the control. The high soil loss of the bare plot compared to the control suggests that planting corn and planting it along the contour reduced soil loss by 73%. By having the ridge tillage system alone, soil loss was further reduced 86% of the control. NVS reduced it further to 97% and combining NVS +RT reduced soil loss to 99%.

Also presented in Table 1 is the average soil loss at the Lantapan site. These are average values in 3 years (1996, 1997 and 1998). The mean annual soil loss across all treatments was 8.74 tonnes/ha/yr. The control treatment at the Lantapan site lost 14.8 tonnes of soil per hectare, which was statistically higher than with other land management systems. The ridge tillage system had a soil loss of 7.4 tonnes/ha, which was 50% less than the control, while the NVS treatment had a 73% reduction in soil loss.

Table 1. Soil loss as influenced by different management systems, Mindanao, Philippines.

	Soil loss (tonnes/ha/yr)		
	Ani-e[1]	Patrocenio[1]	Lantapan[1]
Control (open field – T1)	23.4[a]	7.2[a]	14.8[a]
Ridge tillage (RT – T2)	9.8[b]	3.7[b]	7.4[b]
Natural vegetation strips (NVS – T3)	2.2[c]	0.2[c]	4.1[b]
RT plus NVS (T4)	1.1[c]	0.3[c]	–
Mean	9.1	2.9	8.7
Bare plot*	85.5		

[1]Average value over 3 years, 1993, 1994, 1995.

[2]Average value over 3 years, 1996, 1997, 1998.

Within columns, means followed by a common letter are not significantly different (P>0.05).

Steady state infiltration rate

The effect of soil management systems on the steady state infiltration rate is presented in Table 2. The crop row, which was along the ridge top, had a higher infiltration rate (49 cm/h) than the crop rows in contour ploughing (38 cm/h). Ridge tops seem to act as sponges for water absorption. Inter-ridge areas, however, generally had lower infiltration rates. The infiltration rate was 4-fold higher (59 cm/h) at the lowest side of the alleyway, above the grass strips, than at the central part of the grass strips (15 cm/h). The increased infiltration rate in ridge tillage and in areas above the grass strips dramatically reduced lateral water runoff, thus reducing water-induced soil erosion. The ponding of water in the inter-ridges and increased infiltration rate in grass strips contributed significantly in the very low soil loss in treatment where the ridge tillage and NVS were combined (T4).

Table 2. Effect of different land management systems on steady state infiltration rate (cm/h) at Claveria, Misamis Oriental.

Land management system	Open field/ alleyways		Natural vegetation strips	
	Crop row	Between rows	Middle	Lowest side of alley
Contour ploughing	37.6	17.6	–	–
Ridge tillage (RT – T2)	48.9	16.8	–	–
Natural vegetation strips (NVS – T3)	41.3	27.2	14.9	58.8
RT plus NVS (T4)	47.9	9.1	17.7	47.5

Grain yield

In Claveria (both Patrocenio and Ani-e sites), there were no statistically significant differences between treatments (Table 3). With NVS treatments, T3 and T4, yields were lower (although not significantly lower) than in other treatments, perhaps due to the area allocated to hedgerows. In Lantapan, the Ridge tillage system (T2) had the highest grain yield, significantly higher than NVS, but not statistically different from the control (T1). The reduced yield of NVS was due to the area allocated to hedgerows which were wider in Lantapan than at the Claveria sites due to the steeper slopes at Lantapan.

The effect of land management system on annual corn production is presented in Table 4. The Ridge Tillage systems (T2 and T4) made it possible to grow three crops a year, due to the reduced turn around period between crops. On average, these treatments yielded 13.26 tonnes/ha/yr, compared with the average of 9.48 tonnes/ha/yr for non-ridge tillage treatments (T1 and T3). The additional third crop, which yielded 3.78 tonnes, increased the annual grain yield by 40%. This was one of the important added benefits to the ridge tillage system, where the growing period allows it, particularly in areas similar to Claveria and Lantapan with no pronounced dry season climate.

Table 3. Average grain yields (tonnes/ha/crop) of corn as influenced by different management systems, Mindenao, Philippines.

Management system	Ari-e	Patrocerio[1]	Lantapan[2]
Control (open field – T1)	3.80	4.28	3.46
Ridge tillage (RT – T2)	3.50	4.29	3.56
Natural vegetation strips (NVS – T3)	3.40	4.06	2.98
RT plus NVS (T4)	3.10	4.16	–
Mean	3.45	4.20	3.33
Probability (P = 0.05)	ns	ns	*

[1] Mean of 7 crops (1992–1995).
[2] Mean of 4 crops (1996 1st crop; 1998 1st crop).
* Significant at 5% level.

Table 4. Annual corn yield (tonnes/ha) as influenced by management system. Claveria, Misamis Oriental. 1994.

Management system	Ari-e	Patrocerio
Control (open field – T1)[1]	9.41	6.50
Ridge tillage (RT – T2)[2]	13.16	8.90
Natural vegetation strips (NVS – T3)[1]	9.55	5.70
RT plus NVS (T4)[2]	13.36	7.70
Mean	11.37	7.20

[1] Total of 2 crops.
[2] Total of 3 crops.

Economic analyses

The economic analyses of annual corn production are presented in Table 5, which compares the ridge tillage systems using herbicides (T2 and T4) with the conventional farming system (T1 and T3). The analyses assumed a total of 3 crops in the ridge tillage system, while the conventional farming system assumes 2 crops. The total input cost of the ridge tillage system includes the cost of land preparation during the first crop, fertilisers, insecticide (Furadan 3G) herbicide costs during the two subsequent crops, labour in supplementary weeding, harvesting, shelling, drying, and marketing. The total output represents the total sales of corn grain harvested from the three crops. The conventional farming total input costs for two crops included the cost of land preparation for both crops, fertiliser and pesticide (Furadan 3G).

Table 5. Input-output analysis as influenced by different land management systems. Claveria, Misamis Oriental, Philippines. 1994.

Land management system	Input (P)	Output (P)	Net profit (P)
Ridge tillage (3 crops)	29 080	68 540	39 460
Conventional farming (2 crops)	21 100	46 090	24 990
Comparative advantage of ridge tillage			14 470

The difference in net income between the ridge tillage system and conventional farming was P 14 470, which represented a 58% benefit to the new land management system as compared to the system traditionally used by local farmers.

References

Buchele, Wesley F. 1954. Ridge farming and plan root environment. Ph.D. Dissertation. Iowa State University.

Cassel, D.K., Vans Es, H.M. and Agus, F. 1994. Rapid, indirect assessment of soil structure using small ring infiltrometers. In: Stone, J.A., Kay, B.D. and Angers, D.A. ed. Soil Structure Research in Canada. Proceedings of Eastern Canada Soil Structure Workshop Sept. 10–11, 1990, Guelph, Ontario, Ellis Edwards, 19–27.

Fujisaka, S. 1989. The need to build upon farmer practice and knowledge reminders from selected upland conservation projects and policies. Agroforestry Systems, 9: 141–153.

Mandac, A.M., Magbanua, R.D. and Genesila, M.P. 1987. Multiple cropping systems in Northern Mindanao. Philippine Journal of Crop Science, 12(2): 71.

Thapa, B. 1991. Evaluation of infiltration, surface runoff, and soil losses at various levels of rainfall in relation to surface cover, tillage, and soil management practices. MSc Thesis (Soil Science) University of the Philippines, Los Baños, Laguna, Philippines.

Van Es, H.M., Cassel, D.K. and Daniels, R.B. 1991. Infiltration variability and correlations with surface soil properties for an eroded Hapludult. Soil Science Society of America Journal, 55: 386–392.

Appropriate Spacing of Natural Vegetation Buffer Strips in Upland Conservation Farming Systems

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SOIL erosion is recognised as being the major problem in cultivated sloping uplands in Southeast Asia (Cruz et al.1988; Garrity 1993; Fujisaka et al. 1994; Garrity et al. 1995). It is one of the major problems besetting the uplands of the Philippines and causes rapid degradation in soil quality, nutrient depletion and decline in crop productivity (Lal 1984; Stocking and Peake 1986; El-Swaify 1993; Turkelboom et al. 1993). Contour hedgerow systems using nitrogen-fixing trees have been promoted to minimise soil erosion, restore soil fertility, and subsequently improve crop productivity (Huxley 1986; Young 1986, 1987; Kang and Wilson 1987), and have been a common feature of extension programs for sustainable agriculture on the sloping uplands in Southeast Asia (Garrity 1996). This innovation has not been widely adopted by the upland farmers (Fujisaka et al. 1994), despite positive results having been observed and reported in a number of experimental and demonstration sites. Constraints that limit the effectiveness and adoption of pruned-tree hedgerows include the tendency for the perennials to compete for growth resources, and hence reduce yields, of associated crops planted in adjacent rows, and the inadequate amount of phosphorus recycled to the crop in the prunings (Garrity 1996). But the major problem is the enormous amount of labour needed to prune and maintain them. In one study, farmers' labour investment to prune their leguminous-tree hedgerows was about 31 days per hectare, or 124 days annual labour for four prunings (ICRAF 1996). There is a need for a simple, less labour intensive but effective contour hedgerow system.

The use of natural vegetation filter strips (NVSs) has proven to be an attractive alternative because of their simplicity in establishment and maintenance. NVS are laid out along the contour lines by leaving 40–50 cm of unploughed strips spaced at desired intervals, usually 6 to 10 m apart. The contour lines are determined by using an A-frame. The natural vegetation that is growing in the strips is very effective for soil and water conservation; it filters the eroded soils, slows down the lateral flow of water and enhances water infiltration. Researchers found that these natural vegetation filter strips have many desirable qualities (Garrity 1993). They needed much less pruning maintenance than fodder grasses or tree hedgerows, and offered little competition to the adjacent annual crops compared to the introduced species (Ramiaramanana 1993). They are efficient in minimising soil loss (Agus 1993), and do not show a tendency to cause greater weed problems for the associated annual crops (Moody 1992 pers. com. as cited in Garrity 1996). Natural vegetation filter strips (NVSs) were found to be an indigenous practice on a very limited scale in some localities in the Philippines, including Batangas (Garrity 1996) and, between 1944 and 1977, in Leyte Province (Fujisaka 1993).

Despite the benefits of natural vegetation filter strips, farmers are still concerned about the loss in cropped area (field area allocated to hedgerows), and the consequence of eventual scouring of the upper alleyways (Tulkelboom et al. 1993; Garrity and van Noorwijk 1995; Garrity 1996). The greater the number of strips, the more the reduction in cropped area and scouring of the upper alleyways. The rule of thumb has been to space the hedges at 1 m vertical drop (Watson and Laquihon 1986) which translates into approximately 6 m apart, when the slope is 20%. This is translated into 15% of the cropped area being

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lost to hedgerows. The crops in the alley must therefore increase by at least 15% to compensate for this cropped area loss.

It is logical to assume that a fairly dense pattern of hedgerows would minimise soil loss. But a dense hedgerow pattern removes a larger portion of the field area from crop production, thus reducing the attractiveness of this soil conservation technology in terms of adoption. Hence, our experiment was aimed at determining the relationship between hedgerow density and soil loss. If this question can be answered satisfactorily it is possible to determine with greater precision the implications of starting with fewer strips.

Our experimental hypothesis was that soil loss is negatively correlated with hedgerow density, but follows an asymptotic curve that indicates a much smaller reduction in marginal soil loss as the density of strips increases. Our hypothesis, based on our experience with the Modified Universal Soil Loss Equation (MUSLE), is that the soil loss will not increase proportionally relative to the slope length. Thus, a reduction in hedgerow density to 1/2 or 1/4 of that normally recommended will be associated with the increase in off-field soil loss much less than double or quadruple that indicated if the two factors were proportionally related. This experiment will provide data to calibrate the MUSLE for tropical acid upland soils with natural vegetation filter strips installed at variable distances. The data will also provide clear guidance as to the functional relationship between hedgerow density (alley width) and the concomitant soil loss expected. Better tradeoffs may enable the development of management recommendations for wider hedgerow spacing more consistent with farmers' demands for less than 10% reduction in aggregate crop area.

One further issue to be explored is whether wider alleyways (i.e. greater elevation drop between hedgerows) will exacerbate the development of upper alley scouring effects. This might be expressed as the depth of soil removed from the upper alley, which will be greater as the terraces flatten out.

Materials and Methods

The experimental site is located at Lupoc, Ani-e, Claveria, Misamis Oriental, Philippines. The experiment was conducted on land with about 45% slope owned and managed by the Misamis Oriental State College of Agriculture and Technology (MOSCAT), which was as an institutional collaborator in this research. The soil is classified as Ultic Haplorthox with pH ranging from 4.2 to 5.1, averaging 4.7. The site is part of the college corn production income generating project. Land preparation, crop establishment, maintenance, and protection were carried out by the college. These different field operations were uniformly applied throughout the experimental field. The NVS or the different treatments were laid out in March 1995, before land preparations was carried out.

There were five treatments:

- T1 – no NVS (control);
- T2 – one NVS at the middle of about 50 m long;
- T3 – three NVS spaced at about 4 m vertical drop;
- T4 – seven NVS spaced at about 6 m apart or 2 m vertical drop; and
- T5 – fifteen NVS spaced at about 3 m apart or 1 m vertical drop of this 45% slope.

These 5 treatments were replicated 3 times in a randomised complete block design (RCBD). Individual plots were 48 m long and 6 m wide.

Trenches of 6 m long, 50 cm deep, and 50 cm wide lined with bamboo splits were installed at the bottom of each treatment to collect eroded soils. Galvanised iron sheets lined each plot. The eroded soils were collected once or twice a month or as soon as we observed soil in the trenches. Soil samples were weighed and sub-samples were taken and oven dried to determine the moisture content.

During the onset of rainfall and after the thorough land preparation, which included 2–3 ploughings and 1–2 harrowings, the field was furrowed at approximately 70 cm apart. Three bags of diammonium phosphate (18%N-46%P_2O_5-0%K_2O), 1 bag of potash (0%N-0%P-60%K_2O), 20 bags of chicken manure, and 1 bag of furadan 3G per hectare were applied in the furrow as basal. Lime was applied before the last ploughing and harrowing at the rate of 2 tonnes per hectare. Maize (Pioneer hybrid #3014) was sown at approximately 30 cm spacing between hills and in rows 70 cm apart. Interrow cultivation was done 7 days after emergence (DAE), off-baring (the mouldboard directed away from the plants or towards the middle) at 15 DAE, and hilling-up at 30 DAE. Immediately before the hilling up, 3 bags of urea (46%N) were applied per hectare as side-dressing, followed by handweeding 40–45 DAE. There were 2 pruning operations in each cropping cycle, one before planting and the other in the middle of the growing season. The maize was ready for harvest approximately 110 DAE and was harvested by cutting the plants at ground level row by row from the bottom of the plot to the top. Samples were processed and weighed row by row. Sub-samples were taken to determine moisture content. Cobs were shelled, the grain was dried and weighed, and moisture content was adjusted to 14%, row by row.

The experiment was conducted over 6 cropping cycles, May 1995–March 1999, excluding two crops that are not reported, a crop of upland rice which was completely wiped out by rats, birds and leaf blast and a crop of maize planted right before the onset of El Niño.

Data are based on total plot area, not just the area which was sown to the crop. Collected data on grain yield, total dry matter yield, plant height, soil loss, productive plants, harvest index, pruning parameters were analysed by ANOVA in RCB design using Statistical Analyses Systems (SAS 1996).

Results

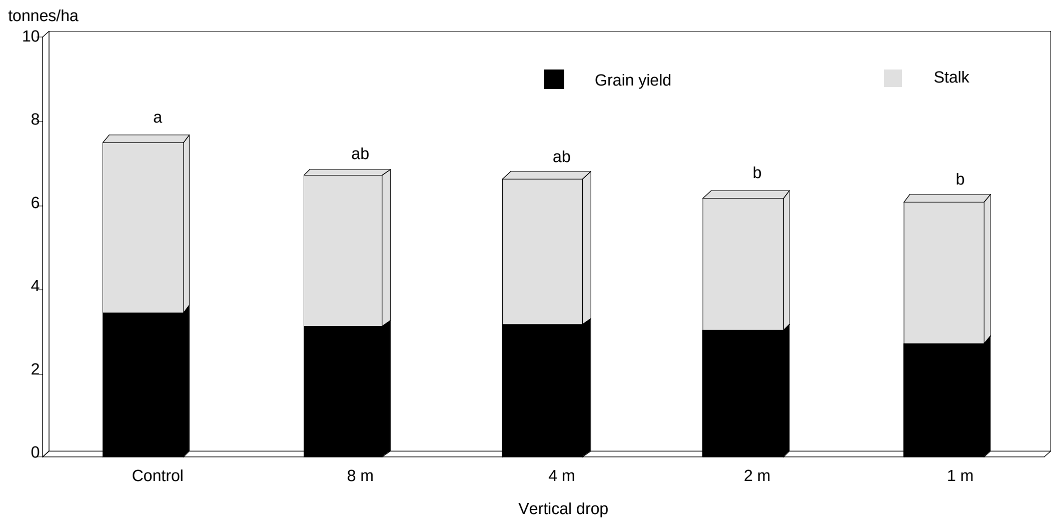
Crop productivity

During the 6 successive cropping cycles, rainfall distribution was good and the crops were able to produce good harvests, except during the El Niño period from October 1997 to May 1998. During this long dry spell, the crop suffered drought stress but was able to produce grain. During the first two crops grain yield and total dry matter yield did not show significant differences between treatments, but differences were significant during the 3rd, 4th, 5th and 6th crops. The treatments with more hedgerows had lower grain and total dry matter yields than those with fewer or no hedgerows (Figure 1). The reduction in grain and total dry matter yields in treatments with more hedgerows was attributed to a lower proportion of cropped land. There were fewer crop rows in treatments with more hedgerows than in treatments with fewer hedgerows. Although there were no significant differences in plant height, plants were taller in the control treatment.

The effect of the different spacings of natural vegetation buffer strips on vertical drop between NVS, alley width, crop area loss, maize row spacing, pruning labour, change in slope and embankment are presented in Table 1. The average row spacing is computed based on the total length of the plot divided by the total number of rows in a given plot. The mean row spacing is wider where hedgerows were dense than where there were fewer hedgerows. This relates to a larger cropped area loss in dense hedgerows (17%) than with less dense hedgerows. The wider the alleys, the higher the vertical drop. A 3 m wide alley gives a 1 m drop where the slope averages 45%.

Change in slope and embankment

The change in slope (in degrees) and embankment 4 years after the establishment of the NVS are presented in Table 1. In the control plot, there was no change in slope gradient, as expected. One single NVS changed the slope gradient of the alley to 19 degrees from 23, a 17% change. Fifteen NVS (1 m vertical drop) dramatically changed the slope to 8 degrees, reducing it by 65%. The closer the spacing of hedgerows, the more rapidly the land forms level



Bars having common letters are not significantly different (Duncan's Multiple Range Test) at 5%

Figure 1. Total dry matter yield of maize as influenced by different natural vegetative filter strips (NVS) spacing. Claveria, Misamis Oriental, Philippines (Mean of 6 cropping seasons).

terraces. The embankments are formed by accumulation above the hedgerow and scouring below it. A single NVS had the highest embankment after 4 years, while fifteen NVS had 30% lower embankments. This indicates that wider-spaced hedgerows accumulate more soil and form high embankments, than close-spaced hedgerows, but it takes them longer to form level terraces.

Soil loss

Soil loss as affected by different spacings of natural vegetation buffer strips spacing is presented in Figure 2. The data are the means of 4 years, from May 1995 to March 1999. The slope length of the erosion plot is 48 m long and 6 m wide, and the mean slope is 45%. The T1 treatment (no hedgerow) lost an average of 42 tonnes/ha/yr, significantly more than any other treatment. A single hedgerow was effective in reducing soil loss by about 40%. Although there were numerical differences in soil loss in all years between treatments T2 to T5, there were no statistically significant differences, due to high coefficient of variation (75–83%). Dense hedgerows (T5 –1 m drop) control erosion by more than 90%. When the number of hedgerows was reduced by half (T2 –2 m drop), the efficiency of the hedgerows reduced slightly to 80%.

Hedgerow pruning and biomass

Pruning in man-days/ha is directly related to the number of hedgerows, which are inversely related to the vertical drop and spacing. The greater the number of hedgerows, the more time it takes to prune them. In the 15 NVS treatment, where alleys were 3 m wide and the vertical drop 1 m, pruning 1 ha required 29 man-days, eight times as long as where there was a single NVS and alleys were 24 m wide. The amount of labor required in pruning the NVS hedgerow is directly proportional to the number of hedgerows; the denser the hedgerows the more the labour required to prune them.

The four major NVS species were *Chromolaena odorata, Imperata cylindrica, Rottboellia cochinchinensis, Ageratum conyzoides*, and a range of minor species collectively termed ‘others’, which includes: *Pennisetum polystachion, Mukania cordata, Passiflora foetida, Elephantopus tomentosus, Setaria geniculata, Bidens pilosa, Borreria laevis, Paspalum conjugatum, Crassocephalum crepidiodes, Mimosa pudica, Centella asiatica* and *Cleome rutidosperma.* Total NVS species weights differed significantly in each pruning schedule. The species composition became more diverse as the cropping progressed, with more annual weeds invading the NVS strips. The danger that NVS species may invade the cropped alleys was not realised, as NVS are usually dominated by perennial species. Some weeds that invaded the NVS, such as *Rottboellia cochinchinensis*, may possibly be the source of weed seeds spreading into the alley, if the hedgerow is not pruned regularly.

The amount of biomass and the corresponding contribution of nutrients (NPK) are directly proportional to the density of NVS; i.e. the denser the NVS the higher the biomass. Having one NVS at the middle yielded (T2) 104 kg of total biomass per crop thus contributing 2 kg of N, 8.3 g of P, and 2 kg of K. Fifteen NVS produced 679 kg of total biomass with NPK contribution of 14.6, 0.5, and 12.5 kilograms, respectively. (Values are on a per hectare basis, with estimates based on total linear metres per hectare as influenced by spacing)

Discussion

Natural vegetation filter strips (NVS) have been suggested to be an alternative to leguminous-tree-based contour hedgerow systems because they are simple, less costly to establish and maintain (Garrity 1996), and less competitive with associated food

Table 1. The effect of frequency of natural vegetation strips (NVS) on vertical drop, alley width, crop area loss, maize row spacing, pruning labour required, and slope and embankment height after 4 years (accumulation + scouring) on an acid upland soil. Claveria, Misamis Oriental, Philippines.

Treatments	Vertical drop (m)	Alley width (m)	Crop area loss (%)	Maize row spacing (cm)	Pruning labour (man-days/ ha/crop)	Slope (degrees)	Embankment (cm)
T1– no NVS	–	–	–	69	–	23	–
T2– one NVS, middle of slope	8	24	6	73	3.5	19	107
T3– three NVS	4	12	9	75	7	18	103
T4– seven NVS	2	6	12	77	15	13	89
T5– fifteen NVS	1	3	17	81	29	8	75

crops (Ramianamanana 1993). They are similarly effective in controlling soil erosion (Agus 1993), and are the farmers' invented technology (Fujisaka and Cenas 1993; Garrity 1996). NVS serve as a foundation for establishing fruit and timber trees that enable the farmers to diversify species on their farms, and could lead to a good and stable agroforestry system.

However, the intriguing issues of cropped area loss, pruning labour and scouring effect are still haunting the minds of farmers, researchers and extension workers, slowing down adoption rate by farmers in the sloping uplands. The current study was aimed primarily at investigating the effect of NVS density on crop production and soil loss, as a contribution to addressing the above issues.

The mean annual soil loss of 41.4 tonnes/ha/yr in T1 (control) did not reduce crop production over the 4 years of the experiment because:

(a) fertiliser input was high, replenishing the eroded soils and nutrients;
(b) the number of plants are higher in this treatment, as there was no loss in cropped area to NVS;
(c) there was no scouring of the upper alleyways and no hedgerows competition.

Barbers (1990) reported that on deeps soils, erosion may have a negligible effect for a short period, stating that erosion rates of around 150 to 200 tonnes/ha/yr. in east Java have not significantly affected crop yields. Lal (1990) suggested that on soils with favourable subsoil properties, nutrient loss through erosion may be replaced using fertilisers so that crop production levels can be maintained. This may be the general observation of a few farmers who apply high rates of fertiliser in Claveria, particularly the vegetable growers, who do not adopt soil conservation measures, and in fact vegetable crops rows are usually oriented up and down the slope. However, few tropical soils have favourable sub-soil characteristics and erosion usually results in drastic declines in crop productivity as the depth of topsoil declines (Lal 1984). As a generalisation, yield declines 60% with the loss of the first 5 cm of top soil, 65% with the loss of 10 cm and 80% following the loss of 20 cm (Doolette and Smyle 1990). Soil losses in T4 and T5 were still at an acceptable rate of 12 tonnes per hectare per year, similar to soil loss under intensive agriculture in the USA, levels also considered acceptable in the tropics, despite the different environmental contexts (El-Swaify 1993).

Upland farmers recognise soil erosion and nutrient depletion as major problems in sustaining crop production in sloping upland soils (Fujisaka 1993; Garrity 1993). They are aware of the need to control soil erosion, and interested in adopting suitable soil

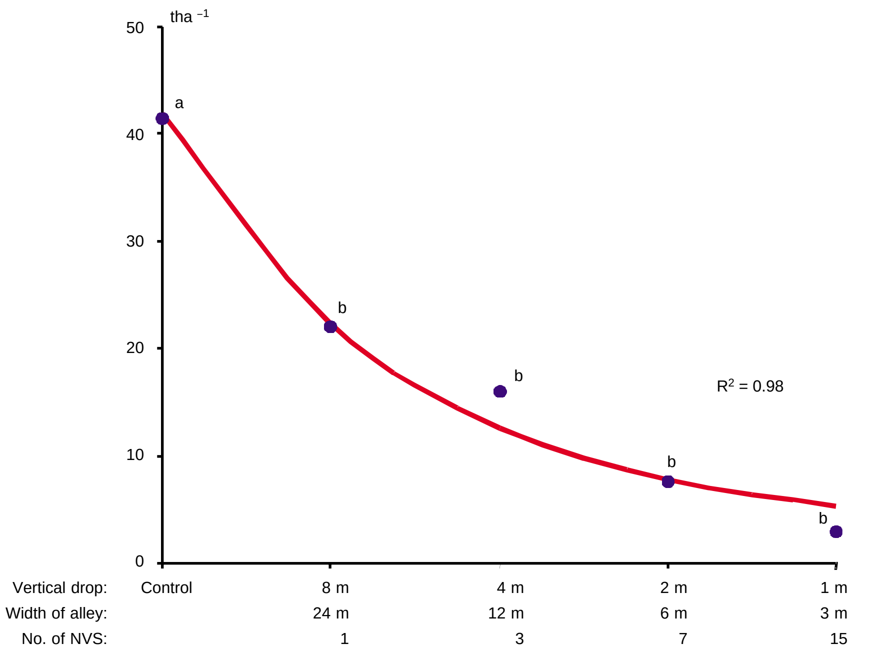


Figure 2. Annual soil loss as affected by different natural vegetative filter strips (NVS) spacing. Claveria, Misamis Oriental, Philippines.

conservation measures. But farmers usually evaluate how the new technology fits their socio-economic and bio-physical environments. This may simply involve thinking about how the new technology might affect their farming operations or family (Follet and Stewart 1985). Although NVS are simple to establish, if they are too dense (3 m apart) they may significantly affect farmers' field operations in terms of convenience and labour requirement, and hence farmers may be reluctant to adopt the technology. Having hedgerows too dense does not provide added benefit but gives an additional burden in terms of labour and farming inconveniences.

The amount of labour required to prune and maintain the NVS is directly proportional to the density. Although the reason why upland farmers want to adopt soil conservation is soil erosion control, allocating 29 man-days per crop to maintain the hedgerow is unaffordable to most of them.

The amount of biomass and nutrient contribution of NVS to the crop production is directly related to the density of NVS. However, the amount of nutrients contributed does not justify the amount of labour invested in dense NVS, and phosphorus, which is the most limiting nutrient under acid upland soils (Garrote et al. 1986; ICRAF 1996), is not recycled (Garrity 1996). *Chromolaena odorata* has higher concentrations of nitrogen, phosphorus and potassium than many other NVS species and is therefore more beneficial as an NVS species, as long as it is managed properly. The grasses (*Imperata* and *Rottboellia*) have lower nutrients concentrations than broadleaved plants (e.g. *Chromolaena*).

The biomass of the NVS prunings declines with successive crops. Frequent pruning puts pressure on the perennials, providing an opportunity for the annual weeds to colonise the hedgerow. In consequence, NVS could become a source of weed seeds to colonise the alley. There is thus a requirement for more frequent pruning to avoid annual weeds from seeding.

References

Agus, F. 1993. Soil processes and crop production under contour hedgerow systems on sloping Oxisols. PhD Thesis, North Carolina State University, Raleigh, North Carolina, USA.

Barbers, E.B. 1990. The farm-level economics of soil conservation: the uplands of Java. Land Economics, 66, 2: 199–211.

Cruz, W., Francisco, H.A. and Conway, Z.T. 1988. The on-site and downstream costs of soil erosion, Working Paper Series, 88–1I. Manila, Philippines, Philippine Institute for Development Studies.

Doolette, J.B. and Smyle, J.W. 1990. Soil moisture conservation techniques: review of literature. In: Doolette, J.B. and Magrath, W.B. ed. Watershed development in Asia: strategies and technologies, World Bank Technical Paper No. 127. Washington DC, USA, The World Bank.

El-Swaify, S.A. 1993. Soil erosion and conservation in the humid tropics. In: Pimentel, D. ed. World Soil Erosion and Conservation, Cambridge, Cambridge University Press.

Follet, R.F. and Stewart, B.A. 1985. Soil Erosion and Crop Productivity, Madison, Wisconsin, USA, Soil Science Society of America.

Fujisaka, S. 1993. A case of farmer adaptation and adoption of contour hedgerows for soil conservation. Experimental Agriculture, 29: 97–105.

Fujisaka, S. and Cenas, P.A. 1993. Contour hedgerow technology in the Philippines: not yet sustainable. Indigenous Knowledge and Development Monitor, 1: 1.

Fujisaka, S., Jayson, E. and Dapusala, A. 1994. Trees, grasses, and weeds: species choice in farmer-developed contour hedgerows. Agroforestry Systems, 25: 13–24.

Garrity, D.P. 1993. Sustainable land-use systems for sloping uplands in Southeast Asia. In: Technologies for Sustainable Agriculture in the Tropics. Madison, Wisconsin, USA, American Society of Agronomy Special Publication 56.

Garrity, D.P. 1996. Conservation tillage: a Southeast Asian perspective. A paper presented during the Conservation Tillage Workshop held at PCARRD, Los Baños, Laguna on November, 1996 (unpublished).

Garrity, D.P., Mercado, A. Jr., and Solera, C. 1995. The nature of species interference and soil changes in contour hedgerow systems on sloping acidic lands. In: Kang, B.T. ed. Proceedings of the International Conference on Alley Farming, IITA, Ibadan, Nigeria, 14–18 September 1992.

Garrity, D.P. and van Noordwijk, M. 1995. Research imperatives in conservation farming and environmental management of sloping lands: an ICRAF perspective. Paper presented at the IBSRAM workshop, Feb. 27–March 2, 1995 (in press).

Garrote, B.P., Mercado, A. and Garrity, D.P. 1986. Fertility management in acid upland environments. Philippines Journal of Crop Science, 11(2): 113–123.

Huxley, P.A. 1986. Rationalising research on hedgerow intercropping: an overview. International Council for Research in Agroforestry. Nairobi, Kenya, Working Paper Series 40.

ICRAF. 1996. Annual Report for 1995. Nairobi, Kenya, International Centre for Research in Agroforestry.

Kang, B.T. and Wilson, G.F. 1987. The development of alley cropping as a promising agroforestry technology. In: Steppler, H.A. and Nair, P.K.R ed. Agroforestry – a Decade of Development. Nairobi, Kenya, International Council for Research in Agroforestry.

Lal, R. 1984. Soil erosion from tropical arable lands and its control. Advances in Agronomy, 3: 183–284.

Lal, R. 1990. Soil Erosion in the Tropics: Principles and Management. New York, McGraw Hill.

Ramiaramanana, D.M. 1993. Crop-hedgerow interactions with natural vegetation filter strips on acidic land. MSc thesis, University of the Philippines, Los Baños, Laguna.

SAS 1996. SAS/STAT[R] User's Guide, Release 9.0 Edition. Cary, North Carolina, USA, SAS Institute, Inc.

Stocking, M. and Peake, L. 1986. Crop yield losses from the erosion of alfisols. Tropical Agriculture, 63(1): 41–45.
Turkelboom, F., Ongprasert, S. and Taejajai, U. 1993. Alley cropping on steep slopes: Soil fertility gradients and sustainability. Paper presented at the International Workshop on Sustainable Agricultural Development: Concepts and measures, Asia Institute of Technology, Bangkok, Thailand, December 14–17, 1993 (unpublished).
Watson, H.R. and Laquihon, W.A. 1986. Sloping agricultural land technology (SALT); a social forestry model in the Philippines. In: Rao, Y.S., Hoskins, M. W., Vergara, N.T. and Castro, C.P. ed. Community forestry: lessons from case studies in Asia and the Pacific region. Honolulu, Hawaii, East-West Center.
Young, A. 1986. The potential of agroforestry for soil conservation. Part I. Erosion control, Nairobi, Kenya. International Council for Research in Agroforestry Working Paper, Series 42.
Young, A. 1987. The potential of agroforestry for soil conservation. Part II. Maintenance of soil fertility. Nairobi, Kenya. International Council for Research in Agroforestry Working Paper, Series 42.

The Amarasi Farming System, its Economic Aspects and the Adoption of Improved Cattle Feeding and Group Pen Systems

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EAST NUSA Tenggara (Nusa Tenggara Timur/NTT) Province is located in the eastern part of Indonesia (KTI). The climate is quite extreme with a pronounced long dry season (8–9 months) and having soil of neutral to high alkalinity. Uplift hill and mountain zones (Nulik et al. 1999), dominate the physiography of the region and thus there is a need for agricultural development to take into account soil and water conservation aspects. Nulik (1998) has described the detail characteristics of the region.

The Amarasi sub-district covers about 737.5 km^2 and is the fourth largest of the 17 sub-districts in Kupang on Timor Island of NTT Province. *Leucaena leucocephala* had been introduced into the area by the 1930s and in the 1970s most of the area was thickly covered with the legume (Nulik 1998; Nulik and Bamualim 1998). Since the introduction of a cattle fattening program by the Livestock Services in the 1970s, the area has been an important beef cattle producing area.

Cattle Husbandry in East Nusa Tenggara

NTT has been well known in Indonesia as an area for animal production, especially for beef cattle. The animal industry in NTT contributes about 11.4% to the gross regional income in general and about 21%–23% to the agricultural sector in the region. The largest contribution comes from cattle industries. However, cattle productivity in the region is still considered to be low. The problem is related to the traditional farming of cattle that relied much on the native grasslands with a free grazing system. As experienced in other semi-arid areas, the productivity of cattle raised under the system fluctuates greatly, depending on both forage production and nutritive value. On average, the native grasslands in the region would only be able to support 1.4 to 2.8 head of Bali cattle/ha/year (Nulik and Bamualim 1998).

Beef Cattle Husbandry in the Amarasi Farming System

Existing cattle husbandry

Starting in the 1970s with a scheme for intensification of cattle raising, the government of NTT, through the Livestock Services, promoted a program of cattle fattening in the Amarasi area. This was known as 'Panca Usaha Ternak Potong (PUTP)' or the Five Efforts in Beef Cattle Husbandry. The cattle raising system in Amarasi in general is in the form of cut-and-carry of forage for fattening.

In the fattening system, animals are tethered all the time in stalls or under very simple sheds and fed forages that consist mainly of *Leucaena. leucocephala* leaf. There are also some farmers who raise cattle for breeding. In this case, the animals are tethered in an area where forage is available and the animal will be moved two to three times a day to let it graze sufficiently, depending on forage availability.

Amarasi, however, is currently well known as a transit area for animals in Timor, before being marketted. Usually, farmers in Amarasi buy steers from other places outside the area to fatten for about 6 to 12 months, before selling at the market. In general, one family at Amarasi fatten 2–3 steers or more in a year.

Cattle husbandry in the area is still considered to be an important extra activity to obtain relative large amounts of cash. The money would pay for certain purposes such as to buy material for house building, to pay for children to go to school, and other needs such as parties and traditional ceremonies. In this case, cattle husbandry may contribute 40% to 70% to the large cash needed.

Forage potential and the existing farming system

From the 1930s to the 1970s, most of the Amarasi area became thickly covered by the small variety of

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L. leucocephala, before farmers started to replace it with the giant variety in the 1970s (Nulik 1988; Nulik and Bamualim 1998).

Following experience with the psyllid (*Heteropsylla cubana*) outbreak in 1986, farmers are currently planting other legume species such as *Sesbania grandiflora* and *Gliricidia sepium*. Although *G. sepium* has been grown in many places within the region, especially as live fencing, it has not yet been utilised very much as fodder. The lack of *G. sepium* usage is related to the belief of farmers that the forage is not palatable to the animal, although in practice free-grazing animals browse on the legume when native grasses start to die off during the dry season. There are, however, some farmers in the area who say they utilise *G. sepium* as a forage, mixing it with other tree leaves.

Currently, the rate of the psyllid attack seems to be significantly reduced, probably as a result of the spreading of biological predators following the outbreak. Early in the development of leucaena in the local farming system, it was planted in rows 2–3 m apart. However, as the management of the row was not properly carried out, the species spread throughout the farmers' lands. The stands of leucaena were then slashed and burnt before dryland food crops were planted. This land is normally be cultivated for 2–3 years, after a which the land is fallowed to let the leucaena cover the area again.

The fallow periods in the early practice was around 5–6 years. Currently, however, with the increasing population and as the land become scarce, the fallow period is reduced and in many instances the lands continue to be cultivated each year. The result is that the leucaena becomes sparse and allows weeds to invade the dryland cropping area formerly covered by leucaena. Thus, one may expect that there could be increasing risk of soil erosion problems, especially on the sloping lands.

The use of leucaena in the area can be considered to be suitable for the slash-and-burn farming system practised as the leucaena contributes to weed control, which is the greatest problem encountered in the dryland farming system in NTT. Besides that, leucaena can be considered as a nutrient pumping tool to extract leached nutrients from the lower soil layers on to the surface to be used by other crops.

However, there is an urgent need to make the farmers aware of the danger of the leucaena disappearing when the lands are cropped each year. It is important, therefore, to get the farmers to spread the seeds of leucaena during the growing season to ensure the best cover of the land after harvesting the dryland food crops.

During the rainy season, native grasses such as *Sorghum nitidum*, annual *Pennisetum* sp., and various other native species (such as *Heteropogon contortus* and *Bothriochloa* sp.) contribute an important part of cattle rations in Amarasi. The grasses can be found under the legume trees in the farmers' forage gardens (1 to 2 ha/household), along roadside and in the communal natural grasslands, outside the villages. There are also some farmers who plant king grass (*Pennisetum purpureum* × *P. glaucum*) or elephant grass (*P. purpureum*).

During the dry season, little forage is available. During this time, *L. leucocephala* trees may lose their leaves, especially if trees are allowed to grow with infrequent cutting. *G. sepium* trees lose their leaves in the dry season and produce seed. Although *S. grandiflora* is still green during this time the production is not abundant.

During the dry season, farmers in Amarasi also rely on the use of large tree leaves, both from leguminous and non-leguminous trees. The well-known native species of large tree legume used in the region is *Acacia leucophloea.* Surprisingly, the tree produces new green leaves at the peak of the dry season (September–October) when most other trees have lost their leaves and native grassland has hayed off and fires are frequent. Forage is also obtained from large non-leguminous trees such as from *Ficus* spp. and *Macaranga tanarius*.

Existing Feed and Feeding System and the Adoption of Improved Feeding System

After the arrival of the psyllid, farmers had to rely on various sources of forage in addition to the existing leucaena. Soon after the early arrival of the psyllid, it was recorded (Sudjana and Talib 1989) that farmers in the area used forage from various sources such as: *L. leucocephala* (54%), native grasses (17%), *S. grandiflora* (10%), legume straw (8%), leaf of banana (5%), corn straw (2%), rice straw (8%), cassava leaf (1%) and leaf of sweet potato (0.4%). More recently it was recorded (Keban et al. 1999) that forage sources included: *Sesbania grandiflora* (turi), *Ceiba petandra* (kapuk), leaf and stem of. banana/ *Musa paradisiaca* (pisang), *Hibiscus rosa-sinensis* (kembang sepatu), the leaf of *Ziziphus mauritiana* (bidara), the leaf of Ficus spp. (beringin), *Mutingia calabura* (kersen) and native annual grasses such as *Sorghum nitidum* and *Pennisetum* sp. There are some farmers who grow and use introduced grasses such as *Pennisetum purpureum* (rumput gajah) and king grass (rumput raja). Recent observations indicate that the condition of the leucaena has significantly improved and that during the rainy season, when forage is abundant, leucaena comprises the dominant part of livestock feed.

In the Amarasi, fattening system the average daily weight gain normally ranges from 0.2 to 0.4 kg/hd/day. Farmers usually need 12–14 months for fattening the cattle before being sold at the market. However, the fattening program introduced by the Research Institute of BPTP (The Assessment Institute for Agricultural Technologies), Naibonat, can obtain 0.5 to 0.8 kg/hd/day, and cattle may be ready to market in only 3 to 4 months. The ration recommended by BPTP consisted of 60% grasses, 40% legumes and mineral block (formulated by BPTP) and a digestion bacterial starter called 'Starbio' (20 g/hd/day) added to the animals' drinking water. The mineral is served in the form of block of 10 cm × 10 cm × 10 cm. The formula of the mineral block consists of: triple superphosphate (TSP) 1.5 kg (15%), urea 1.7 kg (17%), ammonium sulphate 1.5 kg (15%), cement 0.3 kg (3%), lime 1 kg (10%), salt 3.7 kg (37%) and tapioca 0.3 kg (3%). It was observed that an animal would consume around 4–5 g mineral block/day. The starbio can be obtained commercially in the market.

Farmers normally fatten their cattle in an individual pen system. In the fattening program introduced by BPTP, the farmers are grouped and introduced to a pen-group system. By the grouping arrangement, where the monitoring of the body weight gain is done every 2 weeks by weighing their cattle, farmers are motivated to feed their cattle in a better way in order to obtain a higher body weight gain in the next weighing period, to compete with other farmers in the group. Thus, it is inducing a positive competition between the farmers in the group. The grouping of farmers has also strengthened the bargaining position of the farmers against animal traders.

BPTP is also involved in the marketing aspects of the fattened cattle. In this case, BPTP is responsible for finding investors to buy the cattle from the farmers at a fair price. BPTP also conducts extension activities to enable the farmers to obtain capital, such as to obtain credit from local banks and share arrangements with local traders. All of these are done to ensure that the farmers get their fair share of the profit. As a result, farmers in the area are becoming more aware of the economic aspects in the fattening activities, including the value of forage as an input.

In the three villages in Amarasi where BPTP has been introducing the innovative feeding system, farmers have become more aware of the benefit of better feeding and the cost in terms of labour of collecting forage and tending the animals. The farmers have also adopted the use of mineral block and starbio. In many cases, it can be observed that at present farmers are buying the starbio of their own initiative.

Socio-economic aspects

The contribution of cattle husbandry to the income of the farmers varies depending on the.agroclimatic zone of the location. The drier the area (lack of water availability) the larger the contribution from the livestock sector. Sobang (1997), in his research in Kupang district, found that cattle husbandry contribute around 30%–70% to the farmers' income. The contribution is influenced by the number of stock owned, the type and the availability of forage and dry matter consumption. Furthermore, land tenure (the farmer being the owner or profit sharing) also determined the size of the contribution (Lole 1997). In this case the, type of profit sharing also determines the contribution to the farmer's income. In general, it was found that there are about three types of profit sharing for cattle fattening: (i) profit sharing with outside investor, (ii) profit sharing with local (Amarasi) investor, and (iii) profit sharing with government support. The different types of profit sharing were brought about by the different sources of steers obtained by the farmers for the fattening activities. There are also farmers who raise their own cattle, and these farmers obtain the highest income.

According to Keban et al. (1999), there are about five types of cattle raising farmers in Amarasi, i.e.:

(i) **Breeding program:** in many cases the cows belong to the farmer, who will receive the whole price when they are sold. If the cows belong to investors, profit-sharing will be as follows:
   - *The cow is sold because she was sterile (unproductive)*: In this case, the owner receives the initial price, while the farmer receives the whole margin (the selling price minus the initial price).
   - *The cow produces a calf and the calf is sold*: The owner then obtains 40% of the selling price, 40% goes to the farmer, 3% to the local government, 2% to the farmers group, 5% to APPKD and 6% to Livestock Services.

(ii) **Fattening cattle** (3 months): the owner receives the initial price plus 42% of the margin, the farmer receives 42% of the margin and the Livestock Services receives 16% of the margin price. If the cattle belonged to the farmer, he/she will receive the whole price (the initial price + the margin).

(iii) **Government support** for the under-developed village farmers (IDT) (12 months): farmers receive all of the gross margin, while the initial price is allocated to other farmers who have not received support before.

(iv) **Fattening where the steers are provided by investors outside the area** (12–14 months): In this case, the steers are provided by the investor and the farmers provide forage and simple pens. The profit sharing is as follows: the farmer receives Rp. 2000 (predetermined) for every kilogram of body weight gained. The investor receives the rest of the margin plus the initial price of the steers.

(v) **Steers provided by a local investor** (in the Amarasi area): in this case, the farmer is paid Rp. 100 000 to 150 000 for each steer raised when sold. Usually, the steer is fed for 12–14 months.

If the forage fed during the fattening period is counted as a cash input, the highest income is usually obtained from the type 1 (breeding) program, if the cows belong to the farmer. The second highest income is obtained from type 3 (government support type), followed by type 4 cattle raising. In type 5 enterprises, farmers experience a loss. However, as the forage was free of charge and collected by the labour in the family, farmers still practise type 5 fattening, benefiting from the relatively large amount of money received on sale of the steers.

All five types of cattle raising have been running well for quite a long time. This may be because farmers only conduct the activity as a sideline to obtain extra cash, while their main income comes from selling farm produces such as coconut, corn, cassava, bananas and other dryland crops. Thus, the smaller the income from the food crops, the higher the income derived from cattle husbandry activities.

Future Expectations

By the introduction of the 'business fattening cattle program', with its emphasis on improvement of feeding as well as economic aspects, farmers in the Amarasi area have been receiving better incomes from their cattle farming. However, there are still opportunities to improve the system. These include the introduction of psyllid-resistant *Leucaena* spp. with reasonable forage production, other important leguminous trees, such as *G. sepium*, and developing combinations of leguminous forages to obtain better digestion and body weight gain. Possible examples are the combination of leucaena leaf and leaf of calliandra, *G. sepium* or *Acacia leucophloea*. There is also a need to introduce more exotic annual and perennial species of grasses suited to dry climates, and to introduce techniques of forage cultivation to the farmers. It is also important to introduce effective methods of preserving excess forage produced during the rainy season for feeding during the dry season.

Continuing extension activities are required, especially to encourage and to train the farmers to make use of animal manure. There are opportunities to promote compost-making techniques and use of compost on crops as well as for marketing in the Kupang region. There is also a need to settle a fair profit-sharing model to help the livestock farmers obtain a better income as well as giving a fair return to the investors. This profit-sharing model could be issued as a written regulation and be reinforced by the local government.

Conclusions

- The use of leucaena is a normal practice in the cattle husbandry of Amarasi farmers, but there is a need to promote more diversity of tree legumes, to continue extension activities promoting better feeding techniques, to introduce other exotic grasses and their techniques of cultivation and use.
- Cattle husbandry provides relatively large sums of cash compared to other sources of income from the farming system, which are used to cover occasional needs of the farmers, such as to build a better house, to pay for the children to go to school and some ceremonial parties.
- Although there are variations in income obtained by livestock farmers under different types of profit-sharing, farmers have been raising and fattening cattle for quite a long time as they also earn money from selling other farm commodities, and forage is freely available.
- It is possible to shorten the period for cattle fattening needed by the farmers by provision of a properly balanced forage diet, additional minerals, a digestion bacterial starter as well as group pens. However, there is an urgent need to improve forage diversity, cultivation and feeding as well as the pen system practised by the farmers.
- When farmers themselves have experienced the benefit of the technologies, they will willingly adopt them, even if they have to pay extra for buying the starbio.
- To ensure the sustainability of the dryland farming in the Amarasi area by making use of the leucaena, there is an urgent need to encourage farmers to always keep their dryland copping area covered with the legume (i.e. by spreading the seeds of leucaena during the planting season to establish sufficient cover crops).
- There is a need to issue a written regulation by the local government concerning the profit-sharing model to ensure fair profit for the farmers.

References

Keban A., Nono, O.H, Ngongo, Y., Kedang, A. and Budisantoso, E. 1999. Studi Sosial Ekonomi dan Budaya Sistem Pemeliharaan Sapi di Kecamatan Amarasi Kabupaten Kupang. Laporan Penelitian. Lembaga Penelitian UNDANA Bekerjasama dengan Nusa Tenggara Agricultural Area Development Project Component A. BPTP Naibonat.

Lole, U.R. 1997. Kelayakan Finansial Investasi pada Pola Gaduhan Penggemukan Sapi Potong Kasus Kecamatan Amarasi Kabupaten Kupang. Laporan Penelitian Dosen Fapet Undana Kupang.

Nulik, J. 1998. The use of *Leucaena leucocephala* in farming systems in Nusa Tenggara. Paper Presented in the Third Annual Regional Meeting of FSP in Samarinda, East Kalimantan, Indonesia.

Nulik, J and Bamualim, A. 1998. Pakan Ruminansia Besar di Nusa Tenggara. Balai Pengkajian Teknologi Pertanian Naibonat-Bekerjasama Dengan Eastern Island Veterinary Services Project.

Nulik, J., Hosang, E. and Lidjang, I.K. 1999. Profil dan karakter zona agroekologi pada delapan kabupaten perakitan teknologi di Nusa Tenggara Timur. (Paper presented in the Technology Package Application Meeting of BPTP Naibonat in Kupang, 30 September– 1 October 1999).

Sobang, U.L. 1997. Karakteristik Sistem Penggemukan Sapi Pola Tradisional Menurut Zona Agroklimat dan Dampaknya Terhadap Pendapatan Petani di Kabupaten Kupang NTT. Thesis PPS. IPB Bogor.

Sudjana, D. and Talib, Ch. 1989. Penampilan sumber daya usahatani ternak di Kecamatan Amarasi, Kabupaten Kupang, Nusa Tengarra Timur (Profile of farming resources of livestock farmers at Amarasi, Kabupaten Kupang, Nusa Tengarra Timur. Proceedings: Pertemuan limiah Ruminansia, Cisarua, Bogor, 8–10 November 1998. Pusat Penelitian dan Pengembangan Peternakan, Bogor, 139–144.

Growth Performance of *Arachis Pintoi* under Shade of a Dense Oil Palm Plantation

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THE POTENTIAL of livestock-tree integration production systems has been well documented and reviewed (Chen et al. 1991; Shelton and Stür 1991; Tajuddin and Chong 1994) in terms of land sustainability, security of income and environmental protection from land erosion and indiscriminate use of herbicides. The existing cover crops and legumes used in plantations do not persist well under grazing and increasing shade density. *Arachis pintoi* cv. Amarillo exhibited tolerance to heavy grazing and good compatibility with aggressive grasses of the genus *Brachiaria* (Grof 1985).

Further, grazing studies using oesophageal fistulated animals showed that *A. pintoi*, in association with several grasses, was selected in high proportions and that the legume contributed significantly to improving the quality of the diet selected (Lascano and Thomas 1988; Lascano 1994). Studies also confirmed that *A. pintoi* is a high-quality legume and that it is well consumed by previously adapted animals (Carula et al. 1991).

Materials and Methods

The experiment was carried out under 15-year old oil palms in the Experimental Farm of the Department of Veterinary Services at Padan Hijau, Johor, Malaysia. The experimental design was a simple complete randomised block with three replications. Plots measured 8.5 m × 32 m, each with a binary grass/legume mixture. The selected forages were *Paspalum notatum*, *Paspalum wettsteinii*, *Stenotaphrum secundatum*, *Panicum maximum* cv. Vencedor, *Dichanthium aristatum* cv. Floren, and *Paspalum atratum*. (The locally abundant weed species Asystasia intrusa was also included as a sown forage treatment but it rapidly spread and became dominant in the other treatments plots). The interrows of the oil palm were first disc ploughed and harrowed twice prior to establishment of the forages.

The *Arachis pintoi* cv. Amarillo and the selected grasses were initially planted in polybags using three cuttings/polybag. When they were successfully established, they were transplanted in the field at 50 cm spacing within rows and 1 m between rows in January 1997. Each row of *A. pintoi* alternated with a grass row. Every experimental interrow in the oil palm plantation alternated with an interrow used for placement of pruned palm fronds. The whole experimental area was fenced with cyclone fencing to keep out wild boars and other grazing animals.

A basal fertiliser comprising dolomite (1 tonne/ha), phosphorus (15 kg/ha as triple superphosphate) and potassium (30 kg/ha as muriate of potash was applied. The dolomite was applied more than a month before transplanting. The other fertilisers were applied after completion of transplanting. Maintenance fertilisers were applied at 50 kg/ha/year P, as triple superphosphate, and 100 kg/ha/year K, as muriate of potash, in three split applications.

Data collected were:

- dry matter yield and species composition of experimental area before planting in October 1996;
- plant survival one year after transplanting for each species;
- light transmission on 22 August 1997 and 9 June 1998, at distances of 1, 3, 5 and 8 m from the palm bole, using a light linear quantum sensor;
- dry matter yield at 2-monthly intervals. Three 1 m × 0.5 m quadrats were randomly harvested in each plot. Stoloniferous species were defoliated at 5 cm above ground level while erect species were defoliated at a height of 15 cm. The harvested materials were weighed and separated into *Asystasia intrusa* (a major shade-tolerant 'weed' under oil palm), *A. pintoi*, monocot species and

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other dicot species. Subsamples were dried overnight in an oven at 70ºC and weighed; dry matter yield and botanical composition were calculated;
- chemical composition of *A. pintoi* (AOAC 1984)
- nutritive quality of *A. pintoi* (Minson and Mcleod 1972);
- Acceptability of the forages to cattle, scored as the proportion of herbaceous vegetation left behind by cattle grazing for 2–3 days over the whole experimental area.

Data on dry matter yield and botanical composition of the forages were statistically analysed using the completely randomised block design.

Results and Discussion

Light transmission

The light transmission was low, <15% of full sunlight, with maximum light levels in the interrow (Table 1). This was expected, as the 15-year old oil palm canopy, being closed, intercepted most of the sun's radiation. The light profile of the plantation shade confirmed the earlier reports of light measurement undertaken by Chen et al. (1991). Unless alternative planting patterns of oil palms are adopted, low light will still limit forage growth, even with shade tolerance species.

Table 1. Light transmission (% of full sunlight) under a 15-year old oil palm plantation at Padang Hijau.

Distance from palm	Light transmission % (22/8/97)	Light transmission % (9/6/98)
1 m	10.6	6.7
3 m	8.4	14.6
5 m	10.0	14.5
7 m	12.4	13.6

Table 2. Dry matter yield (kg/ha) and botanical composition of ground vegetation under oil palm at Padang Hijau prior to commencement of experiment.

Species	DM yield (kg/ha)	Botanical composition
Clidemia hirta	606	53.6
Asystasia intrusa	212	18.8
Ottochloa nodosa	73	6.5
Axonopus compressus	73	6.6
Ferns	70	6.2
Others	63	5.5
Total	1130	100

Dry matter yield of the ground cover species before the experiment

Due to the low light transmission, standing dry matter yield of the ground vegetation prior to commencement of the experiment was about one tonne per ha (Table 2).

The species comprised mainly the unpalatable *Clidemia hirta* and the edible *Asystasia intrusa*.

Establishment of shade tolerant forages

Since all the shade tolerant grasses and legumes were planted from established cuttings in polybags, there was no constraint to the early establishment of the selected forages in the dense plantation shade. All mixture plots recorded over 90% survival of the planted grasses and legumes, including *A. pintoi*, but the growth of the planted forages was slow, due to the low light level. Commencement of the defoliation treatment was therefore delayed for six months. A uniform cut was imposed in 30 October 1997 prior to commencement of harvest at about 10 weekly cutting interval. The first harvest was initiated on 16 January 1998.

Yield and botanical composition of sown forages and other herbaceous vegetation

Total dry matter yield was 730 kg/ha at the first harvest, with *Arachis pintoi* and monocots being the most abundant species. Total dry matter yield increased in the second harvest and then declined to as low as 450 kg/ha of available dry matter for grazing. Due to the dense canopy cover of oil palms, sown grasses did not persist well and many of the species died out over the first three defoliation cycles. Planted grass species were therefore incorporated into the monocot weed component as shown in Figure 1.

Overall, dry matter production of the monocot species component generally declined significantly ($p<0.05$) to a low level. A similar trend was observed in dicot species (excluding the sown legume *A. pintoi*, and *A. intrusa*). These two species were selected for special consideration because of their major contribution to dry matter yield, as compared with the other dicot species. The only dicot species that established and persisted under defoliation and increased in density was the *A. pintoi*. Dry matter yield of *A. intrusa*, known for its shade tolerance, also declined with defoliation (Figure 1).

It appeared that, under the 2-monthly cutting interval, the shade-tolerant *A. intrusa* could not even sustain itself to remain productive. In contrast, the *A. pintoi* showed a slight increase in terms of dry matter production and botanical composition. This was probably attributable to its prostrate growth habit which enabled it to escape close defoliation. Such a characteristic had been highlighted as a positive mechanism for strong persistence in forages (Jones 1993).

The prostrate growth habit of *A. pintoi* had indirectly contributed to its persistence. It was

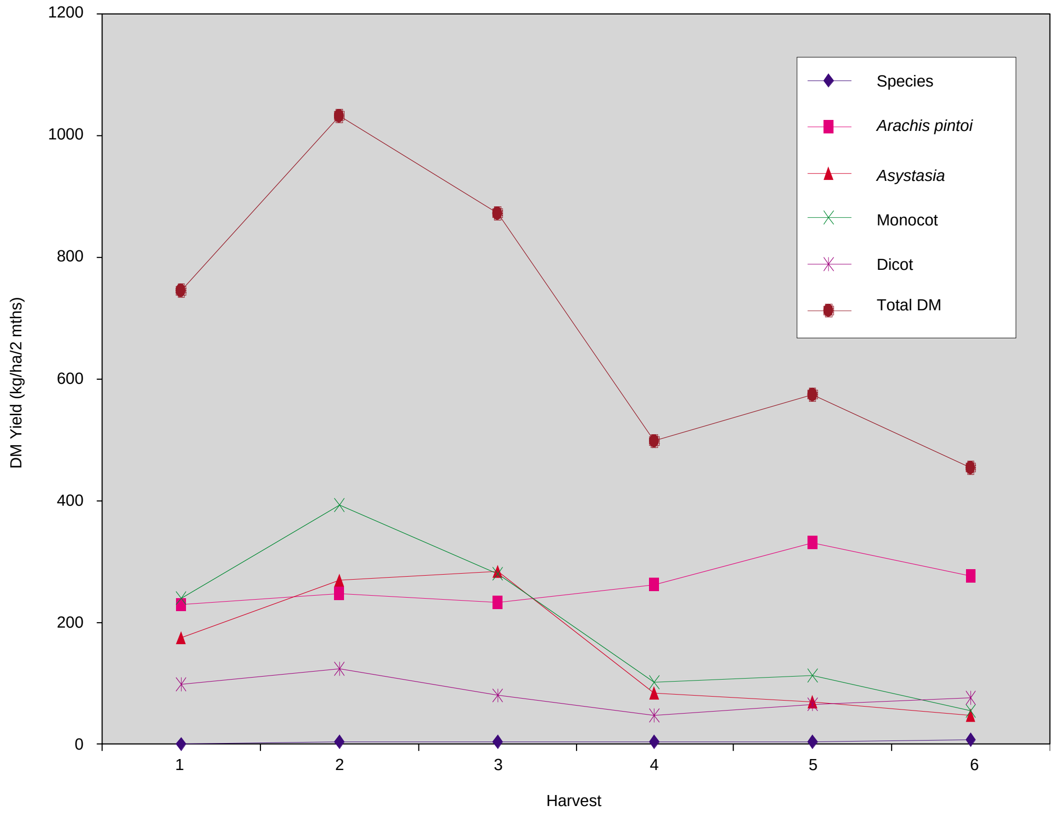

Figure 1. Dry matter yield of ground vegetation.

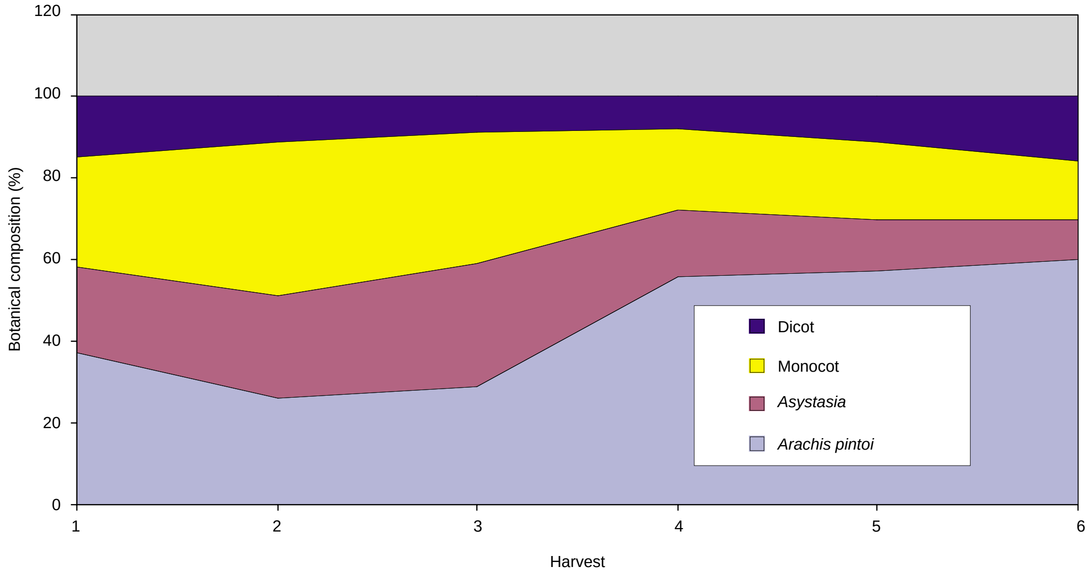

Figure 2. Botanical changes (as % DM) of ground cover species in oil palm plantation.

therefore not surprising to obtain from this experiment an increase in botanical composition of *A. pintoi* significantly ($p<0.05$) from 26% in harvest 2 to over 62% in the harvest 6 under the 2-monthly cutting interval system (Figure 2).

A. intrusa, which was considered a weed in oil palm plantations, increased slightly but subsequently declined significantly to as low as 11.3% in harvest 6. The sown grasses, which were selected for their shade tolerance, also declined over the six harvests in botanical composition. Other moncot species, like the native grasses, also declined with harvesting. On the other hand, dicot species, excluding *A. pintoi* and *A. intrusa*, and comprisng mainly unpalatable broad-leaved weeds, increased gradually from as low as 10% to as high as 18%.

The chemical composition and the in vitro dry matter digestibility (IVDMD%) of *A. pintoi* (combination of harvests 3 and 4 only) are presented in Table 3.

Table 3. Chemical composition (DM%) and in vitro DM digestibility of combined Arachis pintoi herbage from harvests and 4.

Composition	(%)
Crude protein	21.3
Ether extract	2.3
Crude fibre	23.9
Ash	13.5
Calcium	0.77
Nitrogen –free extract	39.0
ME (MJ/kg)	7.18
IVDMD	63

The crude protein and the overall IVDMD were relatively high and this indicated the suitability of the herbaceous vegetation in the oil palm plantation for ruminant production. Carulla et al. 1991) reported that the crude protein and IVDMD of *A. pintoi* leaves on offer were 18.4% and 61.2%, respectively.

In this experiment, the legume component increased over time but the sown grasses declined and died out in 2–3 grazing cycles. The quantity of grass on offer was low and so was that of *A. pintoi*, initially. Nevertheless, the proportion of *A. pintoi* in the forage on offer increased from 38% to 63% in the 6th harvest. The reduction of grasses was associated with heavy defoliation, especially during the dry periods. The proportion of senescent material was generally small.

Conclusions

The results obtained in this experiment confirmed the overall poor performance of shade tolerant grasses under dense plantation shade. In contrast, *A. pintoi* established slowly in dense shade, increasing as a proportion of forage on offer and also, albeit slightly, in terms of dry matter production. It was also found to have high crude protein and IVDMD percentage. However, its low dry matter productivity under dense shade could pose a constraint to provision of feed supply to grazing animals in mature oil palm plantations. In contrast, the dicot weed, *A. intrusa* established readily in dense shade but continual defoliation at the 2-monthly intervals was also detrimental to its persistence. The importance of proper management of the pasture for long term persistence of forages in mature plantations is emphasised.

References

AOAC 1984 Official Methods of Analysis, Centennial Edition, Washington DC, Association of Official Analytical Chemists.

Carulla, J.E., Lascano, C.E. and Ward, J.K. 1991. Selectivity of resident and oesophageal fistulated steers grazing *Arachis pintoi* and *Brachiaria dictyoneura* in the Llanos of Colombia. Tropical Grasslands, 25, 317–324.

Chen, C.P. and Wong, H.K. and Dahlan I. 1991. Herbivores and the plantations. In: Ho,Y.W. et al., ed, Recent Advances on the Nutrition of Herbivores. Proceedings of 3rd International Symposium on the Nutrition of Herbivores, Pulau Pinang, Malaysia, 71–81.

Grof, B. 1985. Forage attributes of the perennial groundnut *Arachis pintoi* in a tropical savanna environment in Colombia. Proceedings of the XVth International Grassland Congress, Kyoto, Japan, 168–170.

Jones, R.M. 1993. Persistence of *Arachis pintoi* cv. Amarillo on three soil types at Samford, south-eastern Queensland. Tropical Grasslands, 27,11–15.

Lascano, C.E. 1994. Nutritive value and animal production of forage *Arachis*. In: Kerridge. P.C. and Hardy, B. ed. Biology and Agronomy of Forage *Arachis*, Cali, Colombia, CIAT, 109–121.

Lascano, C.E. and Thomas, D. 1988. Forage quality and animal selection of *Arachis pintoi* in association with tropical grasses in the eastern plains of Colombia. Grass and Forage Science, 43, 433–439.

Minson, D.J. and McLeod, M.N. 1972. The in vitro technique; its modification for estimating digestibility of large numbers of tropical pasture samples. Technical Report No.8, CSIRO Division of Tropical Pastures, Brisbane, Australia.

Shelton, H.M. and Stür, W.W. 1991. Opportunities for integration of ruminants in plantation crops of southeast Asia and the Pacific. In: Shelton, H.M. and Stür, W.W., ed. Forages for Plantation Crops, ACIAR Proceedings No. 32, Canberra, ACIAR , 5–9.

Tajuddin, I. and Chong D.T. 1994. Ruminant in Plantation Systems in Malaysia. In: Mullen, B.F. and Shelton, H.M., ed. Integration of Ruminants into Plantation Systems in Southeast Asia, ACIAR Proceedings No. 64, Canberra, ACIAR, 97–99.

Direct Seeding for Leucaena Leaf Meal Production

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FORAGE legumes are an excellent source of protein for livestock. Mostly they are fed fresh as fodder or grazed, but can also be ensiled, made into hay, pellets, chaff, wafers or meal. The meal is often mixed with other feed ingredients to form a complete feed for livestock.

Leaf meal from leucaena (*Leucaena leucocephala*) is comparable to alfalfa forage, with crude protein content of about 27–34% and amino acids present in well-balanced proportions, much as in alfalfa (NAS 1977). Leucaena is also a rich source of carotene and vitamins (NAS 1977). Utilisation of leucaena is usually restricted due to the presence of mimosine, an uncommon amino acid which is toxic to non-ruminants.

In the diet of poultry, it is recommended that diets include only 2–5% of leucaena leaf meal, as higher levels have been proven to affect the growth of broiler chickens and reduce egg production (Yeong 1986).

For ruminants, it is recommended that diets with more than 30% leucaena should not be fed for prolonged periods. Dairy heifers fed with leucaena leaf meal at 35% level of the total diet suffered a 19% decline in live weight gain but increased milk yield (Gupta et al. 1992).

The leaf meal production program in Malaysia aims to produce leaf meal from leucaena with emphasis on productivity and quality, as affected by agronomic practices, mechanical harvesting and processing (Aminah et al. 1997). For leaf meal production, the harvested materials have to be dried in a drier for 10–15 hours at about 65°C or under the sun for the same duration to produce dried leaves green in colour. The meal produced has about 91% dry matter content.

To obtain good establishment, leucaena is normally planted using seedlings raised in polythene bags and transplanted when the seedling reaches more than 15–30 cm in height. The plants raised in a nursery normally develop faster where moisture, nutrition and pests are controlled, but the operational cost is higher than direct-seeding.

Using transplants, there is a greater chance of obtaining higher field stands and uniformity in plant growth. The high cost of transplanting is inadvisable for large-scale planting. Effective large-scale leucaena establishment in Central Queensland, Australia, is achieved under a 5 point plan: clean fallow, good soil moisture profile up to 1 m prior to planting; quick effective germination within about 7 to 10 days; good insect control over emerging seedlings and good weed control until the leucaea is 2 m tall (Larsen 1998).

This paper discusses the potential of leaf meal production from leucaena and the possibility of establishing leucaena by direct seeding for leaf meal production in Malaysia.

Materials and Methods

Two lines of leucaena namely, 40-1-18 (line 1) and 62-6-8 (line 2) were used in the present studies, based on their superiority to the existing line ML1 (Wong et al. 1998).

Experiment 1

Prior to planting, basal fertiliser at 30 kg/ha P and 30 kg/ha K was applied. Seedlings of Lines 1 and 2 were planted at 50 cm intervals with six rows in one block. Blocks were spaced 250 cm apart for ease in plant harvest and maintenance. Maintenance fertiliser at 40 kg/ha P and 50 kg/ha K was applied annually in three split applications. One year after planting, the plants were cut back at 50 cm above the ground level and manually harvested at 12-weekly intervals and thereafter. Harvested material, including leaf and stem, was weighed and dried in a drier or under the

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sun before thrashing to separate the leaf and stem portion.

The fresh weight, dry matter yield of leaf and stems from two harvests were recorded. Fresh samples from random plants were taken for dry matter content.

Experiment 2

To support the leaf meal production program, an experiment was designed to determine the possibility of direct seeding leucaena.

Two treatments were imposed:

A) Seedbed covered with an impermeable plastic sheet which acts as a mulch, suppressing weeds and conserving moisture. The plastic sheet was laid down and holes made with a planting stick at appropriate distances apart. Two seeds were placed inside each hole; and

B) Seedbed without a plastic cover and hand-weeded when required.

Prior to planting, the area was ploughed, and basal fertiliser applied at the same rate as in Experiment 1. Seeds of a uniform size (Line 1) were scarified in hot water for 3 minutes and sown at a spacing of 50 cm × 50 cm, at the onset of the rainy season. Plant heights were measured 6-months after sowing. Twelve months after sowing, plant height was measured from ground level to the shoot tips, girth was measured at 50 cm above ground level and branching was scored on a 1 to 5 scale, with 5 the best.

One hundred plants were harvested from each treatment to obtain the dry matter yield and samples were taken for determination of dry matter content. The dried leaf and stem were weighed before milling, using a hammer mill to produce leaf meal.

Results and Discussion

Experiment 1

The mean fresh weight and mean leaf dry matter productivity of the two harvests for Line 1 was higher than Line 2 (Table 1). These results were comparable to dry matter productivity of leucaena lines ML 1 and ML 2 earlier reported with their respective leaf yield of 6 and 8 t/ha/year when harvested at 12-weekly intervals (Izham et al. 1983).

It is anticipated that higher yields could be obtained as plants grow older and branching increases. The mean dry matter contents for both lines were 40.6% and 38.4%, respectively. Line 2 had a higher yield of dried leaf per unit fresh harvested weight than Line 1, and a lower yield of dried stem (Table 1). This was associated with a higher leaf:stem ratio for Line 2.

Table 1. The fresh weight, dry matter productivity of leaf and stem and other agronomic parameters of two hybrid leucaena lines harvested at 12-weekly intervals (2 harvests).

Line	Harvest	Total fresh wt (t/ha)	Dry matter wt. of leaf (t/ha)	Dry matter wt. of stem (kg/ha)	DM % of Total	Leaf DM as % of total fresh wt	Stem DM as % of total fresh wt	Leaf:Stem ratio
1	H1	15.7	1.81	4.47	40	11.5	28.5	0.31:1
	H2	21.9	2.45	6.49	41	11.2	29.6	0.38:1
	Av	18.8	2.13	5.48	41	11.3	29.0	0.35:1
2	H1	13.8	1.84	3.37	39	13.3	24.5	0.55:1
	H2	20.5	2.25	5.01	38	11.0	24.5	0.54:1
	Av	17.1	2.04	4.19	38	12.2	24.5	0.55:1

Table 2. Plant height, girth, branching, DM% and dry weight after 12 months of establishment of leucaena with seedbed covered or not covered with a plastic sheet.

Treatment	6 months	12 months				
	Height (cm)	Height (cm)	Girth (cm)	Branches[1] (rating)	Dry wt/plant (kg)	Dry matter (%)
Covered	117.4	221.6	1.17	2.10	0.32	42.2
Not covered	107.9	247.4	1.48	2.20	0.36	42.0

[1] Score 1 to 5, with 5 being the best.

Further research could investigate opportunities for increasing proportion of the good quality leaf component as well as increasing leaf yield.

Experiment 2

For both treatments, the percentage of plant survival for 12 months was about 70%. Plants in the 'covered' treatment were taller than plants in the 'uncovered treatment six months after sowing, but shorter after 12 months (Table 2). The early benefit of the 'covered' treatment could have been due to conservation of moisture and nutrients under the plastic, as there were few weeds in either treatment.

The height obtained in this trial was much higher than ML 1 (50 cm) measured at 6 months after establishment when mulched with dried grass (Aminah and Mohd Najib 1984). This could be due to the presence of weeds that still managed to grow through the planting holes but were not removed.

The height attained at 12 months was comparable to the expected height of 1.5–2 m of 12–18 month old leucaena (Piggin et al. 1994). Stem girth, branching score and dry matter/plant also showed a small benefit of the 'uncovered' treatment.

It is possible that the poorer performance of the leucaena (after 12 months) when the seedbed was covered with plastic was due to heating of the soil and deficiency of water. This possibility is supported by the observation that some plants were seen to have been scorched shortly after emergence.

Conclusions

The results obtained show that both lines of leucaena could contribute to high dry matter yield for leaf meal production. For larger scale planting, leucaena could be direct seeded in weed-free cultivated areas. From the evidence presented in this paper, there appears to be little benefit in covering the seed bed with a plastic cover if weeding is a viable option.

References

Aminah, A. and Mohd Najib, M.A. 1984. Kesan pembajaan nitrogen dan pengawalan rumpai terhadap pertumbuhan awal petai belalang (The effect of N fertilisation and weeding on the early growth of leucaena). Teknologi Pertanian, 5(1): 38–43.

Aminah, A., Wong, C.C. and Wan Abd. Rahim, W.M. 1997. Leaf meal production from leucaena. Proceedings of the. 9th VAM Veterinary Congress, 3–5 October 1997, Penang, Malaysia, 108–109.

Gupta, B.K., Ahuja, A.K. and Malik, N.S. 1992. Leucaena leaves as high-protein substitute for deolied seed cake in concentrates for dairy cattle in India. Leucaena Research. Reports, 13: 29–31.

Izham, A., Wong, C.C. and Devendra, C. 1983. Petai belalang: Sumber makanan ternakan yang penting (*Leucaena leucocephala*): An important source of animal feed). Teknologi Ternakan, 4(1): 1–7.

NAS 1977. Leucaena — Promising Forage and Tree Crop for the Tropics. National Academy of Sciences, Washington, D.C. 117 p.

Wong, C.C., Chen, C.P. and Hutton, E.M. 1998. Development of acid/psyllid tolerant *Leucaena* hybrids for ruminant production. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. Leucaena — Adaptation, Quality and Farming Systems. ACIAR Proceedings No. 86. ACIAR, Canberra, 132–135.

Yeong, S.W. 1986. Kepentingan tepung daun sebagai sumber pigmen warna di dalam makanan ayam dan itik (The importance of leaf meal as a source of colouring pigment for poultry feed). Teknol. Ternakan, 2(2): 51–53.

Piggin, C.M., Shelton, H.M. and Dart, P.J. 1994. Establishment and early growth of leucaena. In: Shelton, H.M., Piggin, C.M. and Brewbaker, J.L., ed. Leucaena — Opportunities and Limitations. ACIAR Proceedings No. 57. ACIAR, Canberra, 87–93.

Larsen, P.H. 1998. Seed scarification and establishment of *Leucaena leucocephala* — A farmer's view. In: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. and Bray, R.A., ed. Leucaena — Adaptation, Quality and Farming Systems. ACIAR Proceedings No. 86. ACIAR, Canberra, 193–195.

Selecting New Stylos for Anthracnose Resistance in Hainan, China

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THE genus *Stylosanthes* is the most important forage legume for South China and for all tropical regions in the world. It is a very important feed resource for livestock and is usually used either to improve natural pasture or as a component in fully-sown pastures; it is also used for producing leaf meal (Figure 1).

Utilisation of *Stylosanthes* (stylo) is now extending to interplanting under fruit trees (Figure 2), including coconut, lychee and rubber in Hainan, and growing on slopes to prevent water loss and soil erosion. In Hainan, some State Farms and companies return cropland to pasture to raise livestock, and some smallholders plant *Stylosanthes* for feeding chickens, ducks, pigs and other animals.

The most successful cultivar in Hainan, and elsewhere in the humid tropics, is *S. guianensis* CIAT 184 ('Stylo 184'), which has been released in Hainan as cv. Reyan II Zhuhuacao. This cultivar is extremely productive in a wide range of conditions, and has shown good resistance to anthracnose in Hainan and elsewhere in Southeast Asia.

The anthracnose disease has had a devastating effect on various Stylosanthes cultivars elsewhere in the world, and 'Stylo 184' is known to be susceptible to strains of anthracnose occurring in South America. There is a danger that some time in the future, virulent strains of anthracnose may appear in southern China and attack 'Stylo 184'. Selection of new stylos with anthracnose resistance and high yield is therefore a critical research objective.

In this paper, we describe an experiment aimed at identifying accessions of *S. guianensis* with high yield and anthracnose resistance.

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Materials and Methods

Accessions

In 1996, 34 accessions of *S. guianensis* from CIAT (Colombia and the Philippines) CSIRO (Australia) and EMBRAPA (Brazil) and CATAS (Hainan, China) were grown in small plots and visually rated for anthracnose damage, dry matter yield and seed production potential. Another set of accessions was grown by CIAT at Los Baños, the Philippines.

The best 11 accessions were selected for evaluation in larger plots at CATAS, Hainan, in comparison with 'Stylo 184' and the selection cv. Semilla Negra.

The experimental design was a randomised complete block experiment, with four replicates. Plots were 5 × 2 m, with plots 2 m apart. Forty plants were planted in each plot. Three replicates were harvested and used for measuring dry matter yield, and the other for making observations and collecting seed. Plots were cut at a height of 20–25 cm once in 1998 and three times in 1999, the last cut being August 1999. Harvested material was weighed fresh and sampled for measuring dry matter content.

For assessing anthracnose damage, we adopted the visual rating method developed by Chakraborty (1990), using a 0–9 severity scale:

0 no visible disease symptoms;
1 1–3% tissue necrotic;
2 4–6% tissue necrotic;
3 7–12% tissue necrotic;
4 13–25% tissue necrotic;
5 26–50% tissue necrotic;
6 51–75% tissue necrotic;
7 76–87% tissue necrotic;
8 88–94% tissue necrotic;
9 95–100% tissue necrotic.

The first observations were made five weeks after sowing and observations were continued at three weekly intervals. A total of 16 observations were made during 1998 and 1999.

Figure 1. Harvested *S. guianensis* 'Stylo 184' is harvested for leaf meal production in Hainan.

Figure 2. *S. guianensis* 'Stylo 184' grown as a groundcover and for feed in a lychee orchard.

For assessing insect damage, we adopted the following visual scale:

0 no damage;
1 some plants damaged by insects;
2 many plants damaged by insects;

The first observations were made three weeks after sowing in the nursery, and thereafter at three weekly intervals. The type of insect causing damage was also noted.

Soils and climate

The soil at the experimental site is lateritic, and is moderately acidic. Soil phosphorus levels are low (Table 1).

Table 1. Soil characteristics at the experimental site.

Depth	Total N (%)	Organic matter (%)	Available P (mg/kg)	Available K (mg/kg)	pH (H_2O)
0–20	0.07	1.01	0.9	31.5	5.8
21–40	0.05	0.67	0.5	20.0	6.0

Mean monthly temperature and rainfall during the period of the experiment are shown in Table 2. The dry season occurs during the cooler months, extending from December to April. Mean temperature and total rainfall during 1998 were 24.7°C and 1394.3 mm, respectively. Extreme maximum (April 1998) and minimum (January 1999) temperatures were 39.4°C and 9.3°C respectively.

Results

Four accessions had herbage yield which did not differ significantly from that of 'Stylo 184' — GC 1517, 1579, 1480 and 1463 (Table 3). Seed yield and flowering data indicated that these were later flowering than 'Stylo 184' but, in Hainan, they produced higher seed yields.

Although there were significant differences in mean anthracnose score (Table 3), all accessions were affected by anthracnose to a greater or lesser extent. Five accessions had an anthracnose score which did not differ significantly from that of 'Stylo 184'. They also had low mean scores for anthracnose damage (<2.5) and (excluding cv, Semilla Negra) maximum anthracnose scores not exceeding 5.

There was a close negative correlation between total dry matter yield and anthracnose score

Table 2. Mean monthly temperature and rainfall during the experiment.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Temperature (ºC)						
1998	19.0	20.1	24.3	26.8	27.3	29.8	29.2	28.1	26.1	24.6	22.3	18.8
1999	17.6	20.1	23.0	25.5	26.0	27.9	28.4	26.6				
						Rainfall (mm)						
1998	10.5	18.7	8.4	56.5	263.5	101.7	102.6	169.7	393.7	186.1	36.3	50.3
1999	38.9	3.6	17.1	157.6	436.5	406.5	273.9	263.4				

Table 3. Dry matter yield, anthracnose score, seed production and flowering of accessions of *S. guianensis* in Hainan, ranked according to mean anthracnose score.

Accession/cv.	Dry matter yield (tonnes/ha)	Anthracnose score		Flowering date	Seed yield (kg/ha)
		Mean	Maximum		
'STYLO 184'	5.84a[1]	2.10a	4	6/11	30
GC 1517	5.82a	2.15a	5	25/11	154
GC 1579	5.92a	2.23a	5	25/11	70
cv. Semilla Negra	4.48bcd	2.33ab	6	13/10	58
GC 1480	5.39ab	2.50ab	5	25/11	119
GC 1463	5.50ab	2.50ab	5	25/11	143
GC 1576	4.63bc	2.72b	6	15/11	169
GC 1528	3.50def	3.20c	7	25/11	140
FM 7–2	3.95cde	3.23c	6	13/10	89
GC 1524	3.62cde	3.33c	6	15/11	64
FM 7–3	3.27ef	3.43c	7	25/11	21
GC 1557	2.39fg	4.13d	7	6/11	130
GC 348	1.86g	4.97e	8	25/11	26

[1]values within columns followed by the same letter do not differ significantly (P>0.05)

($r^2 = 0.91$), and the four high-yielding accessions also had low mean anthracnose scores.

Most accessions in the trial were damaged to a greater or lesser extent by insects. During the wet season, and when temperatures were high, grasshoppers caused the most damage. At seed maturity, and when temperatures were lower, army worms damaged stylo inflorescences.

All accessions flowered and set seed normally. Six accessions had a seed yield exceeding 100 kg/ha, compared to 'Stylo 184' with 30 kg/ha.

Discussion

This is the first report of *S. guianensis* accessions with comparable dry matter yield and seed production to that of 'Stylo 184'. Although the accessions GC 1517 and 1579 are showing signs of anthracnose infection in Hainan, with 'Stylo 184' they had the lowest levels of infection; also, they are both known to have a high resistance to strains of anthracnose in South America. However, they are somewhat later flowering than 'Stylo 184' which may limit seed production in some Southeast Asian environments.

There is a need to extend the findings from this trial, to test the best accessions in a wider range of environments to provide further information on adaptation, dry matter yield potential, seed production and resistance to anthracnose.

Reference

Chakraborty, S. 1990. Expression of quantitative resistance to *Colletotrichum gloeosporioides* in *Stylosanthes scabra* at different inoculum concentrations and day-night temperatures. Australian Journal of Agricultural Research, 41: 89–100.

Integration of Adapted Forages on Farms in Southeast Asia – Experiences from the Forages For Smallholders Project

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Abstract

This paper presents the experiences of the Forages for Smallholders Project (FSP) in developing forage technologies with smallholder farmers in Southeast Asia. The work was done at 19 sites in four countries (Indonesia, Philippines, Laos and Vietnam), and revealed that technology development is a learning process for both farmers and development workers. Farmers started by identifying problems that they could address by planting forages. Then they planted different forage varieties in small areas near their houses to observe their growth and selected those that were adapted to their conditions. Their next consideration was the benefits they could obtain from the forages. When convinced of the benefits, they started to think about how to integrate the varieties in their farming systems. Farmers learned new ways of using the forages, developing more complex innovations as they gained experience with forages. With time, their preferences for forage varieties and characteristics changed. Farmers must be provided with a broad range of forage varieties and information on ways of growing, managing and using forages on farms right from the start. It is also important to look for entry points for forages that yield immediate impact and encourage farmers to develop innovative forage systems.

GROWING planted forages is a new concept for smallholder farmers in Southeast Asia. Traditionally, feed resources for ruminant livestock have been freely available and could be obtained easily from native vegetation. Introducing forages into smallholder systems is therefore different from introducing new rice varieties since farmers already grow rice and appreciate the value of 'superior' varieties.

The Forages for Smallholders Project (FSP) is developing forage technologies with smallholder farmers in Southeast Asia. The Project uses a participatory approach, which involves farmers in all aspects of the forage technology development process. This paper summarises our experiences of working with smallholder farmers to develop forage technologies for their resource-poor upland systems.

On-farm Sites of the FSP

The smallholder farms included in the Project were located in different farming systems ranging from extensive shifting cultivation areas to intensively cropped upland areas (Table 1). All farmers were resource-poor and dependent on family labour.

As work at each site progressed, it was realised that every farming system was immensely diverse, both between and within farms. For instance, at some sites, farmers had access to small areas of intensively cultivated lowland and a larger area of upland. Other farms in the same area only had access to upland areas. Similarly, access to communal grazing areas differed depending on location and traditional rights.

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Table 1. FSP on-farm sites.

Farming systems	Country			
	Indonesia	Philippines	Lao PDR	Vietnam
Short-duration slash and burn			3	
Grassland	2			1
Extensive upland	2	1		
Moderately intensive upland	1	3		1
Intensive upland	1	1		1
Rain-fed lowland	1	1		

Farmers located in vast expanses of grasslands or extensive coconut-growing areas used these for grazing but their main farm activity was concentrated in small areas of intensively-cultivated crops and fruit trees near their houses.

Problem Identification

One of the first activities in the forage technology development process was the identification of farmers' problems (Tuhulele et al. 2000). This enabled the farmers to identify their problems that could be addressed by forages. General feed shortage was a major problem identified in most sites (Table 2). At five sites, farmers considered feed insufficiency during the cropping season to be a major problem, equivalent to that of dry season feed insufficiency. Only at a few sites did farmers consider the planting of forage as a solution to resource management, for example, for controlling soil erosion, or suppressing weeds. In most cases, farmers saw forages primarily as a solution to animal feeding problems.

Table 2. Problems identified by farmers that could be addressed with forages.

Major problems	Number of sites
General feed shortage	8
Dry season feed shortage	5
Feed shortage during the cropping season	5
Poor feed quality	5
High demand for time and labor to feed animals	5
Grazing animals destroying crops or getting lost	4
Lack of grazing area	3
Weed invasion of cropping areas	3
Erosion of soils	3
Poor animal performance	1

The problems identified reflect the awareness of the farmers on how the forages could help solve their farm problems. They also reflect the situation of the farmers in the different sites.

A very important contribution of participatory diagnosis was that it served as a starting point in working with farmers in a participatory mode. Also, recognition of problems that can be addressed by planting forages was an important step for farmers to get interested in developing forage technologies.

Offering forage options

Before discussions were held with farmers, a range of forage grasses and legumes broadly adapted to the climate and soils of the region had been identified (Stür et al. 2000). After learning the farmers' problems, the issue of what varieties can be tested and how these could fit into the existing farming system was tackled. Deciding on the different options of how the varieties could be integrated on farms was done in discussion with farmers. This involved asking their ideas and discussing how forages had been integrated in other similar farming systems.

Deciding on what particular varieties could be tried was easier in cases where there was a nearby forage evaluation area. Farmers visited the evaluation site to see and select the varieties to try by themselves. In cases where there was no nearby forage evaluation site and farmers were not familiar with forages, choice of variety was based on the knowledge of the development worker.

It was initially thought that specific forage varieties or systems for integrating forages into the farm could be offered. However, it was later realised that each farm was different (in terms of resources and farmer's preferences) and required different forage options. Moreover, we found that our ideas about which forage options would be appropriate for each farming system differed from what farmers adopted (Table 3). The major reason for this was the complexity of factors governing farmers' decisions. These include land tenure, security, labour availability, importance of livestock and also farmers' prior experience with feeding animals and preferences. It was therefore not possible to 'photocopy' forage technology from one place to another.

We also learned that there was a need to keep the suite of varieties offered broad. Farmers often did not find difficulty in evaluating 5–8 forage varieties. However, we also found it to be important to offer farmers the best variety, not just any variety of a species. In one of the sites, farmers complained bitterly when they were given common Centrosema pubescens to try. Some of them had already tested the superior variety 'Barinas' (CIAT 15160), and were concerned when they were supplied with an ‘inferior’ variety.

In the course of time, the importance of active interaction and exchange of ideas with and between farmers about the different ways/options of integrating forages in the farms was realised. There were always some farmers who had tried a different way of growing and managing forages. Enabling them to share these ideas helped a lot in developing and spreading new forage options to other farmers. These interactions also served as a venue for encouraging other farmers to innovate themselves.

Process of integrating forages on farms

The rate of adoption of forage species and ways of using them varied between sites (Figure 1). This reflected the variation in the complexity of factors and opportunities affecting farmers’ decisions with time. For instance, at one site, farmers found that Brachiaria humidicola was growing very well in areas that were not useful for crops because of the very low soil fertility. This provided them with an opportunity to utilise the poor soil areas more productively by establishing forages for livestock production.

Conversely, there were sites where there was very little opportunity for adopting forages. In these cases, very little or no forage adoption occurred. In all sites, farmers usually started testing a range of varieties in small areas. From there, they chose a lesser number of varieties to expand gradually. In this process, the farmers usually based their initial choice on adapted varieties (i.e. those that were growing well). They then started thinking of the benefits that they could gain from the variety, and started to try out ways of integrating the varieties in their farms.

Figure 2. Smallholder farmers mostly used planted forages to supplement other sources of feed.

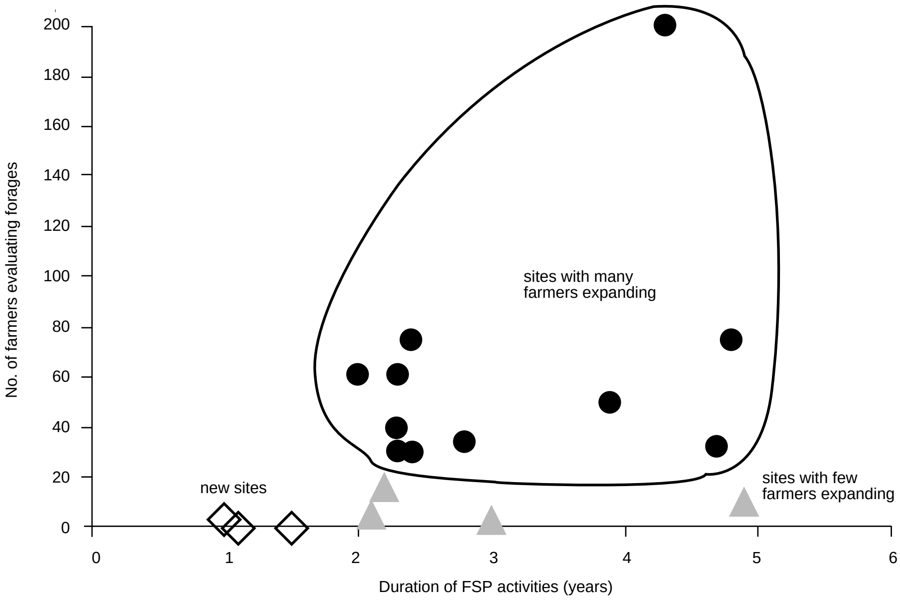

Figure 1. Rate of adoption of forage species at different sites.

Although the entry point was the need for feed, farmers used the planted forages as a supplement to the existing feed resources rather than as a substitute (Figure 2). Moreover, most farmers expanding their forage area did not do so by replacing their crop area but found other ways of fitting forages into their farms.

Among the forage types, the trend was that grasses were expanded and spread fastest. The herbaceous legumes were next while trees tended to be expanded and spread at the slowest pace. A major reason for this was the fact that grasses could be propagated vegetatively whereas herbaceous and shrub legumes mostly had to be propagated from seed. Vegetative propagation allowed the farmers to propagate grasses almost any time of the growing season and when convenient. In the case of forages propagated by seed, farmers were dependent on seed availability which was generally seasonal, and they had to sow early in the growing season.

Another reason was the fast establishment and growth of vegetatively propagated grasses, which provided more immediate impact than slower establishing legumes and trees. The value of herbaceous legumes was usually appreciated only after at least one year. Herbaceous legumes tended to establish more slowly and their performance only showed in the dry season, when they were more palatable and greener than grasses. Trees had the longest establishment period in addition to taking a long time to produce seed.

Another trend was the development of systems for using the forages. At all sites where farmers were expanding their forage areas, the cut-and-carry system was the first system adopted by most farmers (Table 4). This system was adopted even at the early

Table 3. Forage technology options for smallholder upland farms in Southeast Asia.

Farming systems	Forage technology options							
	Cut & carry plots	Grazed plots	Living fences	Hedgerows	Improved fallows	Cover crops in annual crops	Cover crops under trees	Ground covers for erosion control
Short-duration slash & burn	✓	✓	■ ✓	—	■	—	—	—
Grassland	✓	■ ✓	■ ✓	✓	—	—	—	—
Extensive upland	✓	■ ✓	—	✓	—	■ ✓	—	—
Moderately intensive upland	■ ✓	■ ✓	■ ✓	■ ✓	—	■ ✓	■ ✓	■ ✓
Intensive upland	■ ✓	—	■ ✓	■ ✓	—	—	■	■
Rain-fed lowland	■	—	■	—	■	—	—	—

✓ = forage technology adoption occurring.
■ = potential forage technologies originally identified.

Table 4. Diversity of adoption of forage options in different farming systems.

Farming systems	Total number of farmers evaluating	Years of farmer evaluation	Number of farmers expanding forages into systems	% of farmers expanding							
				Cut & carry plots	Grazed plots	Living fences	Hedgerows	Improved fallows	Cover crops in annual crops	Cover crops under trees	Ground covers for erosion control
Short duration slash-and-burn	395	1–3	93	100	1	2	0	0	0	0	0
Grassland	240	2–4	104	88	9	29	21	0	0	0	0
Extensive upland	268	3–4	87	99	1	0	13	1	0	0	0
Moderately intensive upland	452	2–4	29	73	4	27	16	0	6	6	6
Intensive upland	385	2–4	46	63	0	6	35	0	0	0	0
Rainfed lowland	19	1[1]	0	0	0	0	0	0	0	0	0

[1]Forage development activity was stopped after 1 year.

stages when farmers were still testing the forages for the first time.

With time and experience, farmers then tried out and discovered other systems for using forages. For instance, the number of farmers adopting hedgerows and living fences has already started to increase. The use of forages for improved fallow, grazing and cover crops has just started.

These examples all highlight the importance of allowing time for farmers' experience to build up before forage use systems could be developed. The major task of development workers therefore was to provide active input in terms of encouraging farmer innovations (in using the forages) as well as creating an environment where there is a free exchange of ideas with and between farmers.

Farmers' Criteria for Selecting Forage Varieties

In the process of testing and using the forages, farmers developed criteria for selecting varieties best suited to their needs (Table 5). The trend was that farmers first selected varieties based on their growth (well adapted species) plus the most important characteristic relating to his or her perceived need. The main criterion therefore often was whether the variety established and grew well, as well as being palatable to animals (since feed was the primary intended use).

Table 5. Farmers' criteria for selecting forage species.

Criteria	Forage system	
	Cut & carry	Contour hedgerows
Easy to establish*	✓	✓
Grows well*	✓	✓
Palatable to animals*	✓	✓
Fast regrowth*	✓	✓
Persistence*	✓	✓
Easy to cut	✓	
Easy to carry	✓	
High edible yield	✓	
Fattens animals	✓	
Holds the soil		✓
Does not compete with main crop		✓
Grows densely in a narrow row		✓
Not itchy (hairs, sharp leaf)		✓

*Primary criteria for selecting species.

As farmers developed other systems of forage use, a new set of criteria emerged, for example, ease of cutting. These were all related to the characteristics of the forage that would fit their intended use (this intended use could well have been different from the use identified when the farmer started planting forages). However, the farmers only applied these criteria after the species passed the previous set of criteria.

Moreover, farmers differed in the importance they attributed to some criteria. For example, some farmers disliked *Panicum maximum* 'Tobiata' because of its very sharp hairs that made cutting difficult. However, there were other farmers who preferred this cultivar (despite the sharp hairs) because of its high edible yield and fast regrowth.

As farmers gained experience with growing forages they changed their ranking of selection criteria. For instance, some farmers initially favoured and planted *Pennisetum purpureum* as a cut-and-carry species. After some time, they realised that it was difficult for them to go into the plots to cut the grass because of the long stems and leaves that were entangled with each other when plants had not been cut for a long time. They then shifted to using shorter species like *Setaria sphacelata* 'Lampung'.

What Forage Varieties do Farmers Adopt?

As the farmers gained experience, they selected one or more forage varieties for planting in larger areas. Often farmers selected several varieties, not just one. Moreover, they tended to maintain a few other varieties, usually by maintaining the initial testing area.

Some varieties were adopted by many farmers at most sites (Table 6). However, there were also varieties that were adopted by a majority of farmers at only few sites. In addition, some varieties have been expanded or adopted just recently. This change in variety preference was brought about by changes in farmers' recognised problems, their intended use of the forage as well as new opportunities that developed overb time. This once again highlighted the need for providing farmers access to a broad range of varieties.

Farmers' Innovations and Feedback to Research

The farmers developed innovations as they gained more experience with forages. These could be classified into: (a) new uses, and (b) new ways of propagating and managing forages.

One of the new uses that emerged was the use of forages to feed fish (grass carp) in Vietnam. These fish were traditionally fed with native grasses which had become scarce with time. Farmers discovered that some of the new forage varieties could be used for feeding fish. These include *Panicum maximum*

(‘Simuang’), *Paspalum atratum* (‘Terenos’) and *Setaria sphacelata* (‘Solander’). An important characteristic of foliage of these species (aside from being eaten by the fish) was that they floated when thrown in the water, since the grass carps are surface feeders.

Table 6. Forage varieties adopted by farmers.

Species	Adopted by many farmers at	
	many sites	some sites
A. Grasses		
Pennisetum purpureum (Napier) and *P.* hybrids	✓	
Panicum maximum (Simuang)	✓	
Setaria sphacelata (Lampung, Solander)	✓	
Paspalum atratum (Terenos)	✓	
Brachiaria brizantha (Marandu)	✓	
Brachiaria hymidicola (Yanero, Tully)	✓	
Panicum maximum (Tobiata)		✓
Brachiaria decumbens (Basilisk)		✓
B. Legumes		
Gliricidia sepium (local)	✓	
Stylosanthes guianensis (Stylo 184)	✓	
Centrosema pubescens (Barinas)	✓	
Arachis pintoi (Itacambira, Amarillo)		✓
Gliricidia sepium (Retalhuleu, Belen Rivas)		✓
Leucaena leucocephala (K636)		✓
Calliandra calothyrsus (Besakih)		✓

Another use of forage was for feeding chickens, ducks and pigs. This use evolved through farmers having observed that several legume varieties were eaten by these animals when they were let loose. These legumes include *Arachis pintoi* (‘Itacambira’ and ‘Amarillo’) and *Stylo*santhes *guianensis* (‘Stylo 184’).

Some farmers also planted *Arachis pintoi* around their houses and on the roadsides as an ornamental. Likewise, some farmers planted ‘King’ grass (*Pennisetum* hybrid) as a fence since it could grow densely and prevent entry of small animals like chickens.

Other innovations related to the propagation and management of forages. These included sowing of forage seeds in a seedbed to be later transplanted into the farm. This procedure provided savings in labour for maintenance and establishment as well as ensuring survival of the plants. Farmers in areas infested with *Imperata cylindrica* also learned that they could save labour and time by establishing grasses such as *Paspalum atratum* ‘Terenos’ using vegetative propagation directly into the *Imperata* area without land preparation. Subsequent weeding was done to assure survival.

All these innovations demonstrate that farmers innovate as they gain experience with forages. The trend was that they developed more complex ways of planting, managing and using forages with time. The evolution of these innovations also has implications for supporting research.

Lessons Learned

The experiences presented in this paper demonstrate that developing forage technologies with smallholder farmers was, for us, a learning process. This learning process involved both the farmer and the development workers. It was clearly shown that farmers tried out and learned new things. On the other hand, extension workers and researchers involved learned about the importance of facilitating the process of technology development and gained a better understanding of adoption.

It also became evident that technologies that were successful at one site could not be ‘photocopied’ to other sites due the existence of variability not only between sites but also between individual farmers. Farmers’ problems, priorities and preferences changed with time. What is therefore implied is the need to provide a broad range of options (such as forage varieties) for farmers to try and encourage them to innovate as well as exchange ideas with other innovators.

Working with farmers to develop appropriate technologies is rewarding but requires a long-term commitment from all people involved in the process. It requires nurturing and institutional support.

References

Stür, W.W., Ibrahim, T., Tuhulele, M., Le Hoa Binh, Gabunada, F. Jr., Ibrahim, Nakamanee, G., Phimphachanhvongsod, V., Guodao, L. and Horne, P.M. 2000. Adaptation of forages to climate, soils and use in smallholder farming systems in Southeast Asia. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Tuhulele, M., Le Van An, Phengsavanh, P., Ibrahim, Nacalaban, W., Vu Thi Hai Yen, Truong Tan Khanh, Tugiman, Heriyanto, Asis, P., Hutasoit, R., Phimmasan, H., Sukan, Ibrahim, T., Bui Xuan An, Magboo, E. and Horne, P.M. 2000. Working with farmers to develop forage technologies – field experiences from the FSP. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Development of Fodder Tree Technologies through Participatory Research – Experiences from Central Kenya

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Abstract

The Diagnosis and Design method has long been used to identify problems in the farming systems in of the subhumid zone of central Kenya, and to design research proposals. In the semi-arid zone, more participatory tools were used. Although both methods identified fodder shortage and low quality fodder as major constraints to animal production, participatory rural appraisals enhanced a more dynamic research program in the semi-arid zone. Lessons were learned during on-farm and participatory research with exotic and indigenous fodder trees, and they are described in this paper. Adoption of a fodder technology involving the tree *Calliandra calothyrsus* was increased dramatically when farmers were involved in the propagation of the tree, through production of seed and the establishment of on-farm nurseries. Farmers were able to assess accurately the qualities of indigenous fodder trees through their own criteria, and significant differences were obtained among species, through the use of a participatory tool. It was concluded that there is a logical sequence of on-farm and on-station experiments in the development of fodder tree technologies. Training farmers in the propagation of fodder trees is essential for wide spread adoption.

IN THE subhumid highland of central Kenya, agriculture is the most important source of income, and livestock production contributes half of the household cash income from agricultural activities. There is still a vast room for higher income through increased milk production (Murithi 1998).

Major constraints to small-scale dairy production in the region are the low quality of available fodder and lack of fodder during the dry season. Trees can provide high quality fodder supplements and provide green fodder during the dry season when grasses have dried up.

The National Agroforestry Research Project in Embu, Kenya, has carried out research on fodder tree technologies. In order to ensure farmers' participation in the research process, the project's aim has always been to conduct at least 60% of the research on-farm. The objective of this paper is to review the research methodology, to discuss the lessons learned and to make recommendations for similar projects elsewhere in the tropics.

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The case studies are roughly divided into exotic fodder trees in general, *Calliandra calothyrsus*, and indigenous fodder trees.

Problem Diagnosis

In 1987, the International Council for Research in Agroforestry (ICRAF), together with USAID and national scientists, started a network for research in agroforestry in the highlands of eastern Africa. For the identification of areas for research, the Diagnosis and Design (D&D) method was used (Raintree 1987).

A macro D&D study was carried out for the whole bimodal rainfall highlands of eastern Africa (Minae and Akyeampong 1988), followed by a micro D&D study for the highlands of central Kenya (Minae et al. 1988). D&D studies are typically conducted by a team of scientists from multiple disciplines. They review previous diagnostic studies, talk to a few farmers and extension staff and then conduct a major formal survey. These D&D studies were able to identify problems in the farming system, and suggest areas for research to address these problems. However, the D&D studies lacked the flexibility to describe and address problems of non-modal households.

Researchers often know the problem areas before they start interviewing the farmers and the D&D exercise is then used to prioritise these problems. Farmers play a passive role and farmers' ownership of research is not stimulated. There is a high chance that important concerns of farmers are missed out.

In 1993, the Dryland Applied Research and Extension Project (DAREP) conducted broad-based diagnostic surveys in the semi-arid zone of central Kenya, consisting of many Participatory Rural Appraisal (PRA) tools. A comprehensive picture was obtained about the problems in the farming systems. Many stakeholders, such as farmers groups, women groups, NGOs, churches and Ministries, were involved in the PRAs, which enhanced the involvement of these stakeholders in following research activities.

During the exercise, it became apparent that in the region there was a development process going on which resulted in the intensification of the farming systems in the semi-arid lands. One of the features of this process was the adjudication of land by the Government to individuals, resulting in a reduction in communal uses, such as herding of livestock (Sutherland et al. 1995).

Another feature was the influx of people from the more densely populated higher altitude zones, and from regions across the Tana River, where climatic conditions have been much more adverse for farming. The intensification of the farming system also resulted in more intensive livestock production.

A shift was observed away from extensive grazing, with local cattle breeds, towards fencing of grazing land, tethering and cut and carry of fodder for cross-bred and improved dairy cattle breeds. Farmers were eager to experiment with improved fodder technologies, including fodder trees.

Exotic Fodder Trees

One of the first on-farm experiments of the project in the subhumid zone was designed to assess the ability of the fodder trees *Leucaena leucocephala*, *Calliandra calothyrsus* (calliandra), and *Sesbania sesban* (sesbania) to establish in existing plots of napier grass (*Pennisetum purpureum*) (ICRAF 1993). All species showed more than 64% survival in the first six months. Sesbania displayed the most vigorous growth in the first year. An unforeseen finding, however, was that most sesbania trees died after frequent cutting by farmers in subsequent years. In another on-farm experiment, rows of calliandra and napier grass were planted on contour bunds, either alone or together, to assess the biomass production potential (O'Neill et al. 1994). Technicians were to harvest the rows at scheduled times.

During the first few harvests, significant differences were found between yields of species grown alone and in combination. Later on, however, the fodder was harvested by farmers before the arrival of the technician. This finding stressed the significance of the problem of fodder shortage. The method would have to be revised if the original objectives were to be met.

Calliandra

Calliandra performs well in the subhumid zone of central Kenya and is one of the most wanted exotic fodder trees in this region. In order to assess the milk production potential of this tree, on-farm feeding trials were carried out, comparing supplemental feeds of calliandra and concentrates (Paterson et al. 1999).

The dietary treatments were determined in a workshop to which all participating farmers and their wives were invited. Heaps of fresh napier grass, the most common basal diet for cattle in the area, were provided, and farmers made their own heaps to represent the amounts they feed a cow each day. The same was done for calliandra. The average amount of fresh calliandra fed was 1.25 kg per day, but most farmers said they would feed more if they had more trees. The average weight of the napier heaps was 80 kg and this defined the basal ration for all cattle in the experiment.

The first treatment was agreed to be a supplement of 1.25 kg of calliandra per cow per day. The second treatment was an amount of concentrates with an equivalent amount of crude protein as in the amount of calliandra. The third treatment was twice as much calliandra as the first treatment. In this, way farmers' practices, farmers' ambitions and researchers' expertise were combined to obtain satisfactory and uniform treatments.

Based on the results of the experiment, it was calculated that 1 kg of concentrates could be replaced by 3 kg of fresh calliandra without affecting milk production. Franzel et al. (1996) calculated that, if a farmer replaced the amount of concentrates recommended by extensionists (2 kg per day per cow) with calliandra, his or her net profit would increase by US$143 per cow per year.[1] If this amount of calliandra were to be fed in addition to 2 kg of concentrates, the net profit would increase by US$98 per cow per year.

One way of assessing the adoption potential of a fodder technology is to study the spontaneous expansion of the technology by farmers. Farmers, who had received seedlings of calliandra from various

[1]1 USD = 60 KES in 1999.

projects between 1988 and 1993, were asked whether they had expanded. Figure 1 shows that these farmers planted even more seedlings in subsequent plantings than in their first plantings.

A big constraint, which was frequently mentioned, was the shortage of seedlings. The National Agroforestry Research Project realised that it could never respond sufficiently to the great demand for calliandra seedlings. The project had unintentionally created a dependence on seedlings, which was stagnating further expansion of the technology. Since then, the project stimulated farmers to raise their own seedlings on-farm. They were also taught farmers how to produce good quality seeds from the trees, which was important because calliandra is not naturally a prolific seed producer. By mid 1995, 36% of the farmers had established their own nurseries. Adoption of calliandra further increased. Adoption cut across income classes, but was correlated with the importance of the dairy component in the farming system (Franzel et al. 1996).

The establishment of on-farm tree nurseries was considered to be the key to adoption of calliandra. A training expert was therefore hired to train trainers of various organisations to train farmers in the establishment of tree nurseries, and the management of calliandra for feeding livestock. Training of farmers took place in farmers groups, which pre-existed in most cases.

In the first six months of 1999, 160 new on-farm nurseries were developed, involving more than 2000 farmers in 6 districts, and 800 000 seedlings were raised in these nurseries.

This experience shows that, although a technology can spread from farmer to farmer, adoption in a region is greatly enhanced when well equipped extension staff help actively in the diffusion process.

If a technology has proved to be beneficial to farmers, and if any natural expansion has been observed, there would be a big loss of opportunity if the spreading of the technology was not actively facilitated by outsiders.

Indigenous Fodder Trees

In several surveys in the subhumid zone, farmers mentioned that they used indigenous trees to feed their cattle, goats and sheep. In the semi-arid zone, research planning workshops were organised with all stake holders, after the PRAs had finished. In these workshops farmers had expressed interest in planting indigenous fodder trees and shrubs.

A research framework was then developed to incorporate farmers' knowledge, laboratory analysis, feeding trials, literature review, scientists and key informants, on-farm evaluation, on-station evaluation, propagation studies and regular feedback meetings (Figure 2). During the survey on indigenous knowledge and practices of fodder trees, it was found that 160 different local species were used by farmers. The framework of research activities was used to screen these species, resulting in a list of the most promising species in each agroecological zone.

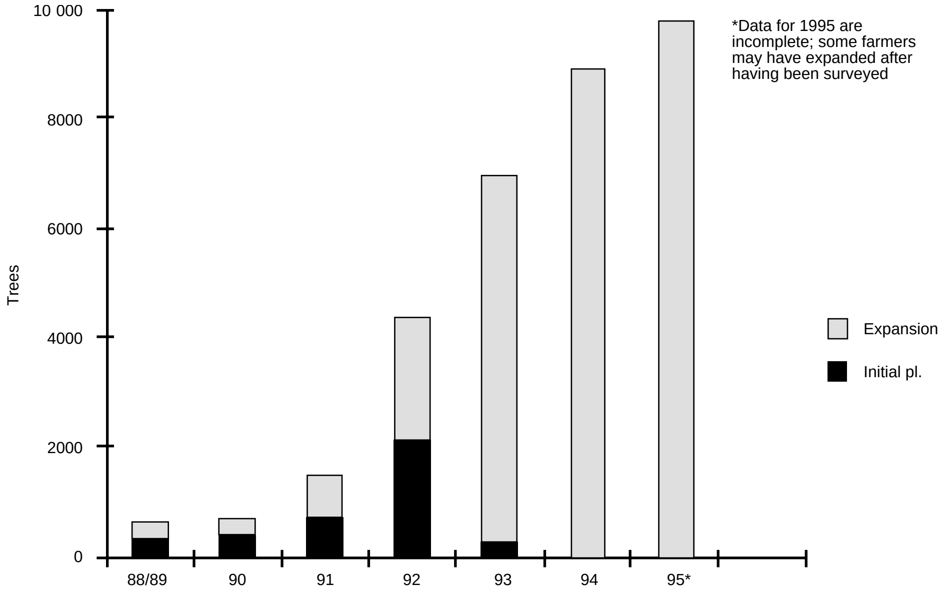

Figure 1. Expansion of calliandra plantings by 45 surveyed farmers who first planted in 1993 or earlier (Franzel et al. 1996).

A traditional wooden game, the *bao* game, was used as a participatory tool for farmers to rate different tree and shrub species for different parameters (Figure 3). These parameters were quality indicators of fodder trees, as defined by farmers, such as palatability to cattle, palatability to goats, effect on animal health, compatibility with crops and drought resistance.

Scientists added some parameters such as growth rate after establishment and rate of regrowth after harvesting. Farmers could allocate 1, 2, 3 or 0 seeds per pocket in the *bao* game, to indicate poor, medium, good or does not know, respectively, simulating matrix ranking. These data were analysed by chi square and significant differences among species were obtained (Table 1).

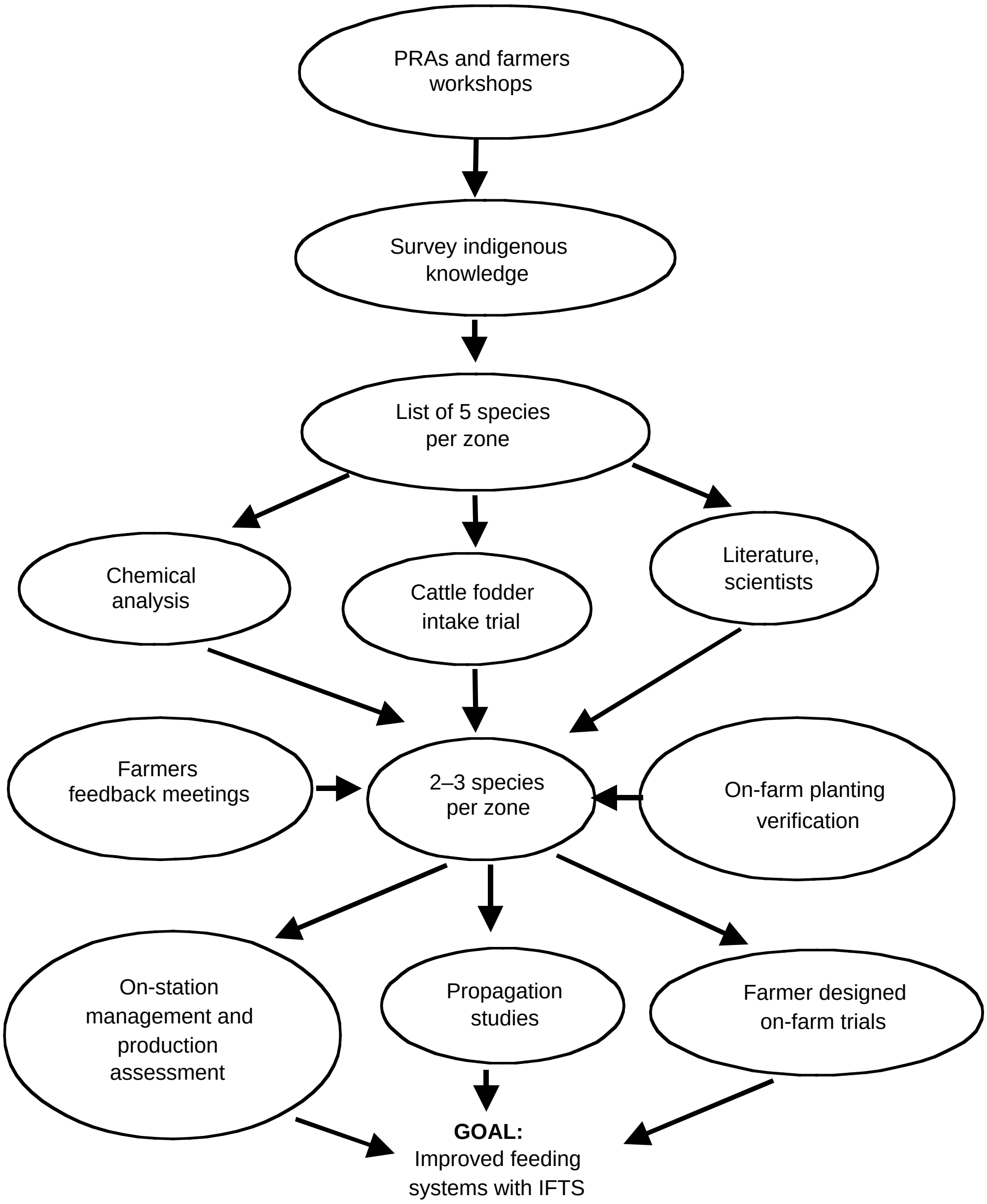

Figure 2. Framework of activities in the evaluation of indigenous fodder trees in different agroecological zones.

Table 1. Farmers' scoring of improved fodder tree species on selected criteria using the bao game, subhumid zone (Roothaert 2000).

	Growth after establishment	Regrowth	Palatability for cattle	Compatibility with crops	Health	Drought resistance
	(mean scores[a] and standard deviations in parentheses)					
Triumfetta tomentosa	2.2 (0.93)	2.3 (0.86)	2.1 (0.90)	1.9 (1.07)	2.4 (0.81)	2.3 (0.75)
Commiphora zimmerm	2.9 (0.34)	2.9 (0.33)	2.6 (0.53)	3.0 (0.00)	2.7 (0.65)	2.8 (0.45)
Bridelia micrantha	1.6 (0.73)	2.1 (0.90)	2.1 (0.69)	1.8 (0.98)	2.4 (0.73)	2.1 (0.99)
Vernonia lasiopus	2.4 (0.79)	2.5 (0.69)	2.1 (0.90)	2.2 (1.10)	2.5 (0.76)	2.3 (0.76)
Tithonia diversifolia	2.9 (0.33)	3.0 (0.00)	1.6 (0.98)	2.2 (1.00)	2.8 (0.50)	2.5 (0.93)
Lantana camara	2.7 (0.47)	2.8 (0.40)	2.7 (0.50)	1.6 (1.00)	3.0 (0.00)	2.1 (0.93)
Significance level	0.004	0.038	0.051	0.11	0.67	0.33

Notes: The number of farmers scoring each species on each criterion varied from 4 to 17.1 = poor, (s.d.).
[a]A rating of 3 indicates good, 2 indicates medium and 1 indicates poor.

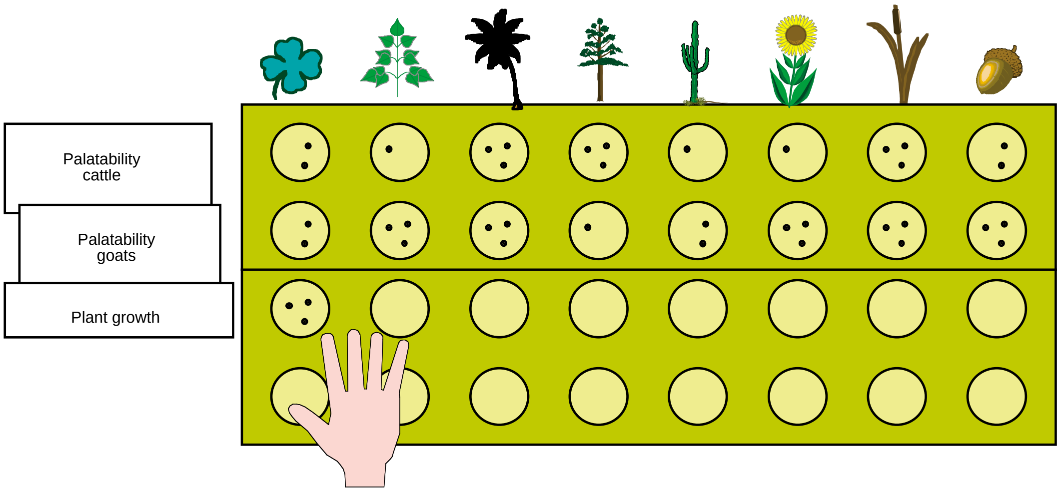

Figure 3. The traditional wooden bao game as a participatory tool for matrix ranking of fodder tree species.

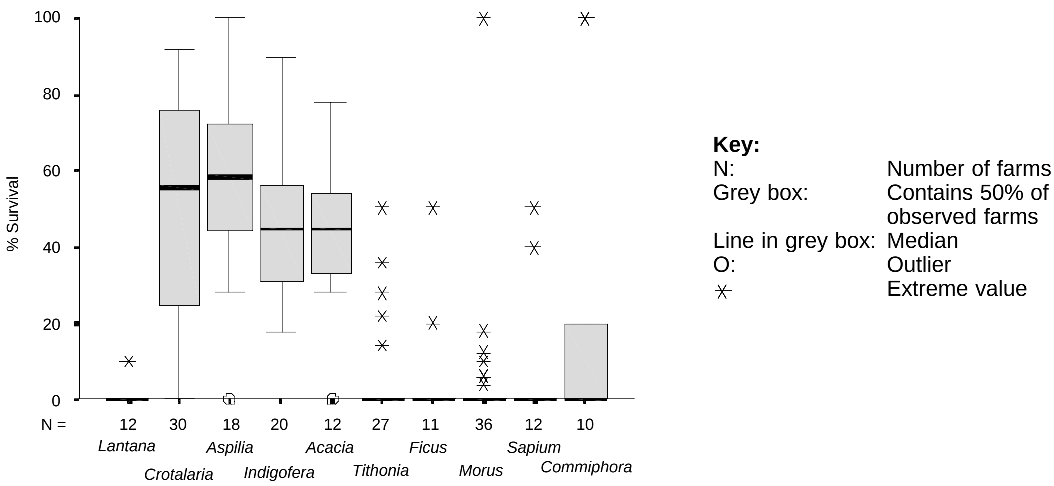

Figure 4. Survival of indigenous fodder trees and shrubs two months after first planting (Roothaert 2000).

Farmers feedback meetings were not only useful to confirm findings from the survey but also to review inaccurate information. For instance, during the survey it was found that in one particular zone, the same trees had different vernacular names from other zones. It was hypothesised that people from another area had migrated there. This was confirmed during the feedback meeting, and the finding had implications for the analysis. Additional information was obtained during the feedback meetings about species which were much used, but which would not be planted, such as *Lantana camara, Bridelia micrantha* and *Maytenus putterlickioides*.

Other examples of additional information obtained were that *Trema orientalis* improves the soil and can be intercropped with coffee, that cutting tree fodder saves time, and that mixing of species was considered positive in the dry area but negative in the subhumid area. The feedback meetings also boosted the confidence of farmers that there was a lot of value in their local practices.

Seedling of the most preferred trees and shrubs were raised in nurseries and selected by 70 farmers in three zones for planting on farm. Unfortunately, during the season of planting (November 1996) there were only 3 weeks of rain, followed by a severe drought. This unforeseen climatic event, however, showed clear differences in survivability of species (Figure 4). Other findings from the on-farm experiment were:

- Seedlings which had been planted in shady places had a higher percentage of survival ($p < 0.05$).
- Species which were common in the subhumid zone and which farmers wanted to try in the medium dry zone were severely affected by termites. This indicated that these particular species, *Tithonia diversifolia* and *Morus alba,* were outside their feasible habitat.
- Species which were given most manure by farmers were *Sapium ellipticum* in the subhumid zone and *Crotalaria goodiiformis* in the semi-arid zone. This practice stressed the preference for these species.
- Species which were more preferred by men than women were *Ficus* spp., *Indigofera lupatana* and *C. goodiiformis*. This finding has implications for the adoption potential among gender groups.
- Women were more persistent in caring for the trees.

The enthusiasm of farmers in the experiment indicated strong interest to intensify the use of indigenous trees and shrubs for fodder.

Conclusions

There is a logical sequence of PRAs, surveys and on-farm and on-station experiments in the development of fodder tree technologies. PRAs provide a fast, holistic and cost-effective way of identifying constraints and opportunities. Surveys are a useful tool to obtain detailed information on a particular subject. Farmers meetings are essential throughout the research process, to confirm earlier findings and to clarify obscurities. On-farm experiments provide practical information while the technology takes shape.

On-station research is needed at some stage to provide information on fodder production potential, which facilitates economic evaluation of the technology. For widespread adoption of a technology, it is essential that planting material is abundantly available.

In central Kenya a successful adoption has been achieved by training farmers to raise their own seedlings of calliandra. There is a big opportunity for the use of indigenous fodder tree species, backed up by a wealth of knowledge.

Acknowledgements

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References

Franzel, S., Arimi, H., Murithi, F. and Karanja, J. 1996. Boosting milk production and income for farm families: The adoption of *Calliandra calothyrsus* as a fodder tree in Embu District, Kenya. In: Mugah, J.O., ed. Proceedings of the First Kenya National Agroforestry Conference on People and Institutional Participation in Agroforestry for Sustainable Development, Muguga, Kenya, Kenya Forestry Research Institute, 421-438.

ICRAF, 1993. Annual Report 1992. Nairobi, Kenya, International Centre for Research in Agroforestry.

Minae, S. and Akyeampong, E. 1988. Agroforestry potentials for the land use systems in bimodal highlands of eastern Africa. AFRENA Report No. 3, Nairobi, Kenya, ICRAF.

Minae, S., Kaumi, S., Avila, M., Okorio, J., Kaboneka, S. and Ghahamanyi, A. 1988. Agroforestry Research Project Proposal for the Coffee Based System in the Bimodal Highlands, Central and Eastern Provinces, Kenya. AFRENA Report No. 16, Nairobi, Kenya, ICRAF.

Murithi, F.M. 1998. Economic evaluation of the role of livestock in mixed smallholder farms of the Central Highlands of Kenya. Ph.D. thesis, Department of Agriculture, Veterinary Epidemiology and Economics Research Unit, The University of Reading, UK, 289 p.

O'Neill, M., Murithi, F., Nyaata, Z., Tuwei, P. and Gachanja, S., 1994. National Agroforestry Research Project, KARI Regional Research Centre – Embu, Annual Report: March 1993-March 1994. AFRENA Report No. 81, Nairobi, Kenya, ICRAF.

Paterson, R.T., Kiruiro, E. and Arimi, H.K. 1999. Calliandra calothyrsus as a Supplement for Milk Production in the Kenyan Highlands. Tropical Animal Health and Production 31, 2,: 115-126.

Raintree, J., ed. 1987. D&D User's Manual: An Introduction to Agroforestry Diagnosis and Design, Nairobi, Kenya, ICRAF, 110 p.

Roothaert, R.L. 2000. The potential of indigenous and naturalized fodder trees and shrubs for intensive use in central Kenya. Ph.D. thesis, Wageningen University, The Netherlands, 174 p.

Sutherland, A., Ouma, J. and Ndubu, J. 1995. Farming in Mbeere. Report of an Informal Diagnostic Survey of the Farming Systems of Lower Embu, Kenya. Volume 1. Embu, Kenya, Kenya Agricultural Research Institute, Regional Research Centre.

Farmer Adoption and Adaptation of the Simple Agro-Livestock Technology (SALT 2) Farming System in Bacungan, Magsaysay, Davao del Sur: A Case Study of 'What happened?' and 'Why?' in Relation to Farmers and Participatory Technology Development and Implementation

J.J. Palmer[1], E. Guliban[1] and S. Musen[1]

Abstract

Adoption and adaptation over a five-year period of an integrated livestock farming system known as Simple Agro-Livestock Technology (SALT 2) is outlined for a village in Mindanao, the Philippines. Adoption of the system as seen by the organisation, the extensionist and the farmers themselves is discussed. Observations are drawn from the farmers' subjective observations as well as on site-analysis. In addition, some simple principles and lessons about community development and participatory approaches are shared and conclusions made.

THE MINDANAO Baptist Rural Life Center (MBRLC) is a non-profit, non-government organisation dedicated to the benefit of the upland farmers of the Philippines. It was started in September 1971 by agriculturist Harold R. Watson in *barangay* (village) Kinuskusan, Bansalan, Davao del Sur on the island of Mindanao. The MBRLC is located on a 19 ha demonstration farm but has a strong focus in community development throughout many villages in the southern Philippines. Out of the current almost 100 staff members, about half are located outside of the main centre serving in village level development programs.

From its inception in 1971, a high emphasis has been given to helping Filipinos in the uplands develop sustainable farming systems for small, upland farm families and communities. Even though the extension methods used with farmers are holistic (including health care, infrastructure, etc.), a heavy response by communities has been in the area of agriculture production. To date, a number of internationally known agroforestry technologies utilising nitrogen-fixing trees and/or shrubs (NFT/S) have been developed by the MBRLC and farmers working together. These are primarily the Sloping Agricultural Land Technologies known generally as SALT (Watson and Laquihon 1985).

Four distinct SALT technologies have been developed (MBRLC 1989, 1991, 1995, 1997a, 1997b, 1997c). Brief descriptions of these follow:

(a) Sloping Agriculture Land Technology (SALT 1)
Since the mid-1970s, the SALT 1 technology has utilised a number of fast growing nitrogen-fixing trees and shrubs (NFT/S) for soil conservation and a biological fertiliser source in the uplands. These NFT/S are planted in double hedgerows along the contour of sloping areas four to five metres apart. These nitrogen-fixing hedges act as a physical barrier to soil erosion as well as providing a rich mulch which reduces soil erosion as well as providing a good source of organic nutrients for the system and a soil covering conditioner. The original SALT 1 model is situated on a one-hectare plot. To date, almost 100 species of NFT/S have been tested and screened by the MBRLC for use as erosion control, biological fertiliser and soil conditioner within the SALT 1 system. The major NFT/S

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hedgerow species utilised are *Desmodium cinerea* (= *'D. rensonii'*), *Flemingia macrophylla, Gliricidia sepium, Indigofera tyesmani, Leucaena* sp. and *Calliandra* sp.

(b) Simple Agro-Livestock Technology (SALT 2)
This technology is a variation of SALT 1 with a heavy emphasis being placed on an animal component. In the SALT 2 model, the main demonstration makes use of an integrated goat dairy on a half-hectare of land. Half of the land area is dedicated to agroforestry trees (mainly NFT/S) which are used solely as forage/fodder for the goats, while the other half is dedicated to growing food crops and generating income for the farm family. Again, the main agroforestry species mentioned above for SALT 1 are primarily used in this system.

(c) Sustainable Agroforest Land Technology (SALT 3)
Another variation of the SALT 1 technology is SALT 3, in which a heavier emphasis is placed on small-scale reforestation for the farm family. This is a two-hectare model in which one hectare is utilised as a regular SALT 1 project while the remaining hectare is planted with trees, as a small, farmer-managed forest. The majority of the agroforestry species utilised in the reforestation area are again NFT/S such as *Albizia saman, Pterocarpus indicus, Acacia auriculiformis, A. mangium,* and *Leucaena diversifolia*. However, a number of non-NFT/S are also used in this agroforestry model including *Swetinia macrophylla, Gmelina arborea* and *Eucalyptus* spp.

(d) Small Agrofruit Livelihood Technology (SALT 4)
Fruit trees often escape the attention of agroforesters, and these are the building block of the SALT 4 technology. Based on the idea that some farmers would prefer fruit production over other commodities, SALT 4 integrates durian (*Durio zibethinus*), lansones (*Lansium domesticum*), rambutan (*Nephelium lappaceum*), mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), coffee (*Coffea* spp.) and calamansi (*Citrus madurensis*) into a half-hectare demonstration with high returns on investment. The majority of agroforestry fruit trees utilised here are non-NFT/S but are supported by the presence of N-fixing hedgerows for erosion control and soil fertility management.

The main thrust of all SALT technologies is to: 1) Minimise soil erosion; 2) improve and maintain soil fertility; and 3) provide food and income for the farm family. In short, the SALT idea has sought to provide sustainable, balanced farming systems where the undesirable farm outputs (erosion, leaching, burning, etc.) are minimised and desired outputs (production) are maximised. All of this is done in a nitrogen-fixing framework where the main inputs to the system are from nitrogen-fixing plants which supply biological fertiliser and act as a soil conditioner (Palmer 1996).

This paper will focus on the adoption of the SALT 2 technology and its adaptation by a group of local farmers in a village. It will give MBRLC approaches, philosophy and principles of community development and make simple observations based upon our years of field experience. It is meant to be open ended, subjective and open for discussion with the group.

The MBRLC Approach to IMPACT Community Development

MBRLC sees development as a process and its approach to development is largely participatory. As a process, technologies and/or development projects are also viewed as practical training grounds for a community gradually to gain capability and control of managing its own development. As a participatory-based process, the community plays a direct and major role in the design, implementation and evaluation of a project.

The MBRLC technician takes the role of a facilitator – living in the village for a period of time and helping the community as they plan and implement community and/or individual projects. Village mapping and analysis of development constraints is done with a variety of tools involving the local people. The availability of local resources influences project design. Continuing education – on positive values and project management capability – marks the whole development effort. Linkage with the local government is a must in the MBRLC approach, recognising the local government as a key player in development.

The MBRLC approaches community development and extension with an IMPACT philosophy. In a village, we work with a small, manageable core-group (or multiple core groups) until they become the 'change agents' within the whole community. Attitudes, values, and capabilities are strengthened within the whole group to the point where they can clearly recognise the constraints to development and are able to analyse and choose ways to solve community problems that are just and fair to the whole community. In a truly successful community development project, in MBRLC's estimation, this core then becomes a 'ripple' to spread the capabilities and knowledge with the rest of the villagers and even to surrounding villages in order to have the greatest IMPACT for development.

The MBRLC Concept of Modeling for Teaching

Along with community development through IMPACT, providing visual models for development participants has been an integral part of the overall MBRLC development philosophy. Whether the modeling is in an actual technology or the quality of the life of our extensionist, we have felt from the beginning that 'teaching by showing' and 'learning by doing' is an integral part in the process of gaining peoples' confidence and respect in development work. Therefore, MBRLC has utilised models in technology development (such as the SALT models) to communicate principles to our farmer participants. Moreover, we have required our staff living in the villages to be incarnational models of development. In this way, we live as well as show what we are trying to teach.

The History of Participatory Extension Work in the Bacungan Impact Area

Demography

Magsaysay (formerly known as Kialeg) is a municipality of Davao del Sur with 22 barangays (villages). The 1995 census puts the total population at 41 979 people making up 8224 families with an average of 5.1 persons per household. Half of the Magsaysay barangays are lowland irrigated and the other half are upland communities ranging from moderate to steep slopes. The whole of Magsaysay is in a dry zone with a pronounced six-month wet and six-month dry season (National Statistics Office 1995).

When MBRLC moved into the area for community development work, the Local Government Unit's (LGU) Municipal Development Council (MDC) steered the MBRLC to work in the most critically impoverished areas of the municipality. These areas were narrowed to basically four barangays: Bacungan (population: 1764), Balnate (population: 979), Malawanit (population: 1365) and San Miguel (population: 1290) or 13% of the total population of Magsaysay. These areas were chosen by the LGU-MDC and MBRLC as primary targets because of their isolation, limited access to basic services, extremely steep topography and high incidence of poverty. The majority of peoples living in these villages are Visayans who have migrated into the uplands populated by mixed-tribal peoples of B'laan heritage.

History of MBRLC work in the area

The MBRLC started work in the area in 1991. From 1991 to 1992, MBRLC community development work was conducted with groups in Balnate and San Miguel. Work was then expanded to include Bacungan (1993 to 1995), Malawanit and Asbangilok (1995 to 1997). Initial contact in the area was made by MBRLC by Mr Rod Calixtro, Base Project Division Leader, and the first MBRLC extensionist assigned to the area was Mr Noel Elmundo. Other extension workers for the life of the project included Mr Ramonito Solana and Mr Jun Elegio.

The MBRLC project was strongly linked to the LGU through the Municipal Development Council and more particularly through relationships with the Barangay Councils, Captains and the Barangay Development Councils (BDCs). Also, a good linkage was established with the European Union (EU) project known as the Southern Mindanao Agriculture Programme (SMAP) through the Department of Agriculture (DA) which provided most of the monetary inputs into the initial projects.

Results of work to date

Overall, there have been more than 250 SALT farmer-adopters in the larger area (Table 1).

Table 1. Adopters of SALT technologies in the Bacungan area.

Barangay	SALT 1 adopters	SALT 2 adopters
Malawanit	60	50
San Miguel	60	20
Balnate	30	
Asbangilok	30	2
Total	180	72

The development work actually carried out in the village was more holistic than implied in this paper. While the agriculture projects were being implemented, a number of 'other' development projects relating to infrastructure, health care, community organising, water development (etc.) were being explored and implemented by the community, with moderate leadership by the MBRLC extensionists.

However, for the purpose of this paper, we will focus on the small group of SALT 2 adopters/adapters and their experience in and around the Bacungan area. We will try to look at what and why technology adoption/adaptation occurred from the eyes of the implementing organisation, the extensionist and, more importantly, the farmers themselves.

What Happened and Why

The technical/organisational perspective

Overall, the adoption and adaptation of the SALT 2 farming system in the Bacungan, Magsaysay area was good and eye opening from the MBRLC's perspective. From 1991 to 1997, more than 200 farm families adopted the technology in a relatively small

IMPACT project area. SALT 1 (primarily addressing soil conservation and food and income generation), SALT 2 (animals), SALT 3 (forestry) and SALT 4 (fruit) type systems were designed and implemented by the local people.

Even though unusually dry El Niño years came during this period, many farmers continued with their farming systems and still do so. Naturally, some farmers are better than others and have continued expanding, also coming up with their own variations to meet the needs of their farming systems. As an example, the SALT 2 model calls for placing manures generated by the animal systems back on the crop production area. Farmers chose rather to use the manures on high-value crops such as fruit trees and their vegetable gardens. Also, many farmers chose to cut their hedges and feed them to the animals rather than placing them on the soil for decomposition and soil fertility maintenance. However, a few did choose to follow the model recommendations of planting a separate area for forages called a 'forage garden' and use the hedges as recommended. Both the adopted and the adapted system were more sustainable than their previous systems.

A big change noticed was the improved quality of the goat breeding stock in the area from the early 1990s until today. The Nubian blood is evident in most of the village goats when compared with other areas in the southern Philippines. Also, a high percentage of farmers in the area have voluntarily gone to cut-and-carry forage systems or total confinement of their animals.

The field extensionist's perspective

The viewpoint of Mr Noel Elmundo, primary MBRLC extensionist working with the project, was explored in an interview and subsequent cross-check. He had worked in the general project area from 1991 to 1997 and in the Bacungan site from 1993 to 1996.

In his opinion, one of the keys to success was the funding by the government, and the organisation of the farmers themselves. He led the farmers in a participatory process by which they designed and implemented their own system.

The farmers themselves set criteria for participation in the government-funded SALT 2 distribution. These were:

- Had to be a SALT 1 farmer;
- Had to have an adequate barn to house the animals;
- Had to have adequate forages planted to feed the animals;
- Must be a full-time farmer to make avail of the dispersal.

According to the extensionist, over a one-year period the farmers formed an association for goat raising and management. They defined roles to be played by each of the participants in the development process (Table 2).

Table 2. Roles of participants in the SALT 2 project in Bacungan.

Farmers	Extensionist	Donor
Pay back for each animal unit (one for one)	Technical support	Nails for the barn
Labour/management materials	Forage seed	Goats
Materials	On-farm training	
Train neighbours	Training seminars	

The extensionist considered that good community development principles and processes were used in helping the farmers start their new animal projects, but the farmers did know about the incentives of receiving goats. Moreover, he said that the association of farmers was formed primarily out of a need to combat low prices of marketable items, even before there was a goat project proposed.

Overall, Mr Elmundo felt that this was a very effective community project, which also spread to other areas outside the primary impact site. He stressed the importance of the good relationships between farmers and the extensionist as a key to the success of projects such as this. He emphasised that it was initially hard to convince the farmers to apply soil conservation techniques such as SALT, but after trying and seeing the benefits, it became much more accepted. He also noted that inputs in the form of counterparts, even though small, were hard for the local people to do. Even so, it was important for the local farmers to have a counterpart and good linkages with the Local Government Unit (LGU) helped the people in the long run.

The farmers' perspective

An informal survey was conducted during August and September 1999 in the IMPACT project area. Farmers were interviewed to get their perceptions of the project.

Four different groups of farmers were interviewed:

- Original adopters who are still utilising the SALT 2 systems after 5 years – (5 interviewees). These were the first recipients of the government's animal dispersal in the area;
- Later-Adopters (second and third generation adopters) who are now utilising the SALT 2 systems (6 interviewees);
- Adopters who abandoned the system – (3 interviewees);
- Non-Adopters/native goat raisers – (5 interviewees).

They were asked various questions about their adoption or failure to adopt the SALT 2 system. In

Table 3. Reasons why farmers went into a SALT 2 system (with frequency of response).

Original adopters	Later adopters	Adopters who abandoned SALT
Help in economic crises (3)	Have plenty forages (3)	Help in economic crises (2)
High income return (2)	Wanted goat milk (2)	High income return (1)
Attended seminar (2)	I wanted a goat (2)	Goats give milk (1)
Encouraged by extensionist	Help in economic crises (2)	To conserve soil (1)
Get goat manure (1)	Help improve my soil (1)	Had plenty of forages (1)
To breed more goats (1)	I wanted manure (1)	To have manure (1)
To get a goat (1)	High income return (1)	
	Easy to sell (1)	
	Encouraged by my father (1)	

questioning, a group process was used as well as individual interviews. MBRLC staff who were not primarily associated with the IMPACT project were utilised as interviewers to minimise bias in questioning.

When the first three groups were asked what factors helped them decide to go into a SALT 2 type farming system, they replied as follows (frequency of response in parentheses) (Table 3).

Most of the reasons seem to be focused on perceived benefits (e.g. 'I wanted a goat', 'Goats give milk', I wanted manure', etc.). The highest and most consistent response was 'Help in economic crises' which may reflect the recent passing of the El Niño phenomena.

When original adopters and later adopters were asked about their feed inputs into their goats, the response was:

Table 4. Feeds used for goats by SALT 2 adopters.

Feed	Original adopters	Later adopters
Rensonii (*Desmodium cinerea*)	5	6
Flemingia (*Flemingia macrophylla*)	5	5
Ipil-ipil (*Leucaena leucocephala*)	5	4
Madre de cacao (*Gliricidia sepium*)	1	1
Napier grass (*Pennisetum purpureum*)		2
Corn bran		1
Grazing	1	

The 'later' or second and third generation adopters included grasses in their feeding scheme and even a little corn bran. It should be noted that only rensonii and flemingia seeds were promoted as primary forages. The others (ipil-ipil, napier, madre de cacao, etc.) were the farmers' innovation. The area is rich in ipil-ipil and it should also be noted that this was the primary feed source (in most cases 100%) during the El Niño years.

In another question, original adopters and later adopters were asked their source of forages for their cut-and-carry SALT 2 systems. The response was:

Table 5. Source of cut-and-carry forages (and frequency of response).

Source	Original adopters	Later adopters
Contour hedgerows	5	6
Forage garden	3	1
Anywhere	1	

In the original SALT 2 model, it is taught that a separate forage garden should be planted and the contour hedge trimmings should be placed on the soil to 'feed' the soil and not be removed for animal feed. However, it is obvious from both groups of respondents that an easy source of feed to the farmer is the contour hedge. Possibly the benefits of the amelioration of the soil due to the application of plant biomass are not valued or understood by the farmers in this case.

When original adopters and later adopters were asked what systems they were currently using to raise their animals, five out of six original adopters and all six later adopters said they were using 'cut-and-carry'. Only one original adopter said he was using 'free grazing'.

After five years, this is a high rate of adoption and is possibly an indicator that this system is moving towards a sustainable system. Moreover, the housing used by both groups above was a raised barn type system for ease of manure removal. One good indicator of sustainability of this project, and that the local people feel ownership, is that three out of five original adopters have rebuilt their barns and continued with the cut-and-carry system. These new barns are located closer to their homes, for easier maintenance. On a side note, non-adopters also use a modified housing system for goat raising called the '*tugway*' system. The animal is tethered out and allowed to graze a defined area but is brought into some type of shelter when it rains.

In comparing the original livestock and barns started with between original adopters and later adopters, the data show:

Table 6. Livestock and barns owned by the original adopters and later adopters.

	Original adopters	Later adopters
Goat breed	Nubian (5); cross (1)	Nubian (1); cross (5)
Goats at start (mean and range)	5 (5–6)	3 (1–5)
Goats in 1999 (mean and range)	4 (0.5–7)	4.5 (3–5)
Mean barn area at start (m^2)	64	137
Mean barn area in 1999 (m^2)	75	137

The original adopters received a higher quality stock at the start of their project than did the later adopters. Five of the original adopters received pure-bred Nubians whereas only one of the later adopters did. Also, original adopters had an average of five animal units dispersed to them while the later adopters averaged only three animal units. The animal numbers have slightly decreased over the years (1995 to 1999) for the original adopters and slightly increased (1997 to 1999) for the later adopters. This may be due to the fact that the later adopters did not get fully started in their programs until after the full effect of El Niño had passed. Many of the original adopters sold some of their stock in order to survive during that crisis time. When interviewed, all farmers said they had plans to expand their flocks.

The barn size for original adopters was uniform and standard, as a requirement of the dispersal program. However, the later adopters opted to build larger barns even though many of them received no assistance in constructing their animal housing. In addition, the original adopters whose original barns became dilapidated built slightly bigger barns when they rebuilt and relocated.

When all four groups were asked about where they learned about SALT 2 or goat raising, the original adopters, later adopters and adopters who abandoned the program all responded 'the extensionist.' However, when non-adopters were asked the same question, they replied 'extensionist' as well as 'my father', 'my neighbour' and 'we've always raised goats.'

A most striking comparison surfaces when the various groups of SALT 2 implementers were asked how SALT 2 was introduced to them. The original adopters and later adopters said they went through a process of analysing their problems and were led by an extension worker in this analysis. However, the adopters who abandoned their SALT 2 projects, when asked the same question, replied: 'I went to a one-day meeting', or 'I was asked to try it.' This response is a far cry from process-oriented community development techniques, and would possibly have contributed to their rapid abandonment: they didn't pass through the process!

When the original group of adopters were asked to describe the process of how they came to choose the SALT 2 farming system, they gave the following responses:

- We started with establishing a farming system that would prevent soil erosion in our farmland.
- In one of our meetings, we discussed what were the possible livestock projects that would help us in times of economic crisis. We discussed choices.
- The MBRLC extensionist asked us if we would be interested in goat raising. We discussed projected income.
- We chose goats because forage for goats is easier to get. Also, because the expected income is

Table 7. Assistance given to start and continue a SALT 2 or goat project.

	Original adopters	Later adopters	Abandoned adopters	Non-adopters
Assistance at start of project				
Training	✔	✔	✔	
Nails	✔	✔	✔	✔
Initial stock	✔	✔	✔	
Building materials				✔
Forage seeds	✔	✔		✔
Mango seedlings	✔			
Assistance during project				
Tee seedlings	✔			
Farmer to farmer training		✔		
Follow-up visit			✔	
Monthly meetings	✔			
Visit from extensionist		✔	✔	
Marketing	✔			
How to worm/de-horn			✔	

higher than from the other livestock project we have discussed.
- We organised ourselves to make each one accountable to the agreement set in relation to the project.

Each group was asked if there was any assistance given to them to help start into a SALT 2 system or to start raising goats, and to continue in the project. Responses are given in Table 7.

All received nails and most received training and initial stock. It should be noted that the initial stock received by the second generation adopters were purebred whereas the third generation adopters received upgraded Nubians.

When original and later adopters were asked what, if any, was their counterpart to the project, the response came back as:

Table 8. Farmers' counterpart in implementing SALT 2 projects.

	Original adopters	Later adopters
Labour for barn construction	✔	✔
Barn materials (excluding nails)	✔	✔
Responsibility for project	✔	
Forage seeds		✔

When adopters who abandoned the system were asked 'why' they decided not to continue to utilise the system, they responded:
- Diseases (2);
- Bila is a dry area (2);
- Water is far away (1);
- Abnormalities in kids (1);
- Sold the goats during El Niño years (1).

The reasons listed by the farmers for abandoning their SALT 2 systems could be grouped into two categories: first would be physiological problems such as disease and kid abnormalities and the second is environmental conditions due to the El Nino crisis and lack of water.

When Non-adopters were asked why they did not choose to go into SALT 2, they replied:
- No area for forage due to limited land (2);
- My forage is not enough (1);
- Water source is very far (1).

Issues of land size and availability tended to be a major issue that discouraged non-adopters in the area from adopting SALT 2. Some raisers of native goats indicated that the SALT 2 system was attractive and were convinced of its advantages, but they were unable to avail themselves of breed-stock dispersals because of the qualifications required by the farmers' organisation. Farmers living on rented land were less able to meet the pre-dispersal qualification of being an established SALT farmer, having limited area to plant to forage and to build a raised-floor goat barn.

Principles and Lessons being Learned by MBRLC in Community Development

Briefly, a few general and subjective observations will be made here based on the data presented and the many other experiences of the MBRLC. In no way are we claiming to be experts in community development and participatory approaches, but we have learned and are still learning certain principles and lessons that are hopefully making us into better developers. These are in no way unique to the MBRLC and by no means all-inclusive. They are simply some of our experiences and thoughts to date.

The process is as important as the product. Outside change agents may stay only for a period of time due to budget, time and other constraints. It is thus strategic that we have highly involved influential and capable insiders to sustaining a development program. The process is a critical factor in strengthening the capability of the people in the community. For instance from the data presented, it is interesting to note that it seems those farmer participants who went through 'a process', which even they themselves could adequately describe after five years, were more likely to continue with the projects over the 'abandoners' who seemed not to have gone through a process.

Development is not done to or for people but rather with people. Created in the image of God, each person has the capacity to build something. We harness a God-given capacity when we work 'with' people instead of 'for' them. Trust is a key factor in development. Working 'with' signifies a high respect for what the people have. People are willing to trust and work with you as partners when they see that you truly hold their knowledge and experiences in high respect.

Ownership of the project from the beginning by the local people is essential for the sustainability of the project. People tend to protect and nurture the project when they have given a significant contribution to it. People's level of investment in the project naturally creates a corresponding degree of importance of the project. In the case of the Bacungan SALT 2 farmers, both original adopters and second and third generation adopters we are able clearly to state their counterparts in implementing their projects (Table 8). Moreover, the original adopters who are still implementing their systems, answered that 'responsibility for the project' as one of their counterparts. This may indicate a high level of awareness of their commitment.

Develop with impact; empower for the ripple effect. Beyond the numerical results, we find that development programs should be so designed as to consider how they will potentially change the life of the individual and the community holistically. People and communities are generally more open to a development project when they see for themselves how it can positively change their lives. Empowering then should be viewed as a crucial strategy to build within and to broaden the scope of participation over time. In the Bacungan case study, even though it is still early, a small ripple effect emerges in which we see second and third generation SALT 2 systems.

Partnerships are essential. As an old saying goes, 'Two are better than one, for together they can do more.' The community and the situations arising are so complex that there is a demand for pooling of resources. Organisations working together can create more impact in the lives of the people than when working alone. One of the observations of Mr Elmundo, MBRLC Extensionist for the project, was that the overall success of the project was directly related to the good relationships with the Local Government Unit (LGU) and the local farmers' organisation.

A key link in any development process is the change agent. It takes a special kind of change agent to produce results without compromising the process. A significant factor is the change agent's understanding that process and result are an integral part of each other. Another factor would be the change agent's wisdom and skills in working with people. The MBRLC heavily invests in staff because it believes that they are our front line change agents. The better we can make them (with physical, emotional, and educational support), the better they are able to work with communities in development and empower them with their own sustainable change agents.

Models can be good or bad but should be viewed as potential good teaching tools. It is important that people see models as an example of how a system can be potentially good. It is equally important to value the adaptation and its significance made by farmers. These models with adaptations become foundations to build upon as you continue to work together. For instance, none of the first generation adopters' SALT 2 project looked exactly like the MBRLC model. However, what they implemented also became a model for their neighbors who in turn 'adapted' to their needs. Second and third generation adopters built bigger barns, used a little different feed sources, etc. but also still held to the zero-grazing, cut-and-carry system, originally modeled forages, etc.

Some individuals are 'champions'. There are plenty of fine people in communities who have a vision and plenty of 'grit' to pursue their vision. Key in on them as a strategy and work with them and help them realise their dream. Many of these may become the sustainable change agents left in the village after the extensionist/catalyst moves on.

Work from where they are, with their own resources but don't be afraid to help them dream. In Bacungan, they had never seen a total confinement system for animal raising. After being given a long period of time to talk and discuss the advantages and disadvantages, they tried it. Today, they are continuing using the system even after five years. From seeing the benefits of confinement, they are also applying the system to other animals besides goats. Linking with the government and local funding agents, they were able to realise their new dreams.

Development takes time and commitment. Good development is not easy. It does not occur overnight. It is a continuing process. More often than not, it takes a relatively long time to see results. Patience and a high level of commitment would help a development worker to continue on.

Conclusions

Community development is largely a process-oriented discipline that works 'participatorily' with people in helping them have the ability and capability creatively to meet their needs. It basically takes place through growth in awareness, increased interaction in and outside the community, participation and interdependency in decision making and then use of resources available in a way that is just, fair and beneficial to the whole community. It is a long-term process with the overall aim of people assuming their own direction for their lives.

Participatory technology development can be seen as a tool in good community development. By allowing the people themselves to become involved and take responsibility for solving their problem, not only are projects and programs implemented but capabilities and abilities are developed. Through this, people are more likely to gain confidence to attack even larger problems. Remember the goal is not just the technology developed but the change in the people who gain skills in solving their own problems!

Too much emphasis on 'self-help' can be rather unfair. There are technologies, models and outside knowledge which can help the community. Sometimes people are poor and have problems not because of local constraints but because of regional, national and even global economic structures. However, too much reliance on 'outside-help' can be equally or even more devastating.

Lastly, we as developers are undergoing a process ourselves as we seek to work with local communities in the same process. As we enter into the lives of local people, our lives become entwined with theirs in the quest for better development. By the time the project is over and the people themselves are moving on to bigger and better things, hopefully we will come away as better developers, ourselves much better prepared for the next task before us. As we participate with people, we, as well as they, will hopefully be refined by the process. If we are truly committed to the community development process and participatory technology development, we will find some new tool, insight, methodology, etc., each time we work with a community.

References

MBLRC 1989. How to Farm Better. 1989 Edition. How to Series No. 3. MBRLC Editorial Staff. MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines.

MBLRC 1991. How to Farm Your Hilly Land Without Losing Your Soil: Sloping Agricultural Land Technology (SALT 1). 1991 Edition. How to Series No. 1. MBRLC Editorial Staff, MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines, 24 p.

MBRLC. 1995. Sloping Agricultural Land Technology (SALT) Test Results. T & D Division. MBRLC Editorial Staff, MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines, 31 p.

MBLRC 1997a. Simple Agro-Livestock Technology (SALT 2) 1997 Edition. MBRLC Editorial Staff, MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines.

MBRLC 1997b. Sustainable Agroforestry Land Technology (SALT 3) 1997 Edition. MBRLC Editorial Staff, MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines.

MBRLC 1997c. Small Agro-fruit Livelihood Technology (SALT 4) 1997 Edition. MBRLC Editorial Staff, MBRLC, Kinuskusan, Bansalan, Davao del Sur, the Philippines.

National Statistics Office. 1995 Census.

Palmer, J.J. 1996. Sloping Agricultural Land Technology (SALT): Nitrogen Fixing Agroforestry for Sustainable Soil and Water Conservation. Mindanao Baptist Rural Life Center, Tesoros Publishing, 59 p.

Watson, H.R. and Laquihon W.A. 1985. Sloping agricultural land technology (SALT): A social forestry model in the Philippines. In: Rao, Y.S., Hoskins, M.W., Vergara, N.T. and Castro, C.P. ed. Community Forestry Lessons from Case Studies in Asia and the Pacific Region. Regional Office for Asia and the Pacific (RAPA), FAO, Bangkok and Environment Policy Institute, East-West Center, Honolulu, Hawaii, USA., 21–24.

Forage Tree Adoption and Use in Asia

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Abstract

Fieldwork was conducted in Asia to examine potentials for adoption of fodder, especially tree legumes, among smallholder farmers with mixed crop and livestock systems. Analysis of traditional systems in Bali suggested that farmers were likely to grow trees for fodder if agriculture was intensive; cattle were penned and fed by cut-and-carry; agroforestry was an integral part of local systems; shade-intolerant annual crops were not relied upon as the major agricultural output; and trees were superior to other sources in providing fodder in the dry season. Work with farmers at sites in Indonesia, Vietnam and the Philippines in which forages are being introduced and tested suggested the above and other factors of importance in the adoption of trees and other forages. Farmers perceived legume tree fodders positively in terms of animal health and weight gain; but were less happy about competition with crops, the (perceived) need to mix tree fodder with other sources, insect pests, and slow regrowth. The adoption of new trees also competed with the adoption or use of new grasses, natural grasses (almost universally viewed as healthy mixtures), and crop residues. Farmers did not appear to consider the difficulty of tree establishment as a constraint to adoption.

SMALLHOLDER farms in Asia vary widely in terms of their mixes of annual and perennial crops, trees, and livestock. Farmers with irrigated lowland rice may have few or no trees and a draft animal at most. Many migrant farmers who settle in forest lands and employ slash-and-burn agriculture to produce rice or maize initially plant few trees and have minimal numbers of livestock. In more intensive upland systems, some farmers produce high value crops and have no animals. Other systems feature mixes of crops and livestock.

Those farmers with livestock employ feeding strategies ranging from herding and tethering animals to exploit natural vegetation, to intensive systems characterised by penned animals, cut-and-carry feeding, and planted forages. In between these poles, other feeding systems combine cut-and-carry feeding of both planted and natural vegetation with animal herding or tethering. Crop residues may also form a significant portion of livestock feed. Planted forages include grasses and legumes, with the latter including trees.

The Forages for Smallholders Project (FSP) has worked with small farmers in various sites in Asia on the participatory testing of new forages and animal feeding systems. Farmers somewhat readily adopted some of the fast growing, high yielding grasses, but have been less quick to adopt legume fodder trees.

Fieldwork was conducted to examine under what conditions farmers have adopted and incorporated trees in their mixed systems. Three sites in Bali, Indonesia, were included to provide understanding of systems in which farmers have incorporated many trees and some grasses in their traditional intensive systems. Three FSP project sites, one each in Vietnam, Sumatra (Indonesia), and northern Mindanao (Philippines), were visited to examine the actual or potential adoption of introduced forages, including trees, in these more extensive land use systems.

Methods

Ethnographic and participatory evaluation procedures were used to understand mixed agricultural systems,

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farmers' animal feeding systems, and farmers' perceptions regarding the forages utilised.

A small team of researchers from the Faculty of Animal Husbandry at Udanaya University (Denpasar, Bali, Indonesia), the Environmental Bamboo Foundation, and CIAT visited Besakih and Petang in the uplands north of Denpasar and sites on the island of Nusa Penida to the south of Bali. These sites featured traditional mixed agroforestry and livestock systems ranging in intensity from fully penned animals in Besakih to cut-and-carry combined with tethering in Peteng and Nusah Penida. Farmers were asked about their wet and dry season fodder use and to evaluate the forages used according to their own criteria. Eighteen to 25 farmers were individually interviewed at each site. Field observations were recorded.

FSP sites were visited in central Vietnam (Xuan Loc, near Hue), northern Sumatra (Marenu), and northern Mindanao (Malitbog). At each site, a small group of researchers collaborating with the FSP project visited both forage adoptors and non-adoptors to discuss forage use and evaluations.

The proportion of fodders used by each interviewed group aggregated the individual forage uses across the sample. Most farmers at each site had similar numbers of livestock. Where a few informants had larger herds, care was taken to determine whether their forage use proportions were similar to those of their neighbours and to correct the aggregate use as necessary.

In terms of participatory forage evaluations, farmers evaluated forages using matrices presenting each respondent's species × each respondent's evaluation criteria and by farmers' assignment of relative values (using beans or maize as counters). Individuals differed in terms of both forages used and evaluation criteria. Data were aggregated in two ways: by presenting relative values for those planting a particular forage and employing a given evaluation criterion; and by presenting the percentage of total 'votes' received by a given species × evaluation criterion combination. The first method over-valued the less frequently encountered species × criteria combinations, that is, it ignored the negative 'votes' of informants not using a particular forage and evaluation criterion combination. The second method undervalued the species × evaluation combinations held by the minority. Data aggregated from farmers' individual evaluations were, therefore, presented to show both sets of values.

The matrix method also suffered in that values assigned to a cell could not be less than zero, eliminating relative degrees of negative evaluations. Farmers were then simply asked to name both positive or 'good' and negative or 'bad' characteristics associated with each forage source.

Findings

Traditional intensive crop/livestock/agroforestry in Bali

Nineteen farmers were interviewed in Besakih. The volcanic slopes used by the Besakih farmers extend from some 1000 to 1500 metres above sea level, providing a cool climate and relatively rich soils suited to agroforestry and root crops. Farm size was a mean 0.95 ha, skewed by three extended families. Mean farm size was 0.6 ha for the 16 families (range 0.2–1.0 ha); while the remaining three families had 2.0–4.0 ha. Coffee and sweet potato were the most important crops followed by cassava, citrus, banana, cloves, coconut, and some maize. *Albizia* sp. was grown for timber for the local wood-carving industry.

The modal number of cattle was two (range 2–6 for the 16 families, 7–20 for the three extended families). Cattle were penned and not grazed or tethered. All feed was provided by cut-and-carry. Farmers relied on-farm feed resources ranging from natural grasses or weeds to planted grasses (*Pennisetum purpureum* (Napier grass)), trees (*Calliandra calothyrsus* (calliandra), *Gliricidia sepium* (gliricidia), *Albizia saman*, and jackfriut), and crop residues (sweet potato vines, leaves, and tubers) (Table 1). [n.b., Farmers near a forested hilltop outside of the study area relied more on natural grasses from the common area and planted fewer trees.]

Farms were intensively cultivated, with small parcels separated by 'live fences' comprising a wide mix of trees and a few grasses. Fence row species included the trees gliricidia, calliandra, *A. saman*, *Erythrina orientalis*, jackfruit, avocado, *salak* (a local fruit), and grasses Napier grass and king grass (*P. purpureum* × *P. glaucum*). Farmers admitted that, as all their animals were penned, the apparent live 'fences' were not established as fences per se. It is more likely that these were 'linear fields' established for fodder (and some fruit and timber) and having the advantages of ease of harvest and, more importantly, the deflection of much of the above- and below-ground competition of the trees into adjacent pathways, roadsides, and terrace walls.

Individual farmers in Besakih evaluated the forages they each used, using criteria each saw as important. When data are aggregated to show entries reflecting the mean score for farmers planting a particular forage and using a given criterion (Table 2), calliandra, gliricidia, Napier grass and sweet potato were judged as somewhat equal and superior to *A. saman*, jackfruit, and local grasses. The most important criteria were yield, palatability, and weight gain. Calliandra scored high in terms of weight gain, yield, animal health, and fast growth. Although scoring high across most criteria, gliricidia was especially valued

Table 1. Farmers' fodder sources (%), wet and dry seasons, Bali.

	Besakih			Peteng			Nusa Penida		
	% Farmers	Weight season	Dry season	% Farmers	Weight season	Dry season	% Farmers	Weight season	Dry season
TREE FODDER		37	43		25	37		41	53
G. sepium	78	11	10	100	12	14	100	32	28
C. calohyrsus	100	20	19	28	2	3		–	–
A. saman	33	2	7	22	1	1		–	–
E. orientalis		–	–	50	4	6		–	–
Ficus sp.		–	–		–	–	89	5	23
Sesbania sp.		–	–		–	–	28	4	2
Jackfruit	61	4	7	83	6	13		–	–
PLANTED GRASSES									
P. purpureum	94	19	15	100	21	13		–	–
LOCAL GRASSES	89	11	8	94	24	11	94	25	8
CROP RESIDUES		13	13		24	30		28	33
Sweet potato (tuber, leaf)	89	13	13		–	–		–	–
Cassava		–	–	61	6	8	63	6	6
Banana stalk		–	–	100	14	15	83	12	16
Coconut fronds		–	–	56	4	7	56	1	10
Bean leaf		–	–		–	–	50	9	1
TOTAL		80	79		94	91		94	94

Table 2. Species evaluation*, Besakih, Bali.

	Evaluation criteria										
	% Plant	Yield	Palatability	Weight gain	Animal health	Dry season	Establishment	Fast growing	Planting material	Total	Rank
Use criteria (%)		78	78	72	50	22	22	17	5		
C. calothyrsus	100	5	4	6	5	3	3	5	2	33	1
G. sepium	78	5	4	4	4	3	4	4	4	32	1
A. saman	33	3	3	2	2	2	3	3	3	21	5
Jackfruit	61	3	3	3	2	2	2	2	3	20	5
P. purpureum	94	6	5	5	2	3	3	4	2	30	1
Local grasses	89	4	3	4	2	1	3	1	1	19	5
Sweet potato	89	4	7	7	4	2	1	6	2	33	1
TOTAL		30	29	31	21	16	19	25	17		
Relative importance		1	1	1	5	7	5	4	7		

*Nineteen farmers each planted different species and used different evaluation criteria. Entries are mean scores for those planting a given species and using a given criterion. Relative scores for species are present planting × total. Relative importance of criteria are percent using criterion × total.

for yield. Napier grass was valued for its high yield; and sweet potato (leaves and tubers) especially high for palatability, weight gain, and fast growth.

Only slightly different results emerged when the percentage of 'votes' gained by each species × evaluation criteria was considered (Table 3). The criteria of yield, palatability, and weight gain remained the most important; and the forages *Calliandra calothyrsus*, *Pennisetum purpureum* and sweet potato were still the highest rated. Gliricidia and local grasses followed in popularity. The 'less important' evaluation criteria for Besakih farmers were animal health, ease of establishment, fast growth, dry season productivity, and availability of planting material.

Moving downslope, 18 farmers were interviewed in Petang. Farm size was a mean 0.6 ha. Cassava was the most important crop, followed by citrus, coffee, banana, cacao, cloves, peanut, coconut, ginger, papaya, and maize. As in Besakih, farmers in Peteng relied on their linear fields for tree fodders (gliricidia throughout the year and *E. orientalis* and jackfriut in the dry season) and Napier grass, as well as local grasses and crop residues – banana stalk, cassava leaf, and coconut fronds (Table 1).

Eighteen farmers were interviewed in Sakti on the small island of Nusa Penida, off the southern coast of Bali. Mean farm size was 2.0 ha (range 0.3–7.0 ha, mode 1.5 ha). The island receives less rainfall, has a drier dry season, and has poorer (limestone) soils than the Balinese uplands. The main crops were cassava, maize, coconut, banana, and beans.

The mean number of cattle was three head per family (range 1–5, mode, 2 head). Cattle were fed by tethering (largely on each farmers' own lands, often under coconut) and by cut-and-carry. Farmers relied on tree fodders, including gliricidia throughout the year and Ficus sp. in the dry season. Local grasses were abundant in the wet season (accounting for 25% of cut-and-carry fodder), but were less abundant in the dry season. Banana stalk was an important feed source throughout the year (Table 1).

Although farmers in Sakti agreed that *Sesbania* sp. (sesbania) was superior to all other forages in terms of weight gain, palatability, and animal health, only one fourth of the farmers maintained the tree, which accounted for only 4% of feed in the wet season and 2% in the dry. Sesbania was not more widely adopted because of its short life span. On the other hand, although Ficus sp. was viewed as providing poor quality fodder, it served as an 'insurance' feed source in the dry season adopted by 50% of the farmers and providing 23% of dry season fodder.

Forages for Smallholders Project: Cooperators, non-cooperators, adoptors, and non-adoptors in Sumatra, Vietnam, and northern Mindanao

The FSP site in Marenu, Sumatra, is a recently settled transmigration site. Farmers, both FSP project

Table 3. Species evaluation*, Besakih, Bali.

	% Plant	Evaluation criteria: Yield	Palatability	Weight gain	Animal health	Dry season	Establishment	Fast growing	Planting material	Total	Rank
Use criteria (%)		78	78	72	50	22	22	17	5		
C. calothyrsus	100	5	5	5	3	1	1	1	<1	21	1
G. sepium	78	4	3	3	2	<1	1	1	<1	15	4
A. saman	33	1	1	<1	<1	<1	<1	<1	<1	3	7
Jackfruit	61	2	2	2	<1	<1	<1	<1	<1	7	6
P. purpureum	94	6	5	5	1	1	1	1	<1	20	1
Local grasses	89	4	3	3	2	<1	1	<1	<1	14	4
Sweet potato	89	4	6	6	3	<1	<1	1	<1	21	1
TOTAL		26	25	24	11	3	5	5	2	100	
Relative importance		1	1	1	4	7	5	5	8		

*Entries are percentage of all 'votes' for each species × evaluation combination. Species rank and relative importance of criteria reflect respective sums of rows or columns.

cooperators (n = 10) and non-cooperators (n = 8) reported having a mean of one ha; although some may have had more land and reported the ‘official’ land holding for settlers. Cooperators had a mean 34 head of sheep; while non-cooperators had 19. The main income sources for cooperators were sheep, upland crops, and off-farm labour. Cooperators additionally claimed lowland rice and oil palm as main income sources. Cooperators complained of wild pigs, drought/lack of water, lack of capital, lack of job opportunities, and sheep theft as problems. Non-cooperators saw pigs, lack of capital, and drought/lack of water as problems. It appeared that non-cooperators had fewer sheep than cooperators, but were more successful in terms of off-farm employment and in the establishment of lowland rice paddies and oil palm plantations.

Sheep were fed by combined grazing on commons and cut-and-carry for mornings and evenings, when animals were penned. Both cooperators and non-cooperators planted grasses and trees. Rates of adoption for several grasses were higher for cooperators, with non-cooperators relying more on king grass than cooperators. Half of the cooperators, but none of the non-cooperators, had sown *S. guianensis*; and more cooperators than non-cooperators had adopted and were using gliricidia and *L. leucocephala* (leucaena). Non-cooperators relied more upon local grasses than cooperators in the dry season (Table 4). Farmers’ evaluations of fodder species were recorded in terms of positive and negative qualities of each (see below).

Ten FSP cooperators and 8 non-cooperators were interviewed in Xuan Loc, near Hue, in central Vietnam. Besides producing lowland rice and sugar cane, almost all farmers were tree planters. Most had fairly large numbers of fruit trees; a large proportion managed re-forestation areas under government contract; and a high proportion had family land similarly sown to plantation forests.

Comparing cooperators and non-cooperators, cooperators had more land (mean 2.4 ha vs 1.6 ha), but, for families having each enterprise, similar areas of lowland rice (0.2 ha), sugar cane (0.2 ha), areas under family forestry (1.3–1.4 ha) and numbers of cattle (4.0–4.4). Greater proportions of cooperators, however, had sugar cane, family forestry, and cattle (67% vs 50%). Although fewer non-cooperators had water buffalo, those having such animals had a higher number per family. More non-cooperators cared for government forest plots than cooperators, but they had smaller areas than cooperators having such contracts (7.5 ha, cf. 9.7 ha) (Table 5).

Farmers identified problems as lack of water for crops, lack of capital, low soil fertility, and lack of transport, followed by a lack of labour for grazing livestock and a lack of grazing land.

Cooperators were just becoming familiar with some of the grasses and a small number of trees through testing (on small plots) as a part of FSP activities. The main evaluation criteria used by farmers were palatability, ‘quality’, yield, weight gain, and animal health. If the evaluations of farmers using particular species and evaluation criteria are

Table 4. Forage use, FSP cooperators and non-cooperators, wet and dry seasons, Marenu, Sumatra.

	Cooperators			Non-cooperators		
	% Farmers	WS	DS	% Farmers	WS	DS
TREES		25	19		13	12
G. sepium	90	10	7	38	4	3
A. saman	50	6	5	50	4	4
L. leucocephala	90	9	7	50	5	5
LEGUMES						
S. guianensis	50	8	4	0	0	0
LOCAL GRASSES	80	12	17	63	19	32
PLANTED GRASSES		45+	50		61	45
P. atratum	90	15	15	100	20	15
P. guenoarum	100	16	12	75	11	8
B. humidicola	60	4	12	25	7	6
B. decumbens	60	7	6	50	9	6
S. sphacelata	20	3	3	13	1	1
King grass	10	<1	2	63	13	9
TOTAL		91	90		93	80

compared (without reference to the actual proportions of farmers actually using a given forage and/or evaluation criteria), native grasses were given highest marks due to high scores in terms of quality, palatability, and yield. *P. maximum* was also rated highly across criteria, and especially in terms of palatability (Table 6). The trees gliricidia and leucaena, although planted by 77% of the informants, scored low across criteria. Factoring in proportions of farmers planting a given forage and using particular evaluation criteria, native grasses, *P. maximum*, and *S. guianensis* (which all farmers were testing or using) were given highest ratings.

Ironically, farmers' tree planting practices appeared to work against the adoption of fodder trees. Most farmers planted a wide range of fruit trees in their home gardens and cared for forest plantations on both their own and on government lands. Introduced fodder trees had to compete with fruit trees in the home gardens and with commercial timber elsewhere. Because farmers perceived the potential for receiving high (and apparently low-risk) returns from forestry, the enterprise competed with livestock husbandry. Maturing forest plantations also resulted in less available natural fodder for either grazing or cut-and-carry. Some farmers had reduced

Table 5. Production assets, Xuan Loc, Vietnam.

	Participants (n = 10)			Non-participants (n = 8)		
	% Sample	Mean	Range	% Sample	Mean	Range
Farm size (ha)	100	2.4	0.3–8.0	100	1.6	0.3–3.4
Paddy area (ha)	83	0.2	0.1–0.3	88	0.2	0.1–0.2
Sugar cane (ha)	89	0.2	0.1–0.3	57	0.2	0.1–1.0
Family forestry (ha)	83	1.4	0.1–5.0	29	1.3	0.5–2.0
Contract forestry (ha)	27	9.7	6.0–20.0	50	7.5	6.0–10.0
Fruit trees (units)	100	104	23–290	86	140	29–280
Cattle (animals)	67	4.4	1–10	50	4.0	1–10
Buffalo (animals)	44	1.7	1–3	25	4.0	3–4

Table 6. Fodder assessment (n = 13), Xuan Loc.

		Criteria								
	% Farmers	Palatability	Quality	Yield	Weight gain	Animal health	Total	Rank	Corrected total	Corrected rank
Use criteria (%)	–	100	85	77	70	38				
S. guianensis	100	2	3	3	3	3	14	4	14	1
P. maximum	70	6	4	4	4	2	20	2	14	1
B. ruziziensis	31	3	7	3	2	2	17	3	5	6
Native grasses	46	7	8	7	4	3	29	1	13	1
G. sepium	77	2	2	2	2	1	9	5	7	5
L. leucocephala	77	2	2	2	1	3	10	5	8	4
TOTAL		22	26	21	16	14				
Relative importance		2	1	2	4	4				
Corrected total		22	22	16	11	5				
Relative importance		1	1	3	4	5				

*Entries are relative mean scores for those planting a given species and using a given criterion. Ranking of species and relative importance of criteria were calculated from sums of rows and columns, respectively. Corrected totals and ranking reflect proportion of those using the species and criterion.

their animal numbers; and the community as a whole may reduce cattle and buffalo numbers further to just the point where draft needs are met.

Future forage adoption will depend on the relative economic importance of lowland rice, sugar cane, forestry, and livestock. The importance of livestock will depend on needs for draft, the importance of farmyard manure, and the long-term investment advantages of cattle compared to forestry. A guess would be that cattle numbers would either stay the same or decrease. Livestock enterprises may, however, intensify in response to demand from Hue, possibly requiring higher quality feed produced on small on-farm areas.

A short period was spent in Malitbog in northern Mindanao, in the Philippines. Small farmers have one or two head of cattle fed by tethering and cut-and-carry. Main crops are bananas, maize, and coconut. Although FSP cooperators were testing a range of new forages, many appeared to be interested in the possibility of receiving cattle via government dispersal programs (which traditionally required adoption of new forages as a pre-requisite). The high availability of banana stalk and open grazing lands meant that fodder resources were available, a factor working against new forage adoption. One community had a large area of mature leucaena trees, which was not being used as a major fodder source. On the other hand, dry-season fodder shortages and increasing demand for meat in the city of Cagayan de Oro may eventually lead to an increase in the genuine adoption of new forages for cattle-fattening enterprises.

An evaluation of forage species across sites

Farmers across sites were asked to name positive and negative characteristics associated with their different forage options (Table 7). The results were aggregated because of the substantial consensus across sites in the three countries (albeit, farmers at each site had a different suite of forages and, therefore did not evaluate all species).

The legume trees, calliandra, gliricidia and leucaena were viewed positively in terms of yield, palatability, animal weight gain, and animal health. Negative characteristics included the need to mix leguminous tree fodder with other fodders, pests, and leaf fall in the dry season (gliricidia). *Sesbania* sp fodder was considered of especially high value in Nusa Penida, but was not more widely planted because of its short life span. Although viewed as producing fodder of low nutrient value, Ficus sp. and jackfruit were valued for their needed dry season productivity. Vietnamese farmers appeared to prefer to plant fruit rather than fodder trees in their home gardens. *Albizia* sp. and jackfruit were valued for their timber as well as fodder.

Although farmers agreed that *Stylosanthes* spp. were good in terms of animal health, nutrition, and weanlings, slow regrowth and itchiness (for farmers harvesting the fodder) were described as problems. Informants disagreed as to the palatability and drought tolerance of *Stylosanthes*.

Most of the planted grasses were found to be desirable in terms of fast growth, high yield, palatability, weight gain, and ease of harvest. Common complaints about the grasses included that old growth was not palatable and crop competition. Farmers sought grasses which were tolerant of cutting and drought, adapted to low soil fertility, and grew quickly after cutting.

Farmers across sites generally favoured their natural grass mixtures as being fast-growing, good for animal health and weight gain, palatable, and, of course, available. In some areas, low production in the dry season was mentioned as a problem.

Sweet potato tubers and leaves were used for cattle fattening and ‘finishing’ in some of the upland areas of Bali. Cassava leaf was commonly used as fodder in many areas, and was also viewed positively in terms of animal weight gain. Banana stalk was a significant fodder source at several of the sites. Among several positive characteristics was that it also provided water in the dry season.

Discussion and Conclusions

Recent studies concerning the adoption of trees on farm, especially for fodder, range from pessimistic to hesitantly optimistic. Case studies in Nepal and India have shown that, in spite of increased tree planting for fuelwood and shifts from open grazing to stall feeding, farmers have relied heavily on crop residues and forage grasses to meet needs for animal feed. Researchers concluded for these cases that ‘In contrast to the previous analysis of fuel, trees on farm do not appear to be a viable strategy for livestock feed’ (Warner et al. 1999). Another review of forage husbandry in the tropics concluded that, ‘A wide and diverse range of trees and shrubs are used as fodder, but few are planted. When they are planted, it is seldom primarily to provide forage. Rather, forage is a by-product of fruit trees, live fences, and erosion-control strips, and makes the planting of these trees more attractive to farmers’ (Bayer and Waters-Bayer 1998, p. 139).

On the other hand, farmers in the highlands of Nicaragua (in an area somewhat similar to the sites visited in Java) used *Leucaena* spp. and gliricidia as fodder sources. They also maintained naturally occurring *Guazuma ulmifolia* and *Acacia pennatula* trees because of their dry-season forage productivity (Nicola Maria Keilbach, personal communication, cited in Bayer and Waters-Bayer 1998). A collection of studies from South Asia and Eastern Africa indicated that, in general, the (albeit few) observed shifts to more intensive on-farm tree planting were occurring in regions undergoing agricultural intensification, and that this intensification has taken place in the more arable and productive areas with relatively higher rainfall (Arnold and Dewees 1997).

For the areas visited in this study, several factors would appear to affect decisions regarding forage and tree forage adoption by smallholder farmers with mixed crop and livestock systems. Tree adoption was encountered where a combination of relatively high populations over a fixed land area had led to agricultural intensification. In Bali, such intensification featured high to exclusive reliance upon cut-and-carry feeding for penned animals; and a high reliance upon forages planted on-farm. In these cases, off-farm commons or open access areas

Table 7. Farmers' evaluations of fodder species.

Species	Good attributes	Bad attributes
LEGUMES		
Albizia sp.	Commercial wood, weight gain, palatable, fast growing, drought tolerant	Difficult to harvest, diarrhoea, not palatable, slow regrowth, excess leads to hair loss
Calliandra calothyrsus	Weight gain, yield, palatable, animal health	Root competition, must mix w/other fodders, reduces animal fertility
Erythrina sp.	Weight gain, palatable, animal health	Low yield, diarrhoea
Gliricidia sepium	High yield, weight gain, animal health, milk production, palatable, prevents diarrhoea, easy to grow, easy to harvest, cutting tolerant, long life	Not palatable if fed too much , must mix, lowers cattle fertility, leaf fall in DS, slow regrowth, pests
Leucaena leucocephala	Palatable, high milk production, easy to harvest, drought tolerant, cutting tolerant, quick regrowth	Pests, must mix, excess causes ewes to bleed
Sesbania sp.	Animal health, weight gain	Short life
Stylosanthes guianensis	Nutrition, animal health, good for weanlings, palatable, drought tolerant	Old growth not palatable (OGNP), itchy, not drought tolerant, slow regrowth, not palatable
GRASSES		
Branchiaria humidicola	Drought tolerant, quick regrowth, cutting tolerant, palatable, easy to maintain	Less leaf production, OGNP, crop competition, cannot plant other crops on same land after
Paspalum atratum	Quick regrowth, cutting tolerant, drought tolerant, high leaf yield, easy to harvest, palatable, all parts consumed	Sharp edged, OGNP
P. guenoarum	Fast regrowth, cutting tolerant, yield, easy to harvest, palatable, weigh gain, produces in DS	Not drought tolerant, OGNP, rots if cut too low
Pennisetum purpureum	Weight gain, fast growing, perennial, yield, palatable, easy to harvest, available	OGNP, must mix, no contribution to animal health, needs fertiliser
Pennisetum hybrid (king grass)	Easy to establish, quick regrowth, palatable, easy to harvest, yield	OGNP, crop competition, not drought tolerant, difficult to maintain, itchy
Setaria sphacelata	Quick regrowth, palatable, drought tolerant	Short life
Local grasses	Natural mixtures for animal health, fast growing, weight gain, palatable, available	Low productivity in dry season
OTHERS		
Ficus sp.	Produces in DS, long life	Low nutritive value, low yield, one harvest per year, not for animal health, shade competition
Jackfruit	Available in dry season/drought resistant, timber, prevent diarrhoea	Low nutrient value, constipation
Sweet potato	Fattening and animal 'finishing'	Diarrhoea
Cassava leaf	Palatable, weight gain	Not palatable 3 days after harvest, bloat
Banana stalk	Animal health, provides water in DS, palatable, easy to harvest, increases milk production in DS	Diarrhoea if fed in excess

supplying grazing land or fodder for cut-and-carry were not available. Indeed, in Besakih every plant – trees, crops and weeds – was privately owned. Fodder tree adoption also appeared more likely where farmers were already agroforesters, growing a range of trees for a variety of purposes. Agroforestry itself also appeared more likely where systems were not largely reliant upon shade intolerant annual crops, such as upland rice or maize. Finally, fodder trees were likely to be adopted where a marked dry season significantly decreased the relative availability of fodder from plants other than trees, as compared to tree sources.

The presence of adequate fodder sources in the form of open grasslands, grasslands under coconut, crop residues (e.g, banana stalk in Indonesia and the Philippines), and the growing of field crops for animal feed (some of the sweet potato in Besakih) would tend to decrease adoption of fodder trees. Livestock serve as a 'bank account' for many small farm systems. Family forestry (in Vietnam) served the same purpose and was viewed as a better long-term investment, thus 'competing' with livestock as an enterprise.

Farmers in project areas may also genuinely adopt new forages as they shift from herding and grazing to increased stall feeding (e.g., goats in Marenu) or spuriously in the hope of receiving animals through cattle distribution programs (e.g., Malitbog). These factors are synthesised in a farmers' decision tree (Figure 1).

Implications for the Forages for Smallholders Project

The FSP is correct in offering farmers at selected sites menus of forage grasses, legumes, and trees; and in facilitating farmer-participatory research in the testing of the introduced materials. The fieldwork reported on in our survey gives rise to several other suggestions:

1. Selection of project sites needs to examine existing forage resources carefully and also the possibly changing relative profitability of livestock over other on- or off-farm enterprises. There may be little opportunity for intensification where livestock simply take advantage of available native forages or where other enterprises such as forestry would 'compete' with livestock.
2. Areas undergoing intensification – e.g. where land is becoming less available and penned animals are replacing grazing – would be likely for the adoption of new forages. 'Linear fields', such as those encountered in Bali, may be appropriate for mixes of trees and grasses where open fields are not available.
3. Farmers in areas with more available land and natural forage resources may still be interested in new grasses and possibly trees if there are clear advantages in terms of dry season productivity. Farmers were willing to plant or use fodder trees producing inferior feed as long as dry season production was assured when needed. The *el Niño* related drought appears to have generated interest in Kalimantan when the new forage species provided the only green to be seen (W.W. Stür, pers. comm. 1999).
4. Farmers expressed a range of perceptions regarding the suitability of legume forages. In general, although good for weight gain and animal health, farmers also thought that legumes needed to be mixed with other foods, that animals refused to eat more than small amounts, and that fertility-related problems could arise. If not already doing so, the project may need to work with farmers willing to experiment with feeding regimes to determine the soundness of such perceptions. Farmers at one FSP site are apparently now more interested in *G. sepium* after recently finding that their goats would, contrary to previous belief, consume lopped branches from the tree (W.W. Stür, pers. comm. 1999).
5. Further research is needed on the gender and age distribution of labour for cut-and-carry systems. Although male informants generally claimed to contribute equal shares of labour to that contributed by women, observations give the impression that women contribute more for cut-and-carry and that children provide more for grazing and tethering. Women may have less involvement in fodder or tree planting decisions; and the opportunity costs of children's labour may be low. Both factors could reduce adoption of new forages.
6. Crop residues were a major animal feed source in the areas visited. The FSP may want to integrate crop residues within any on-farm research.
7. Where natural forages are plentiful, the FSP may want to work with farmers to address the resource use/access issues associated with such forages in order that farmers may benefit from improved management of the resource. For example, communities may be able to work together on enriched natural pastures.
8. Finally, and to repeat several points above, farmers did not appear to be worried about the establishment costs in terms of time to productivity and care of seedlings associated with trees. Competition with crops, longevity, recuperation and regrowth after lopping, tree pests, and fodder suitability were main concerns.

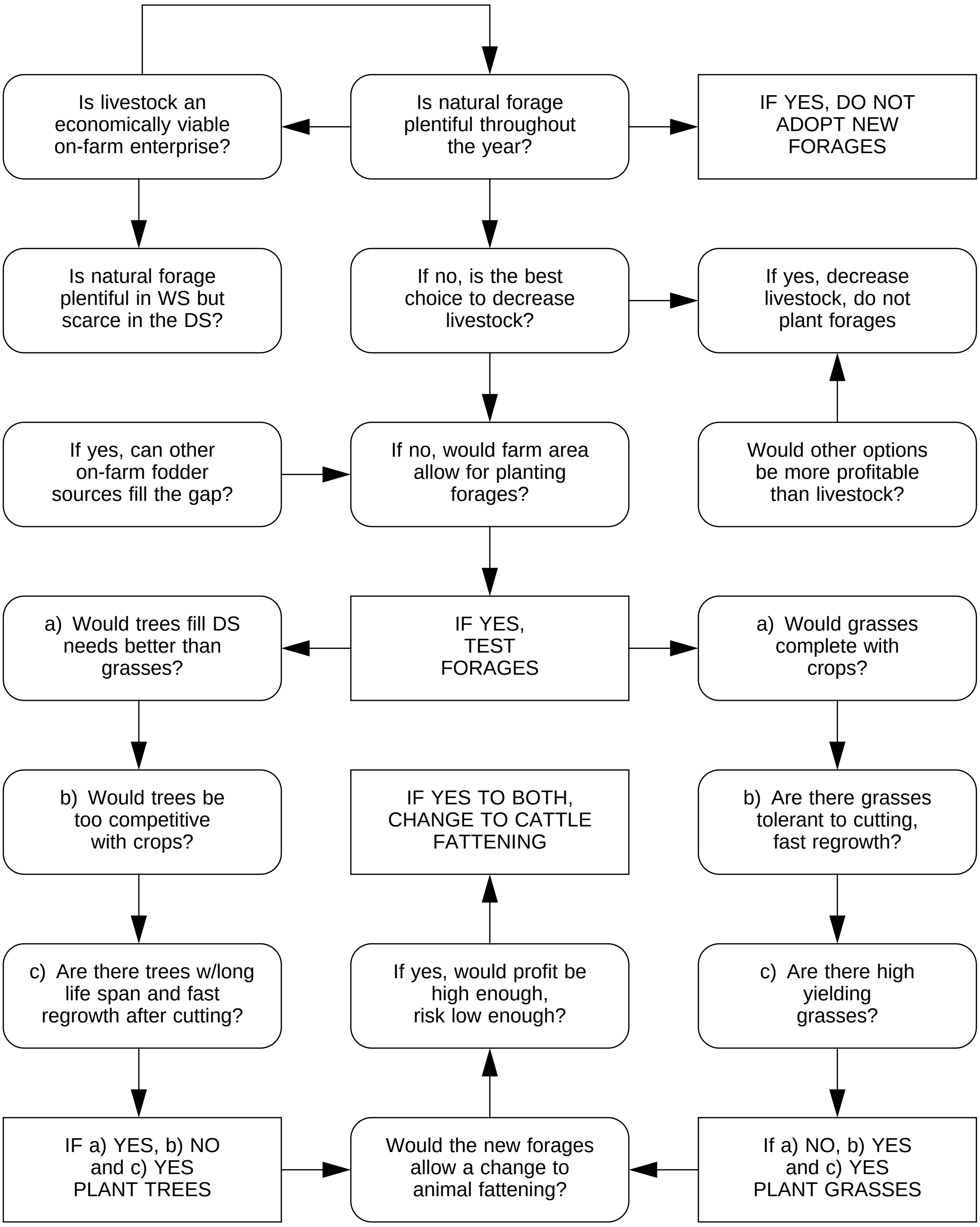

Figure 1. Farmer forage and tree adoption decision model.

References

Arnold, J.E. and Dewees, P.A., ed. 1997. Farms, Trees and Farmers: Responses to Agricultural Intensification, London, Earthscan.

Bayer, W. and Waters-Bayer, A. 1998. Forage Husbandry, London, MacMillan Education Ltd.

Warner, M., Bezkorowajnyj, P.G. and Witcombe, J.R. 1999. Matching livelihood systems to tree selection in high potential farming systems: lessons from participatory research in Nepal and India. ODI Agricultural Research and Extension Network Paper 89.

Participatory Methods in Research and Extension for Using Forages in Conservation Farming Systems: Managing the Trade-offs between Productivity and Resource Conservation

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Abstract

This paper reviews recent experiences related to the development and adoption of forages used for both ruminant nutrition and erosion control. It examines both technical and institutional innovations that were combined into successful adoption processes. It also highlights the interaction between the technical components and the institutional arrangements that have facilitated the dissemination of soil conserving practices through farmer-led organisations. Some forms of contour hedgerow systems combine erosion control on sloping land with the provision of added ruminant fodder for the farm enterprise. Others, for example, vetiver grass hedgerows, are employed basically to conserve soil, water and nutrients, while still others, such as alley cropping, are used with the objective of both erosion control and fertility improvement. The first section of the paper gives background on the current state of knowledge about the various practices, and the directions toward systems that are more attractive to farmers. The second section discusses the benefits and constraints of different systems. The third section presents results from researcher-managed and farmer participatory research (FPR) trials on the effectiveness of various contour hedgerow systems to control erosion in cassava-based cropping systems on sloping land. It describes the potential and constraints of the various species or systems used, and indicates under what circumstances they are most likely to be adopted by cassava farmers. The fourth section describes a participatory research process that led to the identification of natural vegetative strips as a farmer-preferred and widely adopted practice in the uplands of the southern Philippines. The final section discusses the evolution of a farmer-driven Landcare movement in the Philippines, and highlights the potential for this institutional innovation to spread knowledge about forage production systems, and provide a mechanism for involving large numbers of farmers in adaptive research to experiment with forage production systems.

DEVELOPMENT and diffusion of agricultural technologies for upland smallholder farming systems is a complex challenge. The environments and farming systems for which the practices must be designed are enormously diverse. Farmers who might use these technologies generally have little investment capital and by necessity have short investment horizons. Markets are often remote, transport is difficult and costly, and research and extension services are usually inadequate. Steep slopes and low inherent soil fertility provide a fragile resource base. In light of all these constraints, it is obvious that technology development has to be done in close collaboration with the farmers. And extension methods for the dissemination of new practices need to be more demand-driven.

In the countries of Southeast Asia, sloping uplands cover about 60% to 90% of the total land area (Garrity and Sajise 1991). In these hilly areas, the soils are generally highly weathered, infertile, and often of shallow depth. Many are strongly acidic (pH <5.5), and have a low to moderate organic matter (OM) content, low cation exchange capacity

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and base saturation, and low levels of available phosphorus (P). More than 40% of the arable land in the region consists of acidic upland soils classified as Ultisols and Oxisols (Craswell and Pushparajah 1990). It has been determined that soil erosion, as estimated by river sediment load per hectare of watershed, is much more serious in Southeast Asia than in any other region of the world (Milliman and Meade 1983).

Strategies to effectively control soil erosion by water either dissipate the kinetic energy of raindrops before they hit the soil surface, or reduce the velocity of run-off water and increase the water infiltration rate. Measures that employ these principles are classified as either engineering or vegetative techniques. Vegetative practices are generally less expensive and labour-demanding than are engineering practices. They maintain a living or dead vegetation cover to dissipate the force of falling raindrops or use vegetative barriers to reduce the velocity of water runoff.

The vegetative soil conservation technologies that have been used traditionally by farmers in the Philippines and Indonesia include the planting of hedgerows of *Leucaena leucocephala* or *Gliricidia sepium* and/or grasses such as napier grass (*Pennisetum purpureum*) (Kang et al. 1984; IIRR et al. 1992), or retaining natural vegetation in contour lines across the slope (Tung and Alcober 1991). Multi-storey agroforestry systems, commonly found in the Philippines and Indonesia, may also serve as a soil conservation measure. Farmers' local knowledge has proven to be a fruitful base for the development of improved technologies.

Soil conservation innovations, from mechanical methods such as terrace construction (PCARRD 1984) to biological erosion control using planted multi-purpose tree and grass hedgerows (IIRR et al. 1992), have been widely introduced to farmers cultivating sloping lands in the Philippines. Among the vegetative measures, the planting of contour hedgerow has been strongly promoted by government agencies and non-governmental organisations, and has become a major focus of research and extension (PCARRD 1997; Nelson et al. 1998a). The technology has become known in the Philippines and Vietnam as 'Sloping Agricultural Land Technology' or 'SALT' (Tacio 1991; Partap and Watson 1994). Government and non-governmental organisations have been promoting SALT as the basis for sustainable farming on sloping lands during the past two decades.

The following section of the paper gives more background on the current state of knowledge about the various practices, and the directions toward systems that are more attractive to farmers.

The second section discusses the benefits and constraints of the different systems.

The third section presents results from researcher-managed and farmer participatory research (FPR) trials on the effectiveness of various contour hedgerow systems to control erosion in cassava-based cropping systems on sloping land. It describes the potential and constraints of the various species or systems used, and indicates under what circumstances they are most likely to be adopted by cassava farmers.

The fourth section describes a participatory research process that led to the identification of natural vegetative strips as a farmer-preferred and widely adopted practice in the uplands of the southern Philippines.

The final section discusses the evolution of a farmer-driven Landcare movement in the Philippines, and highlights the potential for this institutional innovation to spread knowledge about forage production systems, and provide a mechanism for involving large numbers of farmers in adaptive research to experiment with forage production systems. The paper concludes with some suggestions for needed research.

Contour Hedgerow Systems to Control Erosion

SALT and alley cropping systems

In these hedgerow systems, leguminous trees are commonly planted in double rows along the contour line on cultivated slopes, with field crops being grown in the alleys between them (Kang and Wilson 1987). Periodic pruning of the hedgerows reduces shading and provides either green manure to maintain soil fertility (Kang and Wilson 1987; Nair 1993) or supplies high-quality fodder for livestock. The leguminous trees may contribute nitrogen (N) to the system through N fixation, and recycle phosphorus (P) and potassium (K) by absorbing these nutrients from lower soil layers and depositing them on the soil surface in fallen leaves or prunings.

Tree hedgerows tend to reduce soil loss by 50% to 95% under a wide variety of soil and slope conditions (Garrity 1995). They also, in many cases, have the potential to contribute to the maintenance of acceptable soil fertility levels (Kang et al. 1984; Young 1989; Partap and Watson 1994). Modelling work to predict the long-term changes in soil erosion and crop yield in the Philippines suggests that contour hedgerow systems can slow down crop yield decline, but might not halt or reverse the degradation process (Rusastra et al. 1997; Nelson et al. 1998b). Kang (1993) and Kang et al. (1996) note that the tree hedgerow technology generally has limitations in dry areas and on acidic and poor soils. Phosphorus is often a critical nutrient in systems on strongly acidic soils with low external inputs. The quantities of biomass produced by the hedgerows may be sufficient to supply nitrogen (N) to a maize crop with moderate grain yield of 4 tonnes/ha, but they cannot supply an adequate quantity of P to sustain this yield level (Garrity 1993; Palm 1995). Thus, in continuous production systems, the tree-crop system cannot recycle sufficient amounts of P to meet crop growth needs and replace the amounts removed with the crop harvest. The strategic use of manures or fertilisers is essential to sustain yields in this situation.

The adoption of tree hedgerows by upland farmers in the Philippines has been slow (Nelson 1994; Gerrits et al. 1996). There have been significant constraints to adoption of these systems. These include high establishment and management costs, substantial labour requirements, reduction of the area available for field crops (Smyle and Margrath 1990; Garrity et al. 1993), competition between the tree and crop components, negative allelopathic effects (Nair 1993), the unavailability of adequate amounts of planting material of suitable species, and insecurity of land and tree tenure (Tung and Alcober 1991; Garrity et al. 1993; Carter 1996). Contour hedgerow intercropping has often been disseminated through standard extension packages, notwithstanding the above mentioned constraints and location-specific conditions that require different solutions for different situations (Garrity 1996).

Contour grass strips for cut-and-carry animal fodder

The use of narrow grass strips planted along the contour as a source of animal fodder is another contour hedgerow technology (Lal 1990) commonly applied by farmers who own cattle. A disadvantage of this practice, however, is that when the biomass is removed as cut-and-carry fodder, there is a continuous nutrient drain from the system, if animal manure is not returned to the field. Garrity and Mercado (1994) observed that grass strips of napier grass reduced maize yields by 86% within two years in an on-farm trial in Claveria, Mindanao. This indicates that the competitiveness of the grass was very strong, and that an unsustainable draw down of nutrients and water was occurring.

Vetiver grass hedgerows for soil and water conservation

An alternative approach, initially promoted mainly by the World Bank (World Bank 1990) and now widely promoted by government organisations in Thailand (Office of the Royal Development Projects Board, 1998) and elsewhere, is the planting of contour hedgerows of vetiver grass (*Vetiveria zizanioides*). The main objective is to reduce soil erosion and losses of water and nutrients in runoff. The prunings of vetiver hedgerows are useful as in situ mulch to recycle nutrients, cover the soil, and reduce rainfall impact and erosion. The cuttings may also provide additional income as a roofing material or as a medium for growing mushrooms. However, they produce a very low quality fodder, and are not very suitable for ruminant feeding. Many farmers prefer their hedgerows to be composed of a species that provides a more useful economic product.

Natural vegetative strips (NVS)

The constraints observed with both trees and forage grasses have stimulated interest in an alternative concept, the use of non-competitive species as hedgerow plants (Garrity 1993). Recently, research has recognised natural vegetative filter strips as a low-cost and more readily adoptable technique to reduce soil erosion (Garrity et al. 1993; Fujisaka et al. 1994). NVS are installed by leaving a narrow contour strip unploughed during land preparation. This band, usually about 50 cm wide, fills in naturally with local grass and broadleaf weed species. Over time, the vegetation community shifts toward perennial grasses. In northern Mindanao, the major species in natural vegetative strips include *Paspalum conjugatum* and *Imperata cylindrica*. Another method of establishing natural vegetative strips is to pile crop residues along the contour lines. The natural vegetation establishes in this organic mulch as it decays.

The natural vegetative strip technology is not a new practice. The use of NVS and grass strips is a traditional soil conservation practice in some parts of the world (Reij 1988; Mwaniki 1991; Tung and Alcober 1991; National Research Council 1993). In the Philippines, examples of the traditional use of natural grass strips for soil conservation have been documented (Tung and Alcober 1991) on shallow limestone soils in Matalom, southern Leyte. However, natural vegetative strips also seem to be more recently applied or rediscovered as a low-cost method to reduce runoff and erosion on sloping land (Kemper et al. 1992). As well as reducing soil erosion, natural vegetative strips have also been used as a basis for incorporating perennials into contour farming, such as fruit and timber trees for cash, and for creating more complex agroforestry systems (Garrity 1993).

In the late 1980s, about 180 farmers in Claveria, Northern Mindanao, were trained through farmer-to-farmer extension in installing leguminous tree hedgerows to deal with soil erosion. They were strongly aware of erosion as a major constraint to the permanent cultivation of sloping fields in the area. Farmers started retaining natural vegetation (largely grasses and non-woody perennials) as hedgerow species instead of investing time on planting trees or fodder grasses. These activities were independent from the formal research being conducted on hedgerow intercropping with leguminous trees and fodder grasses (Fujisaka 1993). Several hundred farmers in Claveria installed natural vegetative strips on their sloping fields without outside extension efforts. NVS became popular as the preferred soil conservation technology in the area (Garrity et al. 1998). The major reason for the rejection of the introduced contour hedgerow technology was the high establishment and management costs associated with planted hedgerow species. Secondary reasons included: competition between vigorous hedgerow species and crops, unavailability of planting material and insecurity of land tenure (Garrity et al. 1993). Initial research on natural vegetative strips indicates that they compete less with adjacent field crops than do tree hedgerows and fodder grasses (Ramiaramanana 1993). NVS have also been shown to be at least as effective in reducing soil erosion as tree hedgerows, and are usually more effective (Garrity et al. 1993).

The width of alleys between adjacent hedgerows may vary to accommodate farmers' desired cropping and cultivation practices. It has been recommended that contour hedgerows be spaced at one to two metres vertical interval, to ensure effective soil erosion control (CFSCDD 1986; Prinz 1986; World Bank 1990). This translates into a 3.5 to 7-metre alley width (i.e. distance between hedgerows) on hillsides with 25% slope. The vegetative strip is commonly 0.5 to 1 metre in width. In such a case about 10% to 25% of the crop area is occupied by the hedgerows. Most farmers, however, prefer wider hedgerow spacing to minimise the crop area lost. Experiments conducted at ICRAF's research site in the Philippines have been investigating the effects of different vertical elevation intervals between hedgerows on the amount of sediment loss and yield reduction. Results showed that as the spacing between hedgerows increased, soil loss declined, but at a decreasing rate. The study concluded that the establishment of hedgerows at a 2 to 4 metre elevation drop is most practical (Mercado et al. 1997). Similar results were obtained by Inthaphan et al. (1998) for the spacing of vetiver grass hedgerows.

Aside from using natural vegetative strips, some farmers in Claveria maintain their tree hedgerows, but leave the hedgerow system fallow, commonly for one to three years. The system has been termed a 'fallow-rotational hedgerow system' (Garrity 1994). This system has also been observed in some other locations in the Philippines, for example in Matalom, southern Leyte (Fujisaka and Cenas 1993). The reason for choosing this kind of contour hedgerow management is explained by the limited availability of labour, and the lack of alternative ways to maintain soil fertility (Suson et al. 1997).

Garrity (1994) emphasised that research on sustaining annual crop production on sloping lands needs to follow two pathways: (1) when external nutrient inputs are not available, continuous farming depends on strategies based on fallowing, but (2) when external nutrients can be applied, low-maintenance contour hedgerows are a preferred system to reduce soil erosion and to provide a basis for more productive agriculture or agroforestry systems.

Benefits and Problems of Contour Hedgerow Systems

Narrow grass strips derive their effectiveness in controlling water erosion by shortening the slope length and slowing down runoff water flowing through the close-growing grass strips, and from the increased infiltration rate of water in soil under sod cover, which in turn reduces total runoff. Mature dense grass slows down runoff water, and diffuses and spreads concentrated water flow so that it trickles through the grass barriers with little or no further erosion. As the flow rate of the water is slowed down, and the amount of runoff water is reduced, sediment from the cropped field is deposited within or directly above the grass strip (FAO 1965). The deposition of sediment is accelerated by the adsorption of negatively charged clay particles to positively charged dead plant parts (Wilson 1967). Over time, the deposition of the sediment load results in filling up of rills, ephemeral gullies and related depressions and facilitates the formation of terraces, creating a series of stable bench terraces on the cultivated slope. Even though vegetative contour bunds are usually very stable, rodents may damage grass barriers, which can reduce the effectiveness of the barriers or in some cases cause them to fail (Kemper et al. 1992).

The deposition of sediments above contour hedgerows through water erosion contributes to the formation of terraces. However, in most cases tillage operations on the contour between the hedgerows greatly accelerate the terrace formation process (Egger and Rottach 1986; Anecksamphant and Sajjapongse 1994; Garrity 1996). This process is particularly prominent where intensive ploughing is carried out by draft animals (Garrity 1996). Basri et al. (1990) reported a 60 cm drop in soil level between the alleys after 2.5 years on a field with 25% slope. Comparable rates of terrace development on farmers' fields were also observed by Fujisaka et al. (1995). The levelling effect of terrace formation is one of the major benefits of vegetative contour strips, because it improves water retention in the field, reduces the loss of applied nutrients, and makes land preparation easier. In high rainfall climates, however, nutrient leaching on flat terraces due to greater vertical infiltration may partly negate the benefits of erosion control.

Natural terracing results in the depletion of soil fertility in the upper parts of each terrace, and the increase in soil fertility downslope, because soil and nutrients from the upper part of the developing terrace are eroded or moved downhill by tillage practices, and accumulate on the lower part. Initial research confirmed that soil OM, N, Bray-II extractable P, and exchangeable calcium (Ca) contents increase from the upper to lower alley zones in a linear pattern, while exchangeable aluminium (Al) decreases (Turkelboom et al. 1993; Agus 1993; Samzussaman 1994). This scouring-deposition effect creates a more favourable crop growth environment immediately above the grass strip or tree hedgerow than immediately below it (ICRAF 1993; Turkelboom et al. 1993; Garrity 1996). A soil fertility gradient is visible in crop growth response across the alley. Anecksamphant and Sajjapongse (1994) report from research conducted in Thailand and the Philippines that maize and rice yields were drastically lower on the upper alley zones in contour hedgerow and grass strip trials. A similar study recorded reductions in rice yield of more than 50% in the upper alley zones compared with middle and lower zones on 21–35% slope in Thailand (Turkelboom et al. 1993). Comparable yield reductions of upland rice between hedgerows of either *Gliricidia sepium* or *Senna spectabilis*, combined with *Pennisetum purpureum* (napier grass) were observed by Solera (1993) on a 20% slope in the Philippines. At a nearby location, upper alley yield depression was also recorded in maize associated with *Gliricidia sepium* hedgerows (Agus 1993).

In the light of high initial soil losses from the upper parts of developing terraces, and of the absence of immediate benefits in terms of overall increased crop yields, serious concerns have been raised regarding the sustainability of the contour hedgerow system (Turkelboom et al. 1995; Garrity 1996). A major reason why farmers in Matalom, Philippines, did not continue to maintain previously installed natural vegetative strips in their sloping fields was the unhalted decline of soil fertility in the alleys, as fertilisation was not practised (Fujisaka and Cenas 1993). The biomass produced by natural vegetative strips provides substantially lesser amounts of mulch material than do tree hedgerows (Nelson et al. 1998a), and its contribution to soil fertility maintenance in the alleys is thus minimal.

With time, the scouring effect will dissipate as the terrace surface stabilises (i.e. levels off) and more organic matter can be retained in the surface soil in the upper zones of the alley. However, it is not known how long this process takes at different sites and under different management regimes. On deep soils with moderate to high soil organic matter levels, the scoured areas may recover in a few years, but the process will take longer if the terraces are wider (Garrity 1996). Strongly acidic Ultisols, Oxisols and Inceptisols are physically quite deep, but they are often chemically shallow because of excessive subsoil acidity due to soluble Al. With the loss of topsoil on upper terrace zones, rooting depth is restricted. The effects of soil scouring can be more drastic on calcareous soils with a shallow topsoil over limestone parent material, since the entire topsoil may be removed (Garrity 1996).

The decline in soil fertility of upper terraces can be compensated by appropriate soil management, such as minimum tillage to reduce soil movement on the terraces, and/or through the application of nutrient inputs (crop residues, mineral fertiliser, green manure) biased towards upper terrace zones (Garrity 1996). Experiments have been conducted at ICRAF's research site in Claveria, Northern Mindanao, to reduce the effects of soil fertility scouring on crop yield. Ridge tillage, a minimum tillage technology, proved to minimise scouring effects on crop yield, but slowed down terrace development significantly (Thapa et al. 1996). The application of more hedgerow cuttings and crop residues towards degraded upper terrace zones in tree hedgerow systems did not provide a significant positive effect on crop yield (Mercado et al. 1996). Even though upper terrace soil scouring occurs irrespective of hedgerow species, the effect is best studied in hedgerow systems using less competitive natural vegetation.

In spite of the documented negative effects of soil fertility scouring on crop yield, farmers' interest in the NVS technology in Mindanao is expanding, and the number of adopters has rapidly increased in recent years. There is a need for further study of farmers' experiences with soil fertility scouring in NVS systems, and to assess local strategies to overcome poor crop performance on the upper parts of developing terraces. A thorough understanding of locally-validated practices will allow more confident extrapolation of the NVS technology to other regions where soils and farming systems differ.

Table 1. Effect of contour hedgerow systems on the yields of cassava and intercropped peanut, on gross and net income, as well as on soil loss by erosion in an FPR erosion control trial conducted on a 40% slope by farmers in Kieu Tung village, Thanh Ba district, Phu Tho province of Vietnam. Data are average values for 1996, 1997 and 1998.

Treatments[1]	Yield (t/ha)		Gross income	Production costs	Net income	Dry soil (t/ha)	Farmers' ranking
	cassava	peanut		(mil. dong/ha)			
1. C+P, no hedgerows	18.05	1.05	13.68	5.70	7.98	35.6	4
2. C+P, *Tephrosia candida* hedgerows	17.12	0.76	11.72	6.05	5.67	24.0	3
3. C+P, pineapple hedgerows	20.43	0.91	14.62	5.90	8.72	20.0	2
4. C+P, vetiver grass hedgerows	24.08	0.80	15.19	6.05	9.14	20.1	1

[1]All plots received 10 t/ha of pig manure and 60 kg N, 40 P_2O and 120 K_2O/ha as chemical fertilisers

Participatory Approaches to the Use of Contour Hedgerows for Erosion Control in Cassava-based Farming Systems

Contour hedgerow systems differ in their effectiveness in controlling erosion, improving soil fertility, conserving soil moisture, and in their competitive effects on nearby crop plants. Also, some systems are better adapted to the local soil and climatic conditions, or fit better in the local production systems than others. There are often trade-offs to be made between total productivity of the system, effectiveness in controlling erosion, and the inputs (labour, capital) required for establishing or maintaining the hedgerows (or other conservation practices). Only farmers themselves can make these decisions and select the most suitable practices for their own conditions. It is, therefore, imperative to involve farmers directly in the development and dissemination of soil conserving technologies.

Farmer Participatory Research (FPR) in cassava-based cropping systems, conducted in China, Indonesia, Thailand and Vietnam, and supported by the Nippon Foundation in Japan, has led to the development and adoption of quite different soil conserving technologies in different locations. Table 1 shows the average results of hedgerow treatments in FPR trials conducted for three consecutive years by farmers on 40% slope in Phu Tho province of Vietnam. Vetiver grass hedgerows produced the highest cassava yields, gross and net income, and was the most effective, together with pineapple hedgerows, in controlling erosion; this was the treatment most preferred by farmers. Similar results were obtained in demonstration plots conducted for three consecutive years on a 21% slope at the Agro-forestry College of Thai Nguyen Univ. in Thai Nguyen, Vietnam (Table 2). Vetiver grass hedgerows were again most effective in controlling erosion, followed by those of *Flemingia congesta* and *Tephrosia candida.* Vetiver hedgerows also resulted in the highest cassava yields, increasing yields on average 22% over those in the check plot without hedgerows. Although vetiver grass occupied about 10% of the total land area, productivity in the total area was increased, probably due to improved moisture retention and efficiency of fertiliser use. Erosion was reduced by 67%.

Table 2. Effect of various contour hedgerow systems on cassava yield and soil erosion, as observed in FPR demonstration plots established on a 21% slope at Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam. Data are average values for 1994, 1995 and 1996.

Treatments[1]	Cassava yield (t/ha)	Dry soil loss (t/ha)
1. No hedgerows	16.67	19.73
2. *Tephrosia candida* hedgerows	17.61	11.89
3. *Flemingia congesta* hedgerows	17.21	8.44
4. Vetiver grass hedgerows	20.39	6.46

[1]All plots received 60 kg N, 40 P_2O_5 and 120 K_2O/ha.

In spite of being very effective in controlling erosion, the lack of sufficient planting material and the high cost of establishment will greatly limit adoption of vetiver grass hedgerows in Vietnam. Farmers in some areas of North Vietnam have traditionally used *Tephrosia candida* hedgerows as a green manure to improve soil fertility. Although generally less effective than vetiver grass in controlling erosion, the ease and low cost of establishment (from seed) of *Tephrosia* hedgerows has made this a preferred hedgerow species (Table 3) in northern Vietnam. This technology is now being adopted in some of the FPR pilot sites. In Dong Rang village of Hoa Binh province, the planting of *Tephrosia* contour hedgerows, which often revert to natural weedy strips when the *Tephrosi*a dies after 3-4 years, has resulted in the formation of natural terraces with terrace risers up to 1 metre high. In Kieu Tung village, Phu Tho province, farmers are planting both *Tephrosia candida* and vetiver grass contour hedgerows to control erosion in their fields.

Conditions for Thai cassava farmers are quite different from those in northern Vietnam. The climate is tropical rather than subtropical, the topography is rolling rather than mountainous, cassava fields are generally 5–10 times larger, and land preparation (and sometimes harvesting) is mechanised. Although slopes are quite gentle (0-10%) they are also long, resulting in large amounts of water rushing down the slope in natural drainage ways. This can result in serious soil losses of 50–100 tonnes/ha/year, but mostly localised in a fraction of the total field. Many soil erosion control experiments have been conducted to identify those practices that are most effective in reducing erosion, produce high cassava yields and are easy to establish and maintain. Table 4 shows some recent results from experiments conducted in Khaw Hin Sorn, Thailand. Contour hedgerows of all species tested reduced erosion, but also reduced cassava yields. Vetiver grass hedgerows were most effective in reducing erosion and caused less reduction in cassava yields than those of most other species.

Table 4. Effect of various contour hedgerows on cassava yield and erosion when cassava, cv Kasetsart 50, was grown on a 5% slope in Khaw Hin Sorn Research Station, Chachoengsao, Thailand. Data are average values for 1995/96 and 1996/97.

Treatments[1]	Cassava yield (t/ha)	Dry soil loss (t/ha)
1. No contour hedgerows	30.36	8.09
2. Vetiver grass (local variety) hedgerows	24.17	3.65
3. Vetiver grass (Sri Lanka) hedgerows	21.85	2.72
4. Pigeon pea hedgerows	23.06	7.44
5. *Crotalaria juncea* hedgerows	23.02	7.02
6. *Leucaena leucocephala* hedgerows	20.15	4.91
7. *Gliricidia sepium* hedgerows	19.89	4.12

[1]Pigeon pea and *Crotalaria* hedgerows were established in May 1995; other treatments in Oct 1993. Cassava received 94 kg each of N, P_2O_5 and K_2O/ha

Farmers in Soeng Saang and Wang Nam Yen districts conducting FPR erosion control trials chose to experiment with contour hedgerows of vetiver

Table 3. Effect of various contour hedgerow systems on the yields of cassava and intercropped peanut, on gross and net income and on erosion in FPR demonstration plots established on 9% slope at Agro-forestry College of Thai Nguyen University, Thai Nguyen, Vietnam, in 1998[1].

Treatments[1]	Yield (t/ha)		Gross income	Production costs	Net income	Dry soil (t/ha)	Farmers' preference (%)
	cassava	peanut	(mil. dong/ha)				
1. C+P, no hedgerows	15.42	0.73	11.36	5.06	6.30	21.91	71
2. C+P, natural grass strips	14.83	0.60	10.42	6.06	4.36	20.63	57
3. C+P, *Tephrosia candida* hedgerows	17.75	0.71	12.43	7.08	5.35	11.20	74
4. C+P, vetiver grass hedgerows	15.83	0.63	11.07	7.42	3.65	11.08	34
5. C+P, pineapple+*Tephrosia* hedgerows	16.50	0.65	11.50	7.70	3.80	16.57	34
6. C+P, vetiver+*Tephrosia* hedgerows	16.83	0.77	12.27	7.48	4.79	10.03	51

[1]1998 was first year of establishment of hedgerows
[2]All plots received 60 kg N, 40 P_2O_5 and 120 K_2O/ha

Table 5. Effect of contour hedgerows of vetiver and/or sugarcane on cassava yield and gross income when planted in production fields of 1600 m2 of five farmers in Soeng Saang and Wang Nam Yen districts in Thailand in 1997–1998.

Farmer	Hedgerows	Cassava yield (t/ha)		Gross income ('000B/ha)[1]	
		With hedgerows	Without hedgerows	With hedgerows	Without hedgerows
Mrs. Naakaew[2]	Vetiver	25.72	31.31	38.58	46.96
Mrs. Champaa[2]	Sugarcane and vetiver	9.26	12.45	18.71	18.67
Mr. Sawing[3]	Vetiver	15.99	19.05	23.98	28.57
Mr. Somkhit[3]	Vetiver	16.39	21.66	24.58	32.49
Mr. Phuem[3]	Vetiver	21.81	26.25	35.71	39.37
Average		**18.23**	**22.14**	**28.31**	**33.21**

[1]Prices: cassava: B 1.50/kg fresh roots sugarcane: 3.0/stalk (for chewing)
[2]In Soeng Saang district of Nakorn Ratchasima province
[3]In Wang Nam Yen district of Sra Kaew province

grass, sugarcane and mulberry bushes, as well as with various intercropping systems, and mulching with dry grass. After 2–3 years of testing in small plots on their own fields, they were convinced that vetiver grass hedgerows were the most effective in reducing erosion, but that sugarcane hedgerows or intercropping with peanut, sweet corn or pumpkin produced more income. Farmers have also tried some of these systems on larger areas (1600 m^2) of their fields. Measurements of cassava yields with and without hedgerows revealed that yields were reduced on average 18% (Table 5) by the presence of hedgerows of vetiver grass or sugarcane. The value of the sugarcane (for chewing) more or less compensated for the lower cassava productivity of the system. These data indicate that farmers are often faced with difficult decisions concerning trade-offs between short-term productivity and long-term resource conservation. It also points to the need to make adaptations to make the system more acceptable; in this case the distance between hedgerows must be increased from 1 metre vertical distance to 3–4 metre vertical distance to reduce the negative effect on total crop yield and to facilitate mechanical land preparation.

Eventually most farmers abandoned the intercropping systems and sugarcane because of lack of labour, and frequent intercrop failures during periods of drought. But many expanded the areas with vetiver grass hedgerows, especially since planting material in Thailand is provided free of charge by the government. After having seen the effectiveness of vetiver grass hedgerows in FPR trials in a neighbouring village, farmers in Noon Samraan village of Nakorn Ratchasima province organised a 'Soil Conservation Group'. The group has collected money and the members are now working together to plant 320 ha of sloping cassava land near the village with vetiver grass contour barriers. The combination of a useful technology, developed with farmer participation in a nearby village, government incentives in the form of free planting material, and an active local extensionist working with farmers who are convinced of the need to control erosion on their land, is facilitating the widespread (but still very localised) adoption of vetiver grass barriers for erosion control in cassava fields in Thailand. Even so, adoption will be rather slow due to the enormous task of transporting and planting millions of bagged plants in the field.

As mentioned above, large-scale adoption of vetiver grass barriers, even in Thailand where conditions are most favourable, will remain problematic because of the high cost of producing, transporting and planting of vegetative planting material. While seed sterility in most vetiver grass varieties is considered useful to prevent the grass from ever becoming a weed, it does make large-scale plantings time-consuming and costly. Moreover, in countries like Indonesia where farms tend to be very small and most farmers raise cattle or goats, the use of vetiver grass hedgerows is generally rejected in favour of grasses or leguminous species that produce useful forage for farm animals, especially in the dry season. Various ecotypes of napier grass, dwarf napier, and king grass (*Pennisetum purpureum* × *P. glaucum*), are the preferred hedgerows species, even though they compete strongly with neighbouring crop plants.

To identify grass species that produce useful forage, that can be planted from seed, that do not become noxious weeds, and that do not compete too strongly with neighbouring cassava plants, an experiment comparing 16 grass species/ecotypes was planted in Khaw Hin Sorn research station in Chachoengsao province, Thailand. Contour hedgerows of each grass were planted three metres apart and three rows of cassava were planted in the alleys, as shown in Figure 1.

Cassava yields were determined in each row separately in order to determine the competition effect of the grass barriers on the adjacent and centre rows of cassava. Table 6 shows the cassava yields during all three years of testing, while Figure 1 shows the cassava yields in each row during the third year after grass establishment. During the first and second year after establishment, hedgerows of *Paspalum atratum, Setaria sphacelata* and lemon grass (*Cymbopogon citratus*) resulted in the highest cassava yields, indicating that these grasses were the least competitive. The three vetiver grass varieties were intermediately competitive. During the third year of testing (Figure 1), however, when most hedgerows had become somewhat wider due to lateral tillering, all grasses competed strongly (mainly for soil moisture) with the adjacent rows of cassava. The highly competitive grasses, like napier, king grass and *Panicum maximum*, even competed with cassava in the centre row 1.5 metres from the hedgerow. Least competitive with cassava were lemon grass, vetiver grass (Songkla 3) and *Setaria spacelata*. *Brachiaria ruziziensis* became less competitive (and less productive) during the third year as it had depleted the nutrients in the soil.

Although no definite conclusions can be drawn from this preliminary trial, it appears that *Setaria sphacelata*, *Paspalum atratum* and *Brachiaria brizantha* could become useful hedgerow species. They produce good forage for ruminants, can be planted from seed (without becoming weedy), and they are less competitive than the more traditional cut-and-carry grass species like napier and king grass. More research is needed to determine the optimum management of these species to further reduce their competitive effects. Some of these promising species should be tested in FPR trials in farmers' fields, in comparison with vetiver grass, natural vegetative strips, and possibly other farmer-selected hedgerow species. If farmers find these new species effective in erosion control, useful as an animal feed or mulch, and convenient in establishment and maintenance, their adoption for soil conservation could be greatly accelerated.

Table 7 summarises the locations where, and the conditions under which, particular soil conserving practices are most likely to be adopted, according to the experience of the Nippon Foundation project. Contour hedgerows are likely to feature as an important soil conservation practice in all locations. However, the most suitable species will vary according to the local conditions and farmers' needs, as indicated in Table 7. Moreover, contour hedgerows should be combined with other agronomic practices, such as intercropping, manure and fertiliser application, minimum tillage, closer plant spacing, productive germplasm etc, in order to maximize the effectiveness of erosion control and fertility maintenance, while at the same time increasing yields and/or the farmers' income.

Building on Indigenous Innovations and Farmer-led Technology Dissemination: Participatory Research on Forages and Soil Conservation on Acid Upland Soils

In Claveria, Northern Mindanao Region, research was conducted by the International Rice Research Institute (IRRI) and the Department of Agriculture on contour hedgerow intercropping from 1984 to 1992. The goal of the work was to improve upland-rice-based farming systems in degraded acidic soil environments. Initial rural appraisals revealed that farmers cultivating sloping lands in Claveria commonly experienced soil erosion and soil fertility decline, and associated crop yield reduction. Farmers were interested in learning new techniques to halt the soil degradation process. Since most farmers faced cash and labour constraints, agroforestry-based technologies, such as contour hedgerow intercropping, were tested for their efficacy in controlling soil erosion and maintain soil fertility levels (Fujisaka and Garrity 1989).

Studies were conducted over a period of 7 years (1993–1999) to determine the effects of different forage legumes and grasses as contour hedgerows on productivity of an upland rice — maize crop sequence, their biomass production and their relative

Table 6. Effect of contour hedgerows of various grasses on the yield of three adjacent rows[1] of cassava grown during three consecutive years on a 5% slope in Khaw Hin Sorn Research Station, Chachoengsao, Thailand, from 1996 to 1999.

Contour hedgerow treatments[2]	Cassava yield (t/ha)			
	1st year	2nd year	3rd year	Average
Check without hedgerows	19.62	21.46	29.83	23.64
Vetiver grass-Nakorn Sawan variety	15.68	6.80	9.72	10.73
Vetiver grass-Sri Lanka variety	16.95	8.19	12.04	12.39
Vetiver grass-Songkla 3 variety	19.60	6.46	15.46	13.84
Lemon grass	12.89	12.09	18.18	14.39
Citronella grass	13.68	8.79	13.28	11.92
Setaria sphacelata	22.11	7.81	14.61	14.84
Paspalum atratum	33.05	14.77	10.13	19.32
Panicum maximum TD 58	13.35	7.07	3.50	7.97
Panicum maximum CIAT 6299	9.59	5.50	3.33	6.14
Brachiaria brizantha	16.36	7.50	7.55	10.47
Brachiaria ruziziensis	9.03	5.94	19.52	11.50
Dwarf napier grass	5.14	4.63	5.65	5.14
Normal napier grass	2.38	0.24	0.96	1.19
King grass	10.70	1.39	1.83	4.64
Sugarcane	12.46	5.83	—	—

[1]Two cassava rows planted at 0.5 m and one row at 1.5 m from the center of the hedgerows
[2]Hedgerows established in June 1996

competitiveness on acid sloping uplands in Claveria. *Flemingia congesta* (shrub), *Stylosanthes scabra* (erect fodder legume), *Panicum maximum* (fodder grass), *Vetiveria zizanioides* (grass, no value as fodder), and a control (no hedgerow in contour ploughing and planting) were evaluated. The hedgerows were spaced 6–8 metres apart.

Hedgerows of *Flemingia congesta, Vetiveria zizanioides, Stylosanthes scabra, and Panicum maximum* were all effective in reducing off-field soil losses (Table 8). The two grass species controlled erosion most effectively (about 95% reduction compared with the open-field control). However, the tree legume and the forage legume also reduced soil losses dramatically (greater than 65% reduction). Thus, it is evident that the use of any of these species as the contour hedgerow component will dramatically alleviate soil degradation on sloping terrain (18% to 24% in this case.) The fodder species tested could support 2–4 steers weighing 200 kg per ha through a 360-day feeding period, assuming that feeding rate is 2.5% of the animal's body weight.

Table 7. Location and conditions where particular soil conserving practices have been (or are most likely to be) adopted for cassava-based cropping systems on sloping land in Asia.

Location	Conditions	Soil conserving practices
Java, Indonesia	limestone derived soils (Alfisols); steep slopes; small farms; cattle and goat raising; land constraint	Terracing, hillside ditches; agroforestry; Contour hedgerows of *Leucaena, Gliricidia,* napier, *Paspalum atratum;* Intercropping with maize, rice, grain legumes; Fertiliser+manure application
Java, Indonesia	acid Inceptisols, Entisols; steep slopes; small farms; cattle and goat raising; land constraint	Terracing, hillside ditches; Contour hedgerows of *Gliricidia,* napier, *Paspalum atratum;* Intercropping with maize, rice and grain legumes; Fertiliser+manure application
North Vietnam	acid Ultisols, Oxisols; steep slopes; small farms; pig raising; land constraint	Intercropping with peanut, cowpea; Contour hedgerows of *Tephrosia candida,* pineapple, vetiver, natural grass, *Paspalum atratum;* Manure+fertiliser application
Hainan, China	acid Ultisols, steep slopes; rather large farms; labour constraint	Contour hedgerows of vetiver grass and sugarcane; Manure+fertiliser application
Northeast Thailand	acid Ultisols; gentle but long slopes; large farms; mechanisation; labour constraint	Contour hedgerows of vetiver grass, sugarcane, *Paspalum atratum;* Fertiliser application; Closer plant spacing

Table 8. Average grain and total dry matter yield of an upland rice-maize crop sequence, soil loss, pruning biomass and carrying capacity as influenced by different hedgerow species and different pruning and crop residues managements in an acid upland soil, Claveria, Misamis Oriental, Philippines. (mean of 3 years).

Species	Upland Rice cv IR30716-B-1-B-1-2		Maize Pioneer # 3274		Soil loss (t/ha)	Pruning Biomass (t/ha)	Carrying capacity*
	Grain yield (t/ha)	TDMY (t/ha)	Grain yield (t/ha)	TDMY (t/ha)			
Control	2.46	6.37	4.27	8.99	34.18	—	
Panicum maximum	2.35	5.23	4.04	8.29	1.65	3.04	2
Flemingia congesta	2.26	4.85	4.72	9.73	4.60	5.83	3
Stylosanthes scabra	2.47	6.38	4.61	9.47	7.15	1.63	1
Vetiveria zizanioides	2.23	6.01	4.52	9.62	1.69	4.16	2
Mean	1.27	3.04	4.43	9.22	2.43	3.67	2
CV (%)	4.79	7.47	23.22	20.35	47.93	45.98	

*number of 200 kg steers per ha per year

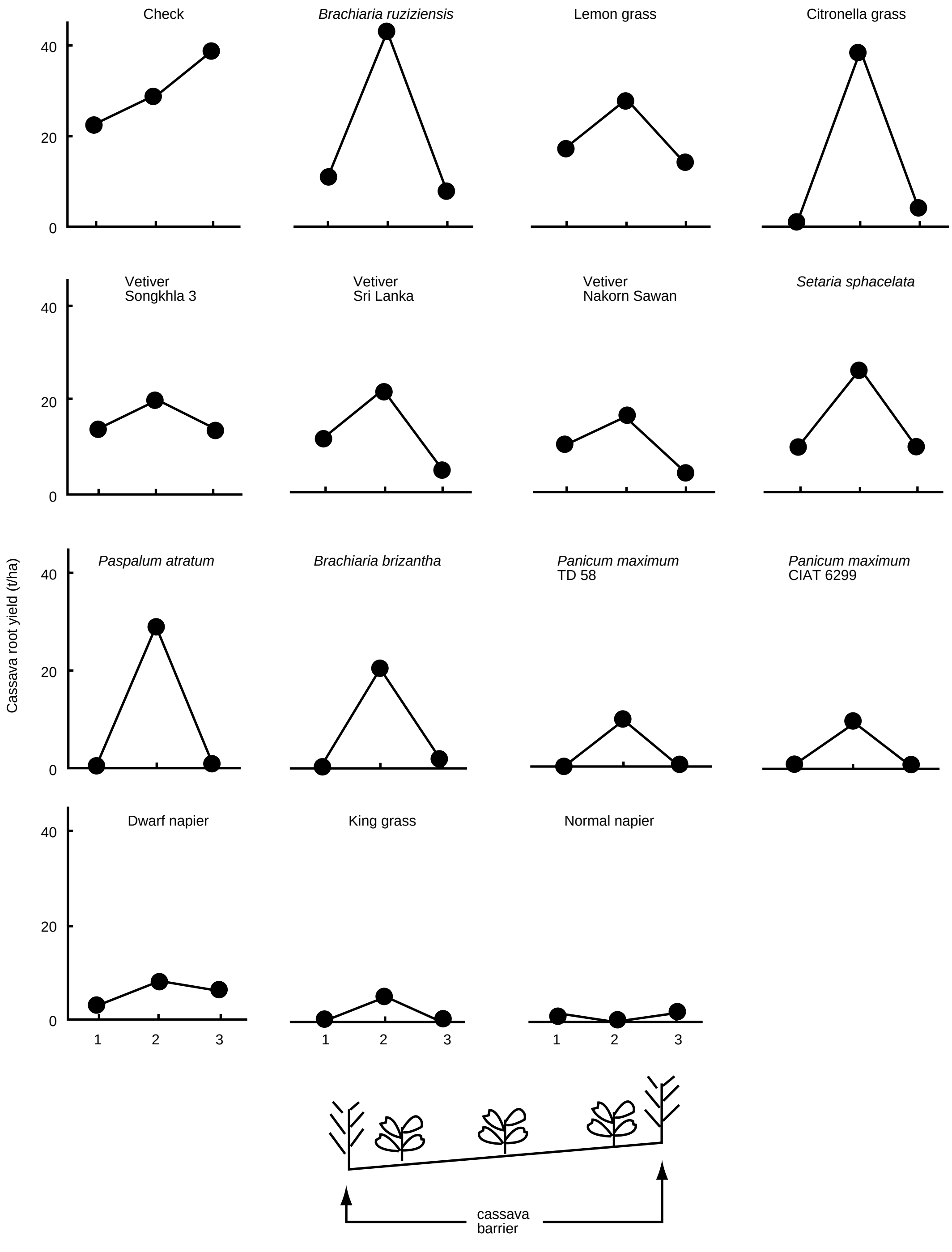


Figure 1. The effect of different grass species as contour barriers on the fresh root yield of cassava, cv. KU 50, grown in three rows between barriers in Khaw Hin Sorn, Chachoengsao, Thailand in 1998/99 (3d year).
Note: row 1 is cassava row just above and 0.5 m from hedgerow; row 2 is centre row and 1.5 m from each hedgerow, and row 3 is just below and 0.5 m from the next hedgerow.

Crop yields (calculated on a whole field area basis) did not differ among the hedgerow treatments and the open-field control. Thus, the soil fertility enhancement provided by the prunings was negated by the additional non-cropped area occupied by the hedgerows. The ranking of hedgerow species from least to greatest in relative competitiveness was stylo, vetiver, flemingia, and guinea grass (*Panicum maximum*). Guinea grass, exhibited severe competitive effects on the associated annual crops and reduced crop yields. This species may not be appropriate as a hedgerow component unless carefully managed to avoid competition. The legume species were not distinctly superior to vetiver in stimulating yields or in exhibiting reduced competition, as might have been expected. On the other hand, vetiver exhibited crop competition, contrary to some claims that it tends to be vertically rooted and is non-competitive.

Napier (*Pennisetum purpureum*) was also extensively used in many of our contour hedgerow experiments. We found that napier can produce from 5.0 to 6.5 tonnes of dry herbage annually in different hedgerow combinations; this can support 3–4 200 kg steers for a 360-day feeding period (Table 2). Monthly harvesting of napier hedgerows for a period of 2 years showed a seasonal range in dry matter production ranging from 50 to 550 kilograms per hectare (Figure 2). The herbage production fluctuated in response to the amount of rainfall during the growing period. Thus, farmers may experience an over supply of fodder during the rainy season and an under supply in the dry season.

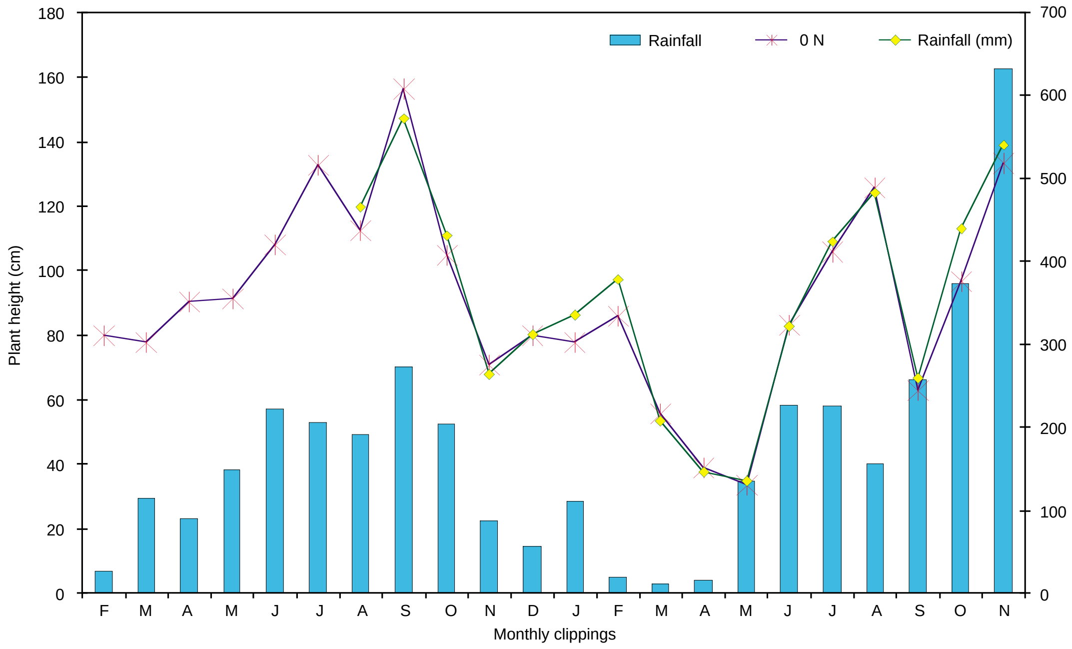
The International Rice Research Institute (IRRI), in collaboration with CIAT, conducted extensive evaluations of forage legumes and grasses as alternative species. Among the species evaluated, *Setaria sphacelata* var. *splendida* was selected by farmers and is now widely adopted because of its being less competitive with companion annual crops, and is palatable and nutritious to ruminants. Vetiver was also introduced to farmers but was not accepted, in spite of being very effective in controlling soil erosion. Farmers were looking for multi-purpose species as contour hedgerows.

Currently, there are more than 1500 farmers in Claveria who have adopted contour hedgerow systems using different hedgerow species, but almost all of them (over 95%) started by using the natural vegetative strips (NVS). They then progressed to planting a range of plants, including fodder grasses, timber and fruit trees, and pineapple. The most popular fodder grasses are *Setaria sphacelata* var. *splendida*, *Panicum maximum* and *Pennisetum purpureum*. A major reason for greater adoption of these particular species was the greater availability of planting materials. Most farmers are concerned about excessive competition by napier and its shading effect when not cut back regularly.

In 1987, six interested farmers from Claveria and two IRRI technicians went to a non-governmental project (initiated by 'World Neighbors', a USA-based NGO) in the neighbouring island Cebu, to learn from farmers how to establish contour lines with the A-frame and how to plant hedgerows. In the original technology, hedgerows were planted on contour bunds, comprised one or two rows of *Gliricidia sepium* (Madre de Cacao), and one or two rows of *Pennisetum purpureum*. Eroded sediment, which was collected in a ditch below the rows of trees and grasses, was regularly returned to the alley above (Fujisaka et al. 1994). The following year, the Cebuano farmers paid a return visit to observe contour hedgerows established in Claveria, discuss the adaptations made by Claveria farmers, and share ideas on how the system might be further developed (Fujisaka 1989). From 1987 to 1989, trained farmers and later adopters in Claveria extended their knowledge to 182 interested farmers, using the same farmer-to-farmer approach which they had learned from World Neighbors in Cebu. Of these trained farmers, 64 had adopted some form of contour hedgerow system by late 1990, and a further seven farmers were identified which had spontaneously adopted the technology after they had observed neighbours' farms (Fujisaka et al. 1995).

Simultaneously to the study of farmers' adoption of the contour hedgerow technology, and its adaptation to local conditions and needs, IRRI conducted formal on-farm research in collaboration with the local DA. Technology adaptation trials managed by the researchers focused on improving upland rice and hedgerow germplasm and farming systems, and emphasised farmer participation in the concurrent technology validation (and adaptation) and extension process (Fujisaka et al. 1994).

Continuous documentation of farmer adoption and modification of the introduced contour hedgerow technology revealed that many farmers in Claveria adopted some form of soil conservation practices, but modified them to minimise labour inputs and reduce competition from vigorous grass and tree species. First, they abandoned the creation of contour bunds before the hedgerows were planted, and discontinued the use of ditches below the hedgerows to capture sediment. They observed that both of these labour-intensive practices were unnecessary. They tended to plant either trees (usually *Gliricidia sepium*) or fodder grasses (predominantly napier), instead of a combination of both. By 1992, the majority of farmers simply left the marked contour lines unploughed during land preparation without planting any trees or grasses (Fujisaka et al. 1994).



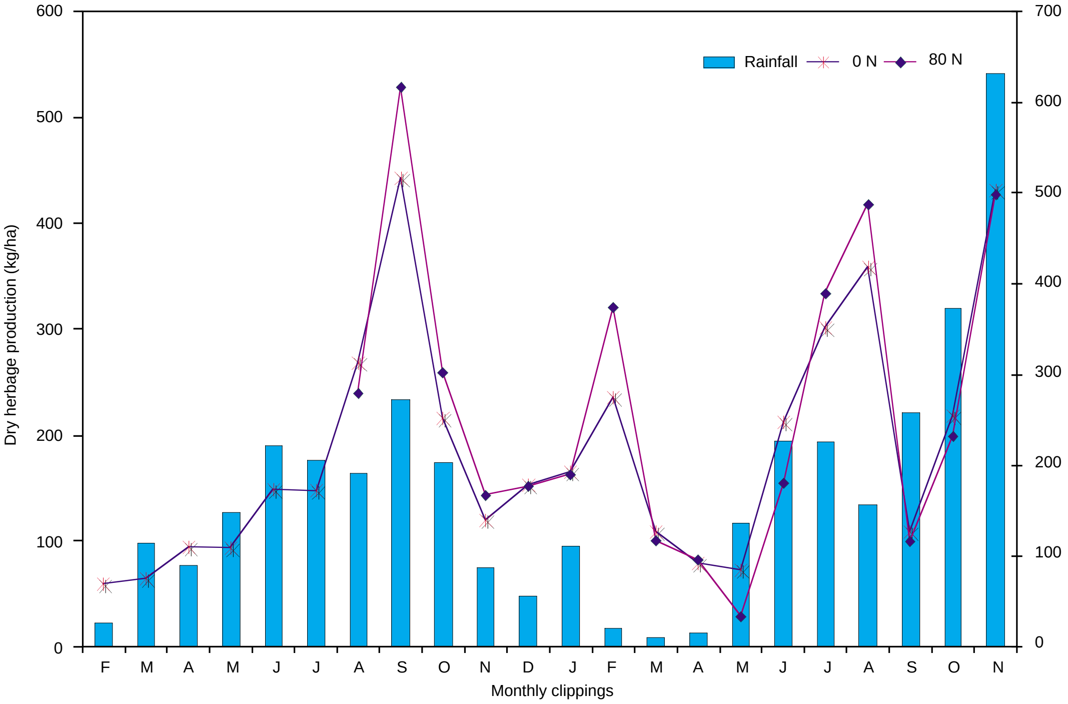


Figure 2. Dry herbage of Napier (*Pennisetum purpureum*) in a contour hedgerow system as influenced by nitrogen applied on the associated alley crops and rainfall. Slopping acid upland soil, Claveria, Misamis Oriental. February 1989 to November 1990.

A study conducted by Cenas and Pandey (1995) showed that among the 64 initial adopters of contour hedgerows of leguminous trees (largely trained by IRRI), 63% eventually abandoned or fallowed their contoured fields, mainly due to labour constraints. However, it was estimated that by 1994 more than 250 farmers in the area had adopted modified forms of hedgerow intercropping, mostly in a spontaneous adoption process, whereby natural vegetative strips and fodder grass strips were preferred to pruned tree hedgerows (Garrity et al. 1998).

Farmer participation in the research process in testing, evaluating and adapting the introduced hedgerow technology under farm conditions, led researchers to re-evaluate the rationale for using leguminous tree species in hedgerows (Fujisaka, 1993). Natural vegetative strips were recognised as a useful intermediate step towards the adoption of more complex agroforestry systems (Garrity et al. 1993). Many farmers in Claveria have shown initiative in establishing fruit and timber trees for cash income on previously installed NVS to make productive use of the space occupied by the vegetative strips (Garrity et al. 1998). The prices for timber have been steadily rising in the Philippines, and so has farmers' interest in planting trees. Contributing to this development are dwindling natural forest resources and the enforcement of a total logging ban in several regions of the country.

The use of leguminous crops as a soil cover, or as intercrops with major food crops, has been recommended as an alternative or complementary option to maintain soil fertility and provide a supply of higher quality fodder for cattle (Garrity et al. 1993). However, farmers' interest in leguminous cover crops has not been enthusiastic, because most species do not perform well on strongly acidic soils, or are prone to destruction from dry season fires. Cover crops also cannot grow undisturbed in areas where fallow land is considered public grazing area (Garrity 1994), as is the case in Claveria. Often, seed supply is a significant problem. Another constraint to the use of leguminous inter- and relay-crops has been their limited potential in systems using animal-power for land preparation and weeding, due to incompatibility of reduced tillage systems with the farmers' traditional tillage methods.

Since 1993, after IRRI had completed its work, the International Centre for Research in Agroforestry (ICRAF) continued research on contour hedgerow technologies in Claveria. The participatory learning approach was reinforced by strengthening researcher and farmer interactions, and by focusing on the identification and validation of local practices. The assessment of minimum tillage as an alternative or complementary measure to reduce soil degradation on sloping lands was continued. Research is allied with the institutional strengthening and capacity building of farmer groups, and is encouraging greater interaction between the groups, local government, and institutions from outside the location. Throughout the whole research process, from identifying research topics to disseminating the findings, farmers' initiative has been a driving force. The stronger redirection of the project towards participatory technology development and dissemination has raised a whole new set of research questions.

The Farmer-Driven Landcare Movement: An Institutional Innovation with Implications for Extension and Research

Smallholders can engage in farming and management of natural resources in both a productive and resource-conserving manner. Awareness of this has focused attention on evolving demand-driven, community-based approaches to natural resource management. A look at current prescriptions for more sustainable farming systems in the uplands reveals an enormous variability in conditions, and consequently a high degree of technical uncertainty about the effectiveness of the solutions proposed. The problems are not solved by simple recipes. Often, the issues need to be tackled cooperatively at the community level, at a scale bigger than the individual household.

In Asia, much attention has been given to the role of local organisations in the management of forests and other common natural resources. This is exemplified by the progress in Joint Forest Management in India, Forest Users' Groups in Nepal, and Community-Based Forest Management in the Philippines (Poffenberger and McGean 1996). But local organisations may also be a means to mobilise knowledge to solve problems in agriculture through improved land husbandry. Particularly in countries where decentralisation of power and fiscal responsibility is occurring, and democracy is becoming institutionalised down to the village level, leadership skills in the farming population are maturing. These skills provide a basis for the evolution of organisations led by farmers that address practical ways of overcoming their problems in creating a more sustainable agriculture.

Among the organisational models for enhancing local initiative in attacking land degradation, one of particular interest is called 'Landcare'. Through this approach, local communities organise themselves to tackle their agricultural problems in partnership with public sector institutions. The distinguishing characteristics of Landcare groups are that they are voluntary, self-governing, and focus on problem-solving resources within the community. Experience in the Philippines (300 groups) and Australia (4500 groups) suggests that such an approach may provide a means to share and generate technical information more effectively, spread the adoption of new practices, enhance research, and foster farm and watershed planning processes. These groups exhibit some similar characteristics to the farmer field schools made popular in integrated pest management. Landcare groups, however, are more formalised and aim at a broader range of land degradation and sustainability issues. Some distinguishing features of Landcare groups are:

- They develop their own agendas and tackle the range of sustainability issues considered important to the group.
- They tend to be based on neighbourhoods or small sub-watersheds.
- The impetus for formation comes from the community, although explicit support from outside may be obtained.
- The momentum and ownership of the group's program is with the community.

Farmer-driven approaches show promise of being more effective and less expensive than current transfer-of-technology approaches. In the southern Philippines, farmer organisations became the basis for a successful grassroots approach to finding new land care solutions, forming partnerships with local government, pulling in outside technical and financial resources, and diffusing new information throughout the community (Garrity in press).

The Landcare movement in the Philippines began in Claveria, Mindanao, in 1996. There are now some 300 village-based Landcare groups in Claveria and in other municipalities in northern, central, southern and eastern Mindanao, with a membership of several thousand households. They have established conservation practices on more than 1500 farms. More than 200 community and household nurseries have been developed, that produced hundreds of thousands of fruit and timber trees seedlings, all done entirely with local resources.

Local governments at the village, municipal, and provincial levels have been notably interested and supportive of this movement. The provincial governments of Bukidnon and Misamis Oriental are launching province-wide Landcare movements. The movement has also attracted the attention of the national government. The national watershed management strategy has now been based on Landcare as a foundation upon which to build an effective community-based approach to sustainable agriculture and natural resources. This has provided the opportunity to scale-up Landcare principles and experiences to other parts of the Philippines. The experience suggests that there is potential for promoting this grassroots approach elsewhere in Southeast Asia.

There are signs that institutions like this could help transform extension systems. Extension agents move from role of teacher of individual farmers one-on-one, to that of being a facilitator to whole farmer groups (Campbell 1994). Conservation farming based on contour buffer strips was one practice that was popularised through Landcare in the Philippines. Another has been nurseries for growing new species of fruit and timber trees to diversify the farm enterprise. But since the agendas of the groups are determined by their own members, we observe a wide range of issues taken up by different groups, including dairy and beef farming, cut flower production, and problems in vegetable crop farming, among others. Landcare groups have also gained significant influence at the local political level. Local governments are actively and enthusiastically assisting the movement with budgetary allocations and solid political support. At the community level, Landcare has proven to be a powerful force for evolving initiatives that protect the whole watershed. The collaborative structure of Landcare is fostered through mutually supportive relationships among the farmers' organisations, local government, and technical support agencies in research and extension (Figure 3). The approach of farmer field schools for conservation farming is currently being experimented with as a method through which community groups may be initiated.

We are only beginning to exploit the opportunities that Landcare provides for enabling major innovations in the way on-farm participatory research is done. We see the prospect for research to be carried out through, and managed by, Landcare groups. This would multiply the amount of work, and the diversity of trials, that can be accomplished, ensuring a more robust understanding of the performance and recommendation domain of technical innovations. Currently, we are conducting surveys through the Landcare groups to get a grassroots feedback on the priorities for research, from the farmers' perspective. In Australia, public sector research institutions such as CSIRO are adjusting to the new reality that through Landcare, farmers sit on, and may even dominate, the boards that decide on research project funding. This is having a galvanising effect on focusing researchers on problems that farmers are concerned about.

We may summarise by listing four hypothetical functions of farmer-led knowledge-sharing landcare organisations:

- Enhanced efficiency of extension or diffusion of improved practices (more cost-effective than 'conventional' extension functions).
- Community-scale searching process for new solutions or adaptations, suited to the diverse and complex environments of smallholder farming (a unique aspect of landcare).
- Enhanced research through engagement by large numbers of smallholders in formal and informal tests of new practices.
- Mobilisation process at the community level to understand and address landscape-level environmental problems related to water quality, forest and biodiversity protection, soil conservation, and others.

There are three significant concerns about the sustainability of the Landcare movement. One is that the Landcare concept is sufficiently popular that there is a definite risk of 'projectising' the movement, i.e. attracting support projects that do not understand the concept, and provide funds in a top-down, target-driven mode that defeats the whole basis of a farmer-led movement. The second is the issue of sustaining such movements in the long run. Networking, and the stimulation from outside contacts, is widely considered to be crucial in the long-term success of such institutions. This can be provided through Landcare Federations, as has evolved locally in Claveria, and through provincial and national federations, which is currently being explored in the Philippines. Third, group leadership is a time-consuming and exhausting task, particularly when it is done on a voluntary basis. Landcare is still very young in both the Philippines and Australia, but increasingly leadership 'burn-out' is discussed as a concern.

Our analysis indicates that the following needs to be done to further release the power of the Landcare concept. The public sector and non-government sector can assist in facilitating group formation and networking among groups, enabling them to grow, developing their managerial capabilities, and enhancing their ability to capture new information from the outside world. They can also provide leadership training to farmer leaders, helping ensure the sustainability of the organisations. Cost-sharing external assistance can also be provided. For this, the use of trust funds should be emphasised, where farmer groups can compete for small grants to implement their own local landcare projects. This has been remarkably successful in the Australian Landcare movement. We envisage that the Landcare approach may be suited to other locations in the Philippines and elsewhere, providing a national focus for the sustained management of resources by farmers with (minimal) local government support.

These farmer-led organisations can be an excellent venue for spreading knowledge about forage production systems for sloping lands. The groups also provide an excellent potential mechanism for involving large numbers of farmers in adaptive research that would experiment with new species and cultivars of forages with superior production and compatibility with soil and water conservation.

Conclusions

Forage production is and will be an important component of many conservation farming systems on small farms in Southeast Asia. The erosion control

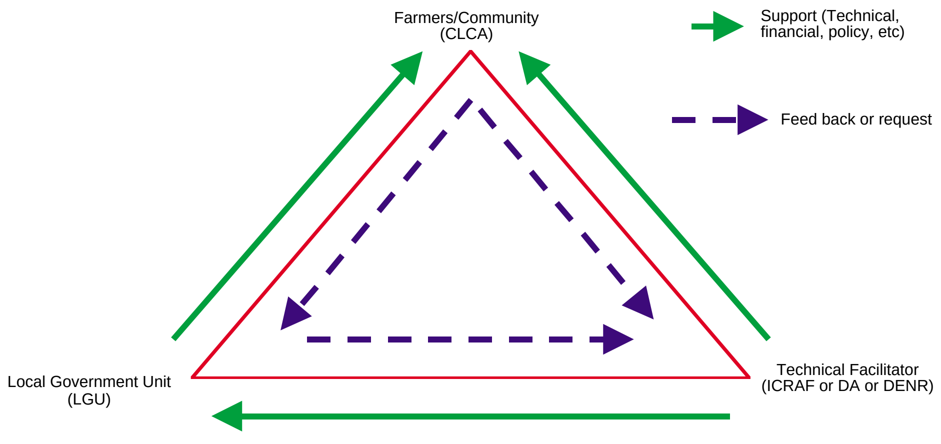


Figure 3. The triangle of Landcare approach: grass organisation (CLCA), local government unit (LGU), and technical facilitator (ICRAF/DA). The success of Landcare as an approach is dependent on how these 3 groups interact and work together. (Mercado et al. 2000).

benefits of forage production in contour hedgerows are well demonstrated. There are, however, a number of significant trade-offs between high, sustained forage production and long-term resource conservation. These trade-offs need to be carefully managed. One of the most serious of these is minimising the competition between the fodder species in the hedgerow and the associated crops in the alleyways, and maximising overall benefits from both enterprises to farm household.

The choice of an appropriate hedgerow species is dependent upon adequate understanding of the trade-off between fodder production, crop yield, and soil and water conservation. Research with farmers in a number of environments has amply demonstrated that this trade-off is very dynamic across locations and enterprise types. Thus, choice of the appropriate system will be a decision that very much depends on each farmer's circumstances and goals. Participatory research is needed to build a much better information base to enable farmers to make informed forage species and cultivar choices. The balance also necessitates careful attention to the nutrient off-take from the field by both the fodder and annual crop. The biomass of the fodder crop must also be carefully managed so as not to cause excessive shading of the annual crop. Currently, there is little research information available to guide soil fertility and pruning management in such fodder-annual crop systems.

More research is needed to identify and analyse the array of intensively-managed and extensively-managed fodder systems for hedgerows for the wide range of smallholder circumstances found in Southeast Asia. Better ways of engaging farmers in this research will be needed so as to do it in an efficient and cost-effective manner. Farmer-led organisations are an excellent means of spreading knowledge about forage production systems for sloping lands. They also could provide an excellent mechanism for involving large numbers of farmers in adaptive research to experiment with new species and cultivars of forages with superior production and compatibility with soil and water conservation. The Landcare movement is one promising manifestation of farmer-led organisations that is growing rapidly. It could become a potent force for accelerating the improvement of smallholder fodder systems that optimise the productivity-conservation trade-offs to suit the diverse needs of upland farmers in many parts of the region.

References

Agus, F. 1993. Soil processes and crop production under contour hedgerow systems on sloping Oxisols. PhD Dissertation, North Carolina State University, Raleigh, NC, USA. 141 p.

Anecksamphant, C. and Sajjapongse, A. 1994. Impacts of soil erosion on crop growth and yield. Paper presented at the International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects. 20–26 November 1994, Manila, Philippines.

Basri, I.H., Mercado, A.R. and Garrity, D.P. 1990. Upland rice cultivation using leguminous tree hedgerows on strongly acidic soils. IRRI Saturday Seminar. Los Baños, Philippines: IRRI.

Campbell, A. 1994. Landcare: Communities Shaping the Land and the Future, St Leonards, New South Wales, Australia, Allen and Unwin, 344 p.

Carter, J. 1996. Alley farming: have resource-poor farmers benefited? Agroforestry Today, 8(2): 5–7.

Cenas, P.A.A. and Pandey, S. 1995. Contour hedgerow technology in Claveria, Misamis Oriental. Paper presented at the 11th Annual Scientific Conference of the Federation of Crop Sciences Societies of the Philippines (FCSSP), April 23–29, 1995, Siliman University, Dumaguete City, Philippines.

CFSCDD. 1986. Guidelines for Development Agents on Soil Conservation in Ethiopia. Addis Ababa, Ethiopia: Community Forest and Soil Development Department Ministry of Agriculture, Natural Resources Conservation and Development Department.

Craswell, E.T. and Pushparajah, E. 1990. Soil management and crop technologies for sustainable agriculture in marginal upland areas of Southeast Asia. In: Blair, G. and Lefroy, R. ed. Technologies for sustainable agriculture on marginal uplands in Southeast Asia. ACIAR Proceedings 33, Canberra, Australia, ACIAR, 93–100.

Egger, K. and Rottach, P. 1986. Methoden des Ecofarming in Rwanda. In: Rottach, P. ed. Ökologischer Landbau in den Tropen: Ecofarming in Theorie und Praxis, Karlsruhe, Germany, C.F. Müller.

FAO 1965. Soil Erosion by Water. Some Measurements for its Control on cultivated lands. FAO Land and Water Development Series No. 7. Agricultural Development Paper No. 81, Rome, FAO.

Fujisaka, S. 1989. A method for farmer-participatory research and technology transfer: upland soil conservation in the Philippines. Experimental Agriculture, 25: 423–433.

Fujisaka, S. 1993. A case of farmer adaption and adoption of contour hedgerows for soil conservation. Experimental Agriculture, 29(1): 97–105.

Fujisaka, S. and Cenas, P.A. 1993. Contour hedgerow technology in the Philippines: not yet sustainable. Indigenous Knowledge & Development Monitor, 1(1): 14–16.

Fujisaka, S. and Garrity, D.P. 1989. Farmers and Scientists: A Joint Effort in Upland Soil Conservation Research and Technology Transfer. Paper presented at the 'International Workshop on Conservation Farming on Hillslopes', 20–29 March, Taichung, Taiwan.

Fujisaka, S., Jayson, E. and Dapusala, A. 1994. Trees, grasses, and weeds: species choices in farmer-developed contour hedgerows. Agroforestry Systems, 25: 13–22.

Fujisaka, S., Mercado, A. and Garrity, D.P. 1995. Farmer adaptation and adoption of contour hedgerows for soil conservation. In: Kang, B.T., Osiname, A.O. and Larbi, A. eds. Alley Farming Research and Development, Ibadan, Nigeria, IITA, 547–555.

Garrity, D.P. 1993. Sustainable land-use systems for sloping uplands in Southeast Asia In: Technologies for Sustainable Agriculture in the Tropics, Madison, Wisconsin, American Society of Agronomy Special Publication, 56: 41–66.

Garrity, D.P. 1994. Improved Agroforestry Technologies for Conservation Farming: Pathways Toward Sustainability. Paper presented at the 'International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects', 20–26 November 1994, Manila, Philippines.

Garrity, D.P. 1995. The fate of organic matter and nutrients in agroforestry systems. In: ACIAR: Management of soil organic matter for sustainable agriculture in Asia. Canberra: Australian Centre for International Agricultural Research (ACIAR): 1–10.

Garrity, D.P. 1996. Tree-crop-soil interactions on slopes. In: Ong, C. and Huxley, P. ed. Tree-Crop Interactions: A Physiological Approach, Wallingford, Oxon, UK, CAB International, 299–318.

Garrity, D.P. (in press). Participatory approaches to catchment management: Some experiences to build upon. Proceedings of the Managing Soil Erosion Consortium Assembly, Bangkok, Thailand, International Board for Soil Research and Management.

Garrity, D.P. and Mercado, A.R. 1994. Reforestation through agroforestry: market-driven small-holder timber production on the frontier. Proceedings of an International Workshop 'Marketing of Multipurpose Tree Products in Asia', December 6–9, 1993, Baguio, Philippines, 265–268.

Garrity, D.P. and Sajise, P.E. 1991. Sustainable land use systems in Southeast Asia: A regional assessment. In: Hart, R.D. and Sands, M.W. ed. Sustainable land use systems research and development. Rodale Press, Emmaus. PA.

Garrity, D.P., Kummer, D.M. and Guiang, E.S. 1993. The Philippines. In: National Research Council: Sustainable agriculture and the environment in the humid tropics. Washington DC, National Academy Press, 549–624.

Garrity, D.P., Mercado, A. Jr. and Stark, M. 1998. Building the smallholder into successful natural resource management at the watershed scale. In: de Vries, P., Frits, W.T., Agus, F. and Kerr, J. ed. Soil Erosion at Multiple Scales: Principles and Methods for Assessing Causes and Impacts, CABI and IBSRAM, 73–82.

Gerrits, R.V., Cramb, R.A. and Garcia, J.N.M. 1996. Adoption and adaption of hedgerow intercropping in the Philippine uplands. SEARCA-UQ Uplands Research Project, Working Paper No. 17, Los Baños, Philippines: SEARCA-UQ (SEAMEO Regional Centre for Graduate Study and Research in Agriculture — University of Queensland).

ICRAF 1993. Annual Report 1993. Nairobi, Kenya, ICRAF.

IIRR, DENR and Ford Foundation. 1992. Agroforestry Technology Information Kit (ATIK). Silang, Philippines: IIRR (International Institute of Rural Reconstruction), DENR (Department of Environment and Natural Resources) and Ford Foundation.

Inthaphan, P., Anecksamphant, C. and Boonlee, S. 1998. Comparison of effectiveness of different vertical intervals, row numbers and plant spacings of vetiver grass for soil and water conservation. In: Chomchalow, N. and Henle, H.V. ed. Vetiver: A Miracle Grass. Proc. 1st Intern. Conf., held in Chaing Rai, Thailand. Feb 4–8, 1996, 220–225.

Kang, B.T. 1993. Alley cropping: past achievements and future directions. Agroforestry Systems, 23, 1, 141–155.

Kang, B.T. and Wilson, G.F. 1987. The development of alley cropping as a promising agroforestry technology. In: Steppler, H.A. and Nair, P.K.R. ed. Agroforestry — a decade of development, Nairobi, Kenya, ICRAF.

Kang, B.T., Garrity, D.P. and Hargrove, W.L. 1996. Agroforestry for sustainable agricultural systems and environmental conservation. Paper presented at the 'Congress of the International Federation of Environmental Journalists', Nov. 11–14, Cebu City, Philippines.

Kang, B.T., Reynolds, L. and Atta-Krah, A.N. 1984. Alley Farming. Advances in Agronomy, 43: 315–359.

Kemper, D., Dabney, S, Kramer, L., Dominick, D. and Keep, T. 1992. Hedging against erosion. Journal of Soil and Water Conservation, 47(4): 284–288.

Lal, R. 1990. Soil Erosion in the Tropics: Principles and Management, London, McGraw-Hill.

Mercado, A.R., Sanchez, N. and Garrity, D.P. 1996. Crop productivity using forage legumes and grasses as contour hedgerow species in an acid upland soil. Paper presented at the '12th Annual Scientific Conference of the Federation of Crop Sciences Societies of the Philippines', May 13–18, 1996, Davao, Philippines.

Mercado, A.R., Garrity, D.P., Sanchez, N. and Laput, L. 1997. Effect of natural vegetative filter strips density on crop production and soil loss. Paper presented at the '13th Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines', Baguio, May 25–29, Philippines.

Milliman, J.D. and Meade, R.H. 1983. World-wide delivery of river sediment to the oceans. Journal of Geology, 91: 1–21.

Mwaniki, J.M. 1991. A Comparison of Different Grasses as Strips for Soil and Water Conservation on Crop Land. Thesis for the MSc. degree in Land and Water Management, University of Nairobi, Kenya.

Nair, P.K.R. 1993. An Introduction to Agroforestry, Dordrecht, The Netherlands, Kluwer Academic Publishers.

National Research Council. 1993. Vetiver Grass: A Thin Green Line Against Erosion, Washington, D.C., USA, National Academy Press.

Nelson, R.A. 1994. Soil erosion and conservation in the Philippine uplands: a review of the literature. SEARCA-UQ Uplands Research Project, Working Paper No. 3. Los Baños, Philippines: SEARCA-UQ.

Nelson, R.A., Cramb, R.A., Menz, K. and Mamicpic, M. 1998a. *Gliricidia*, napier and natural vegetation hedgerows. In: Menz, K., Magcale-Macandong, D. and Rusastra, I.W. ed. Improving Smallholder Farming Systems in *Imperata* Areas of Southeast Asia: Alternatives to Shifting Cultivation, Canberra, Australia, ACIAR, 95–112.

Nelson, R.A., Cramb, R.A., Menz, K. and Mamicpic, M. 1998b. Cost-benefit analysis of alternative forms of hedgerow intercropping in the Philippine uplands. Agroforestry Systems, 39: 241–262.

Office of the Royal Development Projects Board. 1998. Vetiver: A Miracle Grass. Proc. 1st Intern. Conference, held in Chiang Rai, Thailand. Feb 4–8, 1996. 308 p.

Palm, C.A. 1995. Contribution of agroforestry trees to nutrient requirements of intercropped plants. Agroforestry Systems, 30: 105–124.

Partap, T. and Watson, H.R. 1994. Sloping Agricultural Land Technology (SALT). A Regenerative Option for Sustainable Mountain Farming. ICIMOD Occasional Paper No. 23. Kathmandu, Nepal. 141 p.

PCARRD. 1984. The Philippines Recommends for Soil Conservation. PCARRD Technical Bulletin Series No. 28 — A, Los Baños, Philippines, PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development).

PCARRD. 1997. Developments in agroforestry research. Los Baños, Philippines: PCARRD.

Poffenberger, M. and McGean, B. ed. 1996. Village Voices, Forest Choices: Joint Forest Management in India, Oxford, UK, Oxford University Press, 356 p.

Prinz, D. 1986. Erhaltung und Verbesserung der landwirtschaftlichen Produktivität in den Tropen und Subtropen. In: Rehm, S. ed. Grundlagen des Pflanzenbaus in den Tropen und Subtropen, Stuttgart, Germany, Eugen Ulmer, 115–168.

Ramiaramanana, D.M. 1993. Crop-hedgerow interactions with natural vegetative filter strips on sloping acidic land. MSc. thesis, University of the Philippines at Los Baños, Philippines.

Reij, C. 1988. 'Back to the Grass Strips': the Evolution of Soil Conservation Policies in Swaziland. Research Report African Studies Centre No. 33, 202–214.

Rusastra, I.W., Susilawati, S.H., Budhi, G.S. and Grist, P. 1997. Biophysical and economic evaluation of hedgerow intercropping using SCUAF in Lampung, Indonesia. Imperata Project Paper 1997/7, Canberra, Australia, The Australian National University.

Samzussaman, S. 1994. Effectiveness of alternative management practices in different hedgerow-based alley cropping systems. PhD dissertation, University of the Philippines, Los Baños.

Smyle, J.W. and Magrath, W.B. 1990. Vetiver Grass — A grass hedge against erosion. Paper presented at the American Society of Agronomy Annual Meetings, Oct. 22, San Antonio, Texas, USA.

Solera, C.R. 1993. Determinants of competition between hedgerow and alley species in a contour hedgerow intercropping system. PhD Dissertation, University of the Philippines at Los Baños, Philippines.

Suson, P.D., Garrity, D.P. and Lasco, R.D. 1997. Pruned Tree Hedgerow Fallow Systems. Paper presented at the 'Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia Workshop', June 23–27, 1997, Bogor, Indonesia.

Tacio, H.D. 1991. The SALT system: agroforestry for sloping lands. Agroforestry Today, Jan.–Feb., 12–13.

Thapa, B., Cassel, D.K., Garrity, D.P. and Mercado, A.R. 1996. Sustainable soil management systems on acid steepland soils in the humid tropics. Paper presented at the '12th Annual Scientific Conference of the Federation of Crop Sciences Societies of the Philippines', May 13–18, 1996, Davao, Philippines.

Tung, L. and Alcober, D.L. 1991. Natural grass strips are preferred. ILEIA Newsletter, 7, 1&2, 27–28.

Turkelboom, F., Ongprasert, S. and Taejajai, U. 1993. Alley Cropping on Steep Slopes: Soil Fertility Gradients and Sustainability. Paper presented at the international workshop on 'Sustainable Agricultural Development: Concepts and Measures', Dec. 14–17, AIT, Bangkok, Thailand.

Turkelboom, F., Ongprasert, S. and Taejajai, U. 1995. Soil fertility dynamics in steep land alley farming. Paper presented at the 7th Annual Meeting of the Management of Sloping Lands for Sustainable Agriculture in Asia Network, Oct. 16–20, Chiang Mai, Thailand.

Wilson, L.G. 1967. Sediment removed from flood water by grass filtration. Transactions of the ASAE, 10, 35–37.

World Bank. 1990. Vetiver Grass. The Hedge Against Erosion, 3d Ed. Washington DC, USA, 78 p.

Young, A. 1989. Agroforestry for Soil Conservation. Wallingford, UK, CAB International.

How Do Forages Fit into Smallholder Farms in Mixed Upland Cropping Systems?

W. Nacalaban[1], Le Van An[2], P. Asis[3], L. Moneva[4] and E. Balbarino[5]

THE Forages for Smallholders Project (FSP) is working at several sites in Southeast Asia which are mixed crop-livestock upland systems with cropping being the main source of income. Figure 1 shows an example of this type of upland farming system. This poster presents the development of forage technologies at five of these sites. The sites are shown in Figure 2.

Figure 1. An example of a mixed crop-livestock system in Southeast Asian uplands.

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Figure 2. Project areas featured in this paper.

All 5 sites are in humid or sub-humid areas (mean annual rainfall 1700–2300 mm) with dry seasons ranging from 2–4 months (Table 1). Soil fertility at all sites is moderately fertile with moderate soil pH (H_2O). The sites vary in the intensity of land use from very intensive in Guba to moderately extensive in Matalom (Table 1).

At Guba, all agricultural land is used throughout the year and much of the cropping area is contoured. At Matalom, up to 50% of the agricultural land may be left fallow. All sites are hilly or mountainous with only limited areas of flat land for agriculture.

The common feature of all these mixed upland cropping sites is great diversity in the range of crops grown and animals raised. Major crops are maize, fruits and vegetables. At all sites, farmers raise animals and these are either kept in a shed (Guba), tethered in fields and vacant areas (Pagalungan) or grazed in areas away from the village (Xuan Loc). They play an important role in utilising natural vegetation and crop residues from the cropping activities and provide manure for the crops. Manure is recognised as an important by-product of raising animals, particularly at the more intensively-cropped sites.

Table 1. Site characteristics.

	Pagalungan, Cagayan de Oro	Malitbog, Bukidnon	Xuan Loc, Thua Thien Hue	Guba, Cebu	Matalom, Leyte
a) Physical					
Annual rainfall (mm)	1500	1880	2300	1670	2210
Dry months (<50mm)	3.1[1] (2–5)[2]	1.9 (0–4)	3–4	3.1 (1–6)	1.6 (0–2)
Soil fertility			moderately fertile		
Soil pH (H_2O)	5.8–6.5	5.8	5.0–5.5	4.9–6.5	5.0
b) Agricultural system (n=15 per site)					
Farm size (ha)	2.7 (0.75–6)	2.2 (0.1–5)	1.2 (0.2–2.6)[3]	1.5 (0.25–4.5)	2.6 (0.5–3.5)
Land use intensity (1 – 10, where 10 = high intensity)	4	5	7	10	3
Access to other grazing land	✔✔	✔✔	✔✔✔		✔
Main crops	fruits, maize, vegetables	maize, fruits, vegetables	rice, cassava, sweet potatoes	vegetables, fruits, maize, flowers	maize, coconuts, rice, fruits
Cattle and buffalo per family (Head/family)	3.5 (1–9)	1.7 (0–3)	3.9 (1–13)	2.7 (1–5)	1.8 (1–3)
Sheep or goats per family (Head/family)	0.4 (0–5)	1.9 (0–6)	0	1.4 (0–15)	1.5 (1–9)
Income from animals (% of family income)	6%	16%	<20%[4]	4%	8%

[1]Mean
[2]Range
[3]Most farmers also have access to forest areas for grazing
[4]Estimated only, no data available

Animal densities are relatively high in these systems but they contribute only a small portion of the family income.

Problem Diagnosis

Farmers identified lack of feed at specific times of the year (such as dry periods or during planting seasons) and labour requirements for finding enough feed for animals as major issues in raising animals.

Some farmers also mentioned poor animal production, and, at the more extensive sites, weed encroachment (e.g. *Chromolaena odorata*) into cropping areas was seen as a major problem which could be addressed with forages.

Which forage options are emerging?

Most farmers started to evaluate forages with a range of species in small areas near their houses. This gave them the opportunity to observe the performance of the different varieties and feed them to their animals to check palatability. If they decided that forages could benefit them in some way, farmers looked for ways of integrating those varieties they liked best into their farm. As farmers experimented with different ways of growing and using forages, some farmers concentrated on one or two varieties while others grew a wide range of forage varieties. Different systems evolve with time and the information presented here is only a glimpse in time. The results

Table 2. Forage varieties adopted by farmers.

	Pagalunngan	Malitbog	Xuan Loc	Cuba	Matalom
Arachis pintoi ‘Itacambira’ and CIAT 17844	•[1]	•		•	
Brachiaria brizantha ‘Marandu’	•		••		•
Brachiaria humidicola ‘Tully’ and ‘Yanero’		•			
Brachiaria ruziziensis ‘Ruzi’		•	•		
Calliandra calothyrsus ‘Besakih’			••		
Centrosema pubescens ‘Barinas’	•				•
Desmanthus virgatus ‘Chaland’				•	
Desmodium cinerea ‘Las Delicias’	•	•			
Gliricidia sepium ‘Retalhuleu’	•	•			
Leucaena leucocephala ‘K636’	•	•	•		
Panicum maximum ‘Simuang’ and ‘Tobiata’	••	•••	•••		
Paspalum atratum ‘Terenos’	••	••	•	•	
Pennisetum purpureum and *Pennisetum* hybrids	•••	•••		•••	•••
Setaria sphacelata ‘Lampung’ and ‘Golden Timothy’	•	••		•••	•
Stylosanthes guianensis ‘Stylo 184’	•		•		•

[1]• = few farmers, ••• = many farmers

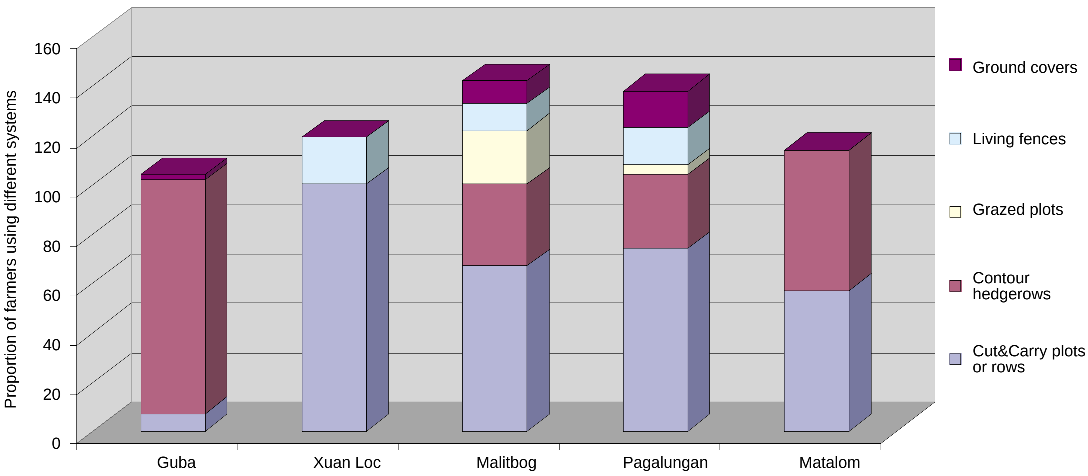

Figure 3. Percentage of farmers integrating forages in different ways (column totals exceed 100% where farmers plant forages in more than one system).

are based on a survey conducted in mid to late 1999. More and different systems will emerge with time as farmers gain more experience with growing and using forages.

Contour hedgerows and intensive cut-and-carry plots have emerged as the main ways farmers integrate forages into their agricultural system (Figure 3). Other ways of integrating forages (living fences, ground covers and small grazed plots) are starting to emerge at some sites. It seemed to be the moderately intensive upland farming systems where farmers planted forages in many different systems (Figure 3) while farmers at the most intensive site (Guba) adopted mainly contour hedgerows and farmers at the most extensive site (Matalom) adopted cut-and-carry and hedgerows systems.

What type of forage species are farmers selecting?

The most frequently used forage varieties are grasses which lend themselves to contour hedgerows and intensive cutting (Table 2). However, a large range of forage varieties are used by some farmers and other ways of integrating forages are being evaluated by farmers. These include *Arachis pintoi* as a ground cover (e.g. Malitbog) and under grapes (Guba), tree legumes along contours and small grazed plots.

Initially, farmers tended to integrate grasses rather than legumes into their farm. There are many reasons for the preference for grasses such their higher yield, cattle and buffalo tend to prefer to eat grasses, and their growth habit, which makes them suitable for growing in rows which seems to be a preferred way of planting forages. However, some farmers have already recognised the high quality of legumes and their ability to increase animal production. For example, many farmers comment on the positive effect of *Arachis pintoi* on egg production of chickens and young animals. We expect that farmers will integrate more legumes to use as a supplement to other feed resources as they gain experience.

The way farmers are growing forages and the species they are using is changing as farmers are gaining experience with forages. For example, the use of *Panicum maximum* ‘Tobiata’ is declining in hedgerows while the use of *Paspalum atratum* ‘Terenos’ is increasing. This process is expected to continue for several years.

Conclusions

Farmers in mixed crop-livestock systems in South-east Asian uplands regard animals as an important part of their agricultural system and are interested in growing forages, mainly in contour hedgerows and intensive cut-and-carry rows between crops. Forages are integrated into the cropping system, utilising whatever areas are available. They are not replacing crops but are used in areas which are not usable for crop production. It is likely that more complex forage technologies will emerge as farmers gain experience with growing and using forages.

Forage Technologies for Smallholders in Grassland Areas

Ibrahim[1], Truong Tan Khanh[2] and Heriyanto[1]

THE grasslands of Southeast Asia occur mostly in areas with long dry seasons, such as eastern Indonesia or southern Laos, or in areas where forests have been cleared and a cycle of cropping and fire has led to dominance of *Imperata cylindrica* and native grasses, such as central Vietnam and eastern Kalimantan. Often grassland areas are utilised for extensive grazing of cattle by smallholder farmers living in these areas (see, for example, Figure 1). Many unsuccessful attempts have been made to convert these grasslands into improved pastures for extensive, commercial livestock production.

The Forages for Smallholders Project (FSP) has taken the approach of working with smallholder farmers in these grassland areas to develop forage technologies to improve their livestock production system. The Project selected two sites; these were Sepaku, East Kalimantan Province, Indonesia and M'Drak, Daklak Province, Vietnam (Figure 2).

Figure 1. Cattle return to village after grazing in Sepaku, Indonesia.

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[2] Tay Nguyen University, Ban Me Thuot, Vietnam. Email: TanKhanh@dng.vnn.vn

Figure 2. Location of featured project sites.

Different Countries, Similar Problems

The two locations have similar farming systems but M'Drak is considerably drier than Sepaku (Table 1). Soil fertility in Sepaku is very poor and soil acidity is severe. Soil fertility is moderate in M'Drak.

Both sites have been progressively settled by transmigrants over the past 25 years, following forest clearing (in the case of M'Drak, following chemical defoliation during the Vietnam war) (Figure 3a). Farmers established small home gardens and rice paddies in the few suitable areas. Large areas of upland crops were established in Sepaku but not M'Drak because of limited land tenure (Figure 3b). Regular fires in the fallows led to the development of large grassland areas. In Sepaku, fire and wild pigs destroyed all attempts at upland cropping. (Figure 3c). By 1999, increasing populations at both sites have allowed the slow expansion of lowland cropping and home gardens (Figure 3d).

Cattle are an essential part of both farming systems. In Sepaku, farmers generally keep from 2–10 head of cattle. In M'Drak, there is a larger variation in herd size, ranging generally from 2–50 head per family, depending mainly on how much land they have been allocated.

Farmers at both sites identified similar problems:

- grasslands provide very poor quality feed for animal production;
- at particular times of year there is not enough feed for animals nearby and farmers have to go long distances to find sufficient feed;
- it takes too long to find and cut native grasses to feed sick animals.

Similar Problems, Similar Solutions

The FSP has been working with farmers at Sepaku for four years and M'Drak for three years to develop forage technologies that have potential to solve these particular problems. The pattern of forage development has been similar at both sites:

Initially, farmers evaluated a range of species in small plots near their houses. Later, most farmers planted forages in cut-and-carry plots or rows (Table 2). Very few planted forages in grazed plots. In Sepaku, some farmers planted forages in contour hedgerows which they managed as cut-and-carry feed.

Table 2. Proportion of farmers planting forages in different systems (based on a survey in 1999).

Forage systems	M'Drak (n = 31)	Sepaku (n = 78)
	(% of farmers[1])	
Cut-and-carry plots or rows	100	85
Grazed plots	3	8
Contour hedgerows	3	27
Living fences	0	10

[1]Some farmers used more than one forage system, thus column totals exceed 100%.

Table 1. Site characteristics.

Sites	Annual rainfall (mm)	Likelihood of dry months (%)[1]	Soil characteristics	Farming system
Sepaku	2750	10	pH (H_2O): 4.5–5.0, infertile	Small areas of home gardens and lowland rice with extensive areas of native grasslands on surrounding low hills. Slowly expanding areas of upland crops and fruit trees near houses and villages.
M'Drak	1890	80	pH (H_2O): 5.0–5.5, moderately infertile	

[1] = percent of years with 4 months of <50mm rainfall (average from 10 years)

The forage varieties preferred by farmers depended on their individual needs, but there were some common varieties used by many farmers (Table 3). Initially, most farmers were interested in forage grasses rather than legumes. This preference is likely to be related to the need for more feed, grasses having a much higher yields than legumes. It is anticipated that farmers will become interested in forage legumes as they experience the large positive effect of supplementing the low-quality basal diet with legumes containing high protein contents (Lanting et al. 2000).

New forage options are starting to emerge. These include forage for feeding fish in M'Drak, establishing intensively-managed plots for short-term grazing of animals in the evening before being penned, and the use of 'Stylo 184' as a cover crop to suppress *Imperata cylindrica*, and the use of 'Stylo 184' as a protein supplement.

The FSP is now working directly with 250 farmers at Sepaku and 95 at M'Drak. Many of these are planting from 500–5000m^2 of forage; some up to 10 000 m^2.

Table 3. Forage varieties adopted by many farmers in M'Drak and Sepaku.

Forage varieties	M'Drak	Sepaku
Andropogon gayanus 'Gamba'		✔
Brachiaria brizantha 'Marandu'	✔	✔
Brachiaria decumbens 'Basilisk'		✔
Brachiaria humidicola 'Tully' and 'Yanero'		✔
Brachiaria ruziziensis 'Ruzi'	✔	
Panicum maximum 'Simuang'	✔	
Paspalum atratum 'Terenos'		✔
Pennisetum purpureum and *Pennisetum* hybrids		✔
Setaria sphacelata 'Solander' and 'Lampung'	✔	✔
Stylosanthes guianensis 'Stylo 184'	✔	✔

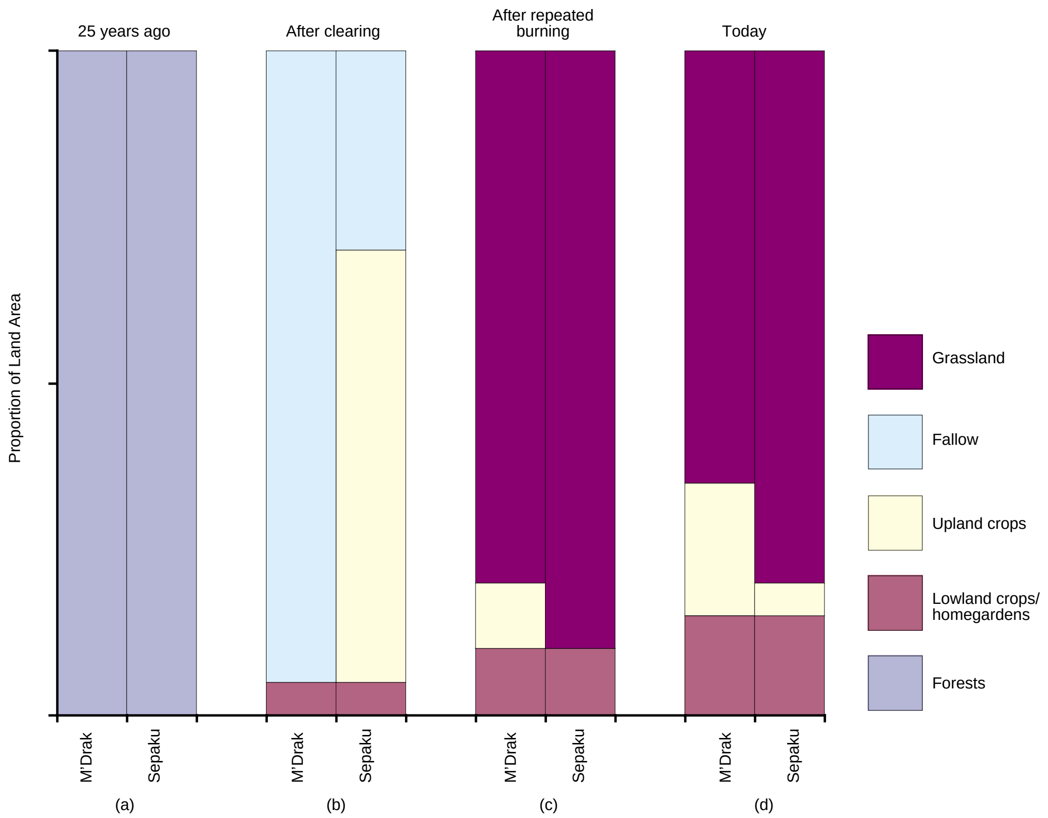

Figure 3. Changes in land use.

Lessons Learned

Through working with farmers, we have learned that:

- **Managed-forages are being used to supplement native grasslands rather than to replace them.** Initially, some farmers imagined they could use forages to replace or improve the native grassland. As they became familiar with the species and the ways of utilising them, they invariably opted for forage systems that provide supplementary feed to animals grazing on the native grassland.
- **Minimising the labour required to look after animals is a major issue in the grassland areas.** At both sites, farmers frequently commented that a significant benefit of having planted forages is the time it saves them cutting native grass for their penned animals.

References

Lanting, E., Sevilla, C. and Gabunada, F. Jr. 2000. Stylo 184 as a protein source in rice straw-based rations for sheep. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Forage Options for Fish and Pigs in Vietnam

Vu Thi Hai Yen[1] and Le Hoa Binh[2]

THE provinces of the northern midlands and mountains of Vietnam are generally considered to be the poorest areas in the country. The intermontane valleys of the north are intensively cultivated and heavily populated but the surrounding hills and mountains are mostly infertile and used for forestry and upland crops such as maize and cassava. Farmers in these areas have diverse agricultural systems, often comprising a mix of lowland and upland crops. Most farmers also keep a wide range of animals such as chickens, pigs, ducks, fish, buffalo and cattle to supplement their diets and incomes.

In 1997, the Forages for Smallholders Project was asked to work in the midlands of Tuyen Quang province (Figure 1) to start developing forage options with farmers to feed their buffalo and, to a smaller extent, other ruminants. The farmers had limited land areas for planting forages but were interested to test small areas for supplementing their animals when penned, especially in the dry season.

Discovering New Uses for Forages — Feeding Fish

By 1998, 53 farmers were testing forages in small plots but were also discovering new ways of using the forages. From 30–80% of farmers in the northern lowlands and intermontane valleys raise carp (grass carp, common carp and mud carp) in small ponds — fish that feed on plants (Figure 2). Some of these farmers, working with the FSP, discovered that several varieties of forage grasses appeared to be excellent fish feed. This proved to be an exciting discovery for them. As one explained: 'If we do not provide feed for our buffalo, they can still find feed somewhere, but if we do not feed our fish, they die!'

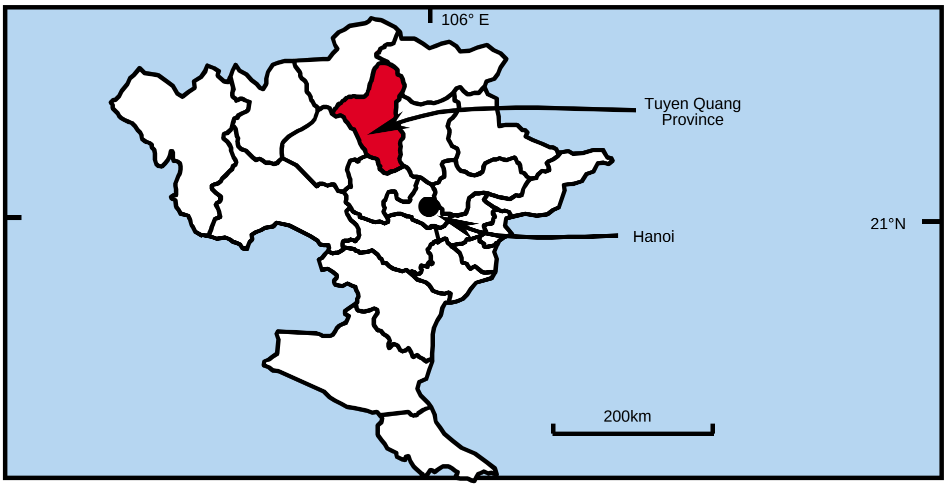

Figure 1. Location of Tuyen Quang.

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[2]National Institute of Animal Husbandry, Hanoi, Vietnam. Email:fspvietnam@hn.vnn.vn

In the project area (Ham Yen district), fish ponds are commonly 600–900 m^2. To feed the fish in a pond of 800 m^2, a farmer would typically cut about 30–40 kg of plant material each day, consisting mainly of native grasses (such as *Eleusine indica.*, *Echinochloa* spp. and *Hymenachne* spp.), banana (leaves and stems), cassava (leaves and roots), fresh rice straw and maize leaves (after harvest). A well managed and fed pond of this size could yield the equivalent of 4 tons of fish per hectare per year, bringing the farmer 3–4 million Dong (US$250–300) per year which is equivalent to the income of two high-yielding rice crops from 2500 m^2 of irrigated paddy.

Traditional feed resources for fish are becoming increasingly scarce, so many of the farmers working with the FSP have started to expand their forages. They generally prefer the grasses *Panicum maximum* 'Simuang', *Paspalum atratum* 'Terenos' and *Setaria sphacelata* 'Solander', because they are high-yielding, easy to cut, persistent, and stay green into the cool dry season. Another important characteristic of good fish feed is that grasses need to have smooth, soft leaves and float on the surface of the water where the carp feed.

By July 1999, the project was working with 173 farmers. Most of these were planting between 400–1000 m^2 of forages around their ponds or near their houses. Rapid expansion of forage systems to new farmers (largely by vegetative propagation) is expected to continue because of intense local demand.

Discovering New Uses for Forages — Feeding Pigs

It is also common for smallholder farmers in Ham Yen to keep 1–3 sows, selling up to 10 pigs a year. The normal practice is to cut green feed for the pigs once or twice a day (including leaves of peanut, sweet potato banana and cassava). Many of the green feeds need to be chopped or cooked to make them palatable to the pigs and are not always available. A growing number of farmers are expanding their areas of *Stylosanthes guianensis* 'Stylo 184' as a pig feed, mainly because it is highly palatable, nutritious, persistent and productive.

Returning to Traditional Uses for Forages — Feeding Buffalo

In 1998, the provincial agriculture department banned the free grazing of livestock in order to reduce damage to crops. This has stimulated many farmers to reconsider planting forages suitable for buffalo, including *Brachiaria brizantha* 'Marandu', which farmers had earlier evaluated and rejected only because they could not use it to feed their pigs and fish.

Two Important Lessons…

1. **Developing forage 'solutions' has been a process, not a 'once off' transfer of technology** Initially, farmers evaluated forages for buffalo but very quickly developed different forage systems to solve more-important needs: the feeding of fish and pigs. As farmers gained experience with growing and using forages, they found new uses for them. Some farmers are now integrating forages into their farming system to control soil erosion (e.g. hedgerows) and improve soil fertility through the introduction of legumes. In 1999, other farmers diversified into either breeding or fattening local catttle and are planting *P. maximum* and other grasses and shrub legumes (e.g.

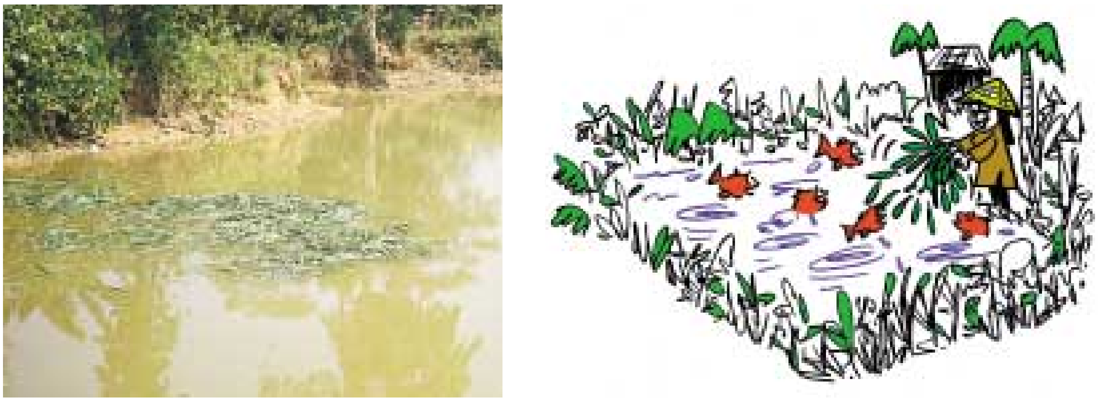

Figure 2. Floating grass for fish in Tuyen Quang, Vietnam (Cartoon – Dave Daniel)

Gliricidia sepium), along field edges for this purpose. The lesson we learned is that it is often impossible to predict the directions that on-farm technology development will take. Therefore, it is necessary to offer a broad range of technology options to farmers at the beginning, actively involve farmers in the development process and remain flexible in the way we respond to the innovations they develop.

2. A common major benefit of forages for farmers has been labour savings

Researchers tend to think of the benefits of forage in terms of improved productivity of animals and improved natural resource management. Farmers frequently have other equally important objectives. In Tuyen Quang, they have commented on the labour saving benefits of planting forages, not just the better feed supply.

Forage Options for Smallholders raising Sheep or Goats in Indonesia

T. Ibrahim[1], Tugiman[1], Ibrahim[2] and R. Hutasoit[1]

SHEEP and goats are managed differently from cattle and buffalo. In many areas, smallholder farmers keep small ruminants in barns for most of the time and only take them out for short periods for grazing. Most of the feed for small ruminants is cut-and-carry forage, and farmers have to spend considerable time gathering sufficient feed.

Although much of the feed consists of grasses and herbs (as for cattle), sheep and goats eat feeds such as tree leaves that are not always accepted by cattle. An example is the leaves of *Gliricidia sepium* which are always palatable to sheep and goats whereas cattle sometimes need to be trained to eat foliage of this species (Figure 1).

The Forages for Smallholders Project (FSP) has been working with smallholder farmers who raise sheep and goats in several locations in Southeast Asia. Two Indonesian sites are featured in this paper. These are Marenu (sheep) in North Sumatra and Makroman (goats) in East Kalimantan, Indonesia (Figure 2).

Site Descriptions

Both areas are in the humid tropics with only a short dry season in most years (Table 1). Soil fertility is poor and farmers are more dependent on income from livestock than similar farmers in more fertile upland areas.

Farmers in Makroman migrated to this area from Java in 1974 and the farming system is relatively stable, with food security ensured by lowland rice. Most farmers have been able to secure additional agricultural land to the originally allocated 2 ha. Marenu is a new transmigration area (first settlers

Figure 1. Sheep eating *Gliricidia sepium* in Marenu, Indonesia.

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arriving in 1995) which was designed with emphasis on sheep production. Farmers received 20 sheep and planting material of king grass (*Pennisetum* hybrid). While some farmers have concentrated on increasing animal numbers and income from animal sales, others are dependent mainly on off-farm income. Income from sheep sales is low, even in families with larger flocks, since they are in the process of building up their flocks.

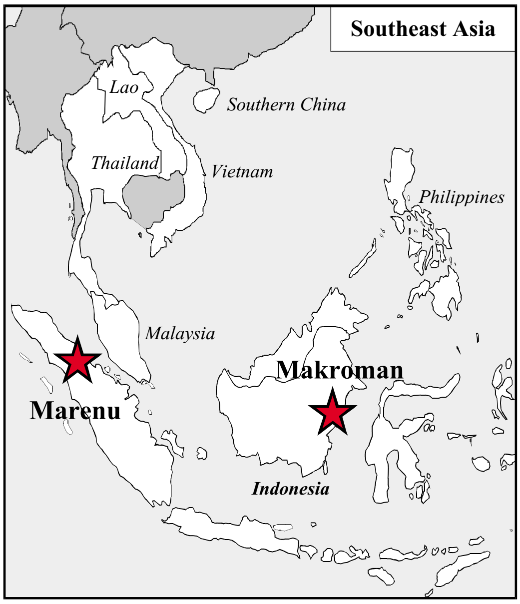

Figure 2. Location of Makroman and Marenu project sites.

In Makroman, goats are kept mainly in the barn and are fed cut-and-carry feed. In Marenu, farmers graze sheep for 3–4 hours per day and provide additional cut-and-carry feed. Before the FSP started working with farmers at these sites, the cut feed consisted mainly of naturally occurring grasses which were cut along roadsides, fields and other vacant areas by all family members. The time needed to cut sufficient feed varied with feed availability from 1–2 hours in the wet season and 2–4 hours in dry months. At both sites, farmers were growing king grass, but yields were low because of the low soil fertility, and many plants died during dry periods.

Developing Forage Options

The FSP has been working with farmers at Marenu for three years and Makroman for four years to develop forage technologies. The pattern of forage development has been similar at both sites:

- Initially, farmers evaluated a range of species in small plots near their house.
- After 1–2 years, most farmers started to plant grasses in cut-and-carry plots or rows, and tree legumes as living fences of along existing fences (Table 2).

Table 2. Proportion of farmers planting forages in different systems (based on a survey conducted in 1999).

	Marenu (n = 81)	Makroman (n = 51)
	(% of farmers)[1]	
Cut-and-carry plots or rows	90	94
Legume covers in annual crops	0	18
Ground covers for erosion control	5	0
Hedgerows	0	4
Living fences (tree legumes)	73	61

[1]Column totals exceed 100% since many farmers are using more than one forage system.

Table 1. Site characteristics.

	Makroman	Marenu
a) Physical		
Annual rainfall (mm)	2750	2350
Dry months (<50mm)	0–4	1–3
Soil fertility	moderately infertile	infertile
Soil pH (H_2O)	4.6–4.8	4.6–4.8
Aluminium saturation (%)	64	85
b) Agricultural system[1]		
Farm size (ha)	0.5–1 ha lowland plus 1–2 ha upland	1 ha upland
Main crops	rice, cassava, maize	vegetables, rice
Number of sheep or goats per family[2]	10	21
	(9–14)	(4–45)
Income from sheep and goats (% of family income)	26%	22%

[1]Means based on data from 40 farms in Makroman and 60 farms in Marenu.
[2]Mean and (range in parenthesis).

- The area of king grass declined over the last two years to less than 25% of the original area planted, being replaced by better-adapted forage species.
- Farmers experimented with many varieties but some species are becoming more popular than others (Table 3). *Paspalum atratum* 'Terenos' is used extensively by many farmers at both sites. Open-ended evaluation showed that farmers liked 'Terenos' since it has a high leaf yield, is easy to cut, regrows fast following cutting, and is liked by sheep and goats. *Setaria sphacelata* 'Lampung' is also a preferred variety by many farmers in Makroman where it is adapted. Following initial reluctance because of a concern about poor palatability, farmers at both sites have 'discovered' the usefulness of *Gliricidia sepium* varieties and many farmers are now planting this species in rows as fence lines, and around fields and houses. Small ruminants tend to prefer legumes to grasses and, in response, farmers growing forages for small ruminants tend to plant more legumes than do farmers growing forages for cattle and buffalo.
- Many farmers prefer to feed a mix of forage varieties to their animals rather than feeding only one or two varieties.
- Several novel forage options have been emerging. In Makroman, some farmers are using *Centrosema pubescens* 'Barinas' as a cover crop in annual crops such as maize and cassava to suppress weeds and provide feed for their animals. Others are growing *Stylosanthes guianensis* 'Stylo 184' to improve egg production of local chickens. In Marenu, some farmers are using king grass as a dense fence around chicken yards. In many instances, farmers grow forages inter-cropped with upland crops such as cassava and maize, or along field boundaries and home gardens.

The FSP has been working directly with more than 100 farmers at Makroman and 85 at Marenu who each plant up to 5000 m^2 of forage for their sheep and goats. The areas planted with forages and the number of farmers adopting forages for use on their farms are both increasing at both sites.

Lessons Learned

Farmers raising sheep and goats are:

- dependent on cut-and-carry feed, and are very interested in growing forages that reduce the time required to cut feed for their animals;
- adopting tree legumes to a much larger extent than farmers raising cattle and buffalo since their animals particularly like leaves from tree legumes.

Table 3. Forage varieties used by many farmers in Marenu and Makroman for feeding small ruminants (based on a survey conducted in 1999).

	Marenu[1]	Makroman
Albizia falcataria	•	
Andropogon gayanus 'Gamba'		•
Brachiaria brizantha 'Marandu' and CIAT 16337	•	••
Brachiaria humidicola 'Tully' and 'Yanero'	•	
Centrosema pubescens 'Barinas'		•
Gliricidia sepium 'local', 'Retalhuleu', 'Belen Rivas', 'Monterrico'	••	••
Leucaena leucocephala 'local' and 'K636'	•	•
Paspalum atratum 'Terenos'	•••	•••
Paspalum guenoarum 'Bela Vista'	••	
Pennisetum purpureum and *Pennisetum* hybrids	••	••
Setaria sphacelata 'Lampung'		•••
Stylosanthes guianensis 'Stylo 184'	•	

[1] • = few farmers, ••• = many farmers.

Forage Options for Smallholder Farmers in Shifting Cultivation Farming Systems of Lao PDR

P. Phengsavanh[1], Sukan[2], H. Phimmasan[3], V. Phimphachanhvongsod[1], V. Phengvichith[1] and S. Novaha[4]

Figure 1. The mosaic of shifting cultivation in northern Laos.

SHIFTING cultivation is the dominant land-use in the northern uplands of Laos and occupies up to 80% of the cultivated land in the whole country (Figure 1). Typically, secondary vegetation in steep upland fields is slashed and burned, and the fields are sown to annual crops such as upland rice, maize or a cash crop. These are grown for one to three years and the field is then left fallow for 3–15 years.

In the past, the traditional system of long rotations (>15 years fallow) resulted in forest fallows, which supported efficient nutrient cycling and sustainable land use. With increasing populations, however, fallow periods are becoming very short in most areas (often no more than 3–5 years) and the resulting fallow vegetation is shrubby. When the fallow is slashed and burned, little of the organic matter is returned to the soil and consequently soil fertility is declining (Roder et al. 1997). The shrubby fallows produce huge quantities of seed which increases the weed problems in the subsequent crops. As a result, at least two rounds of weeding are necessary to grow upland rice, which can take from 140–190 person-days/ha, amounting to >50% of the total labour input into these crops (Roder et al. 1995). Furthermore, farm sizes are declining, with each family now only cropping 0.5–2 ha each year.

Often the area cultivated by a family is limited by the amount of labour available to provide the huge inputs required to maintain the crop. Pressure on land resources also forces farmers to cultivate steeper and more marginal lands leading to increasing soil erosion and associated downstream siltation. The combined pressures on land and human resources have led to declining crop yields and greater susceptibility of upland communities to risk (Figure 2).

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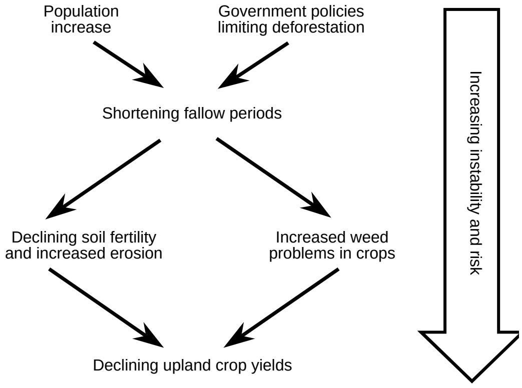

Figure 2. Shifting cultivation is becoming environmentally and socially unsustainable.

Weeds, rodents, insufficient rainfall and the inter-linked problems of land availability and shortening fallows are the main problems identified by farmers in the shifting cultivation areas of northern Laos.

Rural communities and government/development organisations in Laos are looking at a range of strategies that together will help stabilise shifting cultivation. These include:

- intensifying lowland rice production;
- encouraging sedentary agriculture in the uplands, where possible;
- promoting cash crops, fruit trees and farm forestry;
- developing infrastructure, access to markets and social services;
- improving land use planning and land tenure;
- developing better livestock systems.

The Role of Livestock in Shifting Cultivation

Most farmers in the uplands of Laos keep small numbers of cattle, buffalo and small animals such as pigs for one or more of the following reasons:

- there is a constant market demand at relatively stable prices (livestock commonly provide 50–70% of all household income);
- large livestock can walk long distances to market;
- manure can be used to fertilise crops and home gardens (especially as farmers try to intensify production from their small areas of good land);
- livestock give a high profit per unit of labour;
- ruminant livestock utilise an otherwise unused feed resources.

Traditional management systems tend to be low input, being mainly free grazing with cattle returning to the village only occasionally, or limited grazing where cattle return to the village each night. Long-cycle rotational grazing systems are common, with communities designating whole areas to remain fallow for one or several years and be used for grazing.

As shifting cultivation systems intensify livestock numbers are increasing, since many farmers see livestock raising as a 'stepping stone' out of poverty and out of reliance on labour-intensive and unproductive farming systems. As this happens, however, farmers are increasingly experiencing some of the following problems:

- Livestock destroying crops, which is a common cause of conflict in villages. In some places, free-grazing is banned or limited to particular areas, and commonly farmers devote a lot of labour to building fences each year.

Table 1. Expected (●) and emerging (✔) forage options for shifting cultivation systems.

Forage species currently being evaluated by farmers	Forage options					
	Cut-and-carry plots	Grazed plots	Living fences	Hedgerows	Improved fallows	Erosion control
a) Grasses						
Andropogon gayanus 'Gamba'	● ✔	—	—	✔	—	—
Brachiaria brizantha 'Marandu'	● ✔	—	—	✔	—	✔
Brachiaria decumbens 'Basilisk'	● ✔	—	—	✔	—	—
Panicum maximum 'Simuang'	● ✔	—	—	✔	—	—
Setaria sphacelata 'Solander'	● ✔	—	—	—	—	—
b) Legumes						
Stylosanthes guianensis 'Stylo 184'	● ✔	—	—	—	●	—
Calliandra calothyrsus 'Besakih'	●	—	●	—	—	—
Gliricidia sepium 'Retalhuleu'	● ✔	—	●	—	—	—
Leucaena leucocephala 'K636'	●	—	●	—	—	—

● = In 1997, the FSP expected these options to be of interest to farmers.
✔ = Options that are actually emerging on-farms in 1999.

- Loss of traditional grazing land to protected/planted forests or cropping resulting in feed shortages in the wet season (when this land is normally used for grazing).
- Insufficient feed in the dry season. It is common to meet farmers who spend 1–3 hours each day cutting grass for their animals.

These problems are motivating many farmers to experiment with better management of their livestock, including the use of planted forages as a supplement to the diminishing traditional feed resources.

Forage Options for Shifting Cultivation

Since 1997, the Forages for Smallholders Project has been working with farmers in shifting cultivation areas of Laos to help them integrate forages on their farms. Initially, we expected particular forage systems, such as the use of legumes for fallow improvement, to emerge but farmers invariably started testing forage species in small plots before moving on to evaluate forage systems (Table 1).

By the end of the 1999 wet season, 395 farmers were evaluating forages with 204 new farmers having joined in the 1999 wet season. Of the farmers who had been evaluating for two or more years, 85% had started to expand their areas, mostly for providing cut feed. No farmers have shown interest in large areas of planted forages for grazing (Table 1). Instead, farmers addressed specific feeding problems such as saving labour on cutting or providing forage for sick animals by planting forages for cut-and-carry as a supplement to their traditional feed resources.

The Future

Across all countries and farming systems where the Forages for Smallholders project has been operating in Southeast Asia, we have found that farmers do not immediately adopt integrated forage systems, but experiment first with forage varieties. Only once they have confidence in the varieties will they begin to experiment with integrating them into their farming systems. This has certainly been the case in northern Laos, but many farmers are now beginning to experiment with forage integration.

The challenge now is to work with farmers to develop integrated forage systems that not only provide benefits for feeding livestock but capitalise on the potential benefits for natural resource management (in particular, soil fertility improvement and weed control).

A new project (the Forage and Livestock Systems Project; FLSP) funded by AusAID and managed by CIAT (Centro Internacional de Agricultura Tropical) has been designed partly to focus on this goal in northern Laos from 2000–2005. In particular, the FLSP will use participatory approaches to technology development to integrate forage and improved livestock management strategies into upland farming systems that will:

- increase income by improving the productivity of small and large livestock;
- increase labour efficiency and reduce workloads of both men and women farmers in the livestock production systems;
- enhance sustainable cropping systems by increasing soil fertility and reducing soil erosion; and,
- sustain livestock production within the national policy of stabilising shifting cultivation.

References

Roder, W., Phengchanh, S., Maniphone, S., Songnhikongsuathor, K. and Keoboulapha, B. 1995. Weed management strategies aimed at reducing labour for upland rice production. Proceedings of the International Rice Research Conference, 13–17 February 1995, IRRI, Los Baños, Philippines.

Roder W., Phengchanh, S. and Maniphone, S. 1997. Dynamics of soil and vegetation during crop and fallow period in slash-and-burn fields of northern Laos. Geoderma 76: 131–144.

Integration of Sheep and Utilisation of Fodder Trees in Rice-based Cropping System in Tarlac Province, the Philippines

E.E. Victorio[1] and F.A. Moog[1]

"OUR problem in the village is purely religious; technicians come and preach like gods!" (Adapted from a T.R.E.E.S. editorial cartoon). Farmers live on experience; they learn by doing. Researchers and extensionists, on the other hand, are concerned with delivering services and aim to augment the farmers' incomes.

So, how do we introduce to the farmer an animal he or she knows only from the Bible? Worse, in addition to the animal, is the task of persuading the farmer to grow fodder tree species and to cut-and-carry the foliage. At the same time, we need to show that one technology is better than another technology including putting the technology to test!

Objectives

The project aimed to promote the integration of sheep-raising in rice-based cropping systems. It sought to highlight the acceptability and economic viability of sheep-raising in these systems as a means of augmenting farm income. The study also sought to demonstrate the advantage of involvement of farmers in research.

Methodology

Sheep distribution

The study area is a rain-fed lowland rice village in Tarlac, the Philippines, and the study was conducted from 1994 to 1998. An account of the early stages of this study was published by Victorio and Moog (1995). Thirteen farmer-cooperators were selected, based on expressed willingness to raise sheep under a repayment-in-kind arrangement, whereby two female lambs had to be repaid for each ewe received. Each farmer was provided with the number of ewes he or she wanted to raise.

To prevent inbreeding, a ram was provided by the Bureau of Animal Industry (BAI), the custody of which was rotated annually among cooperators, while repayment sheep were extended to new cooperators.

Feeding practices

Fodder tree supplementation practices were introduced among farmer cooperators. Pre-identified fodder tree species were *Leucaena leucocephala*, *Gliricidia sepium*, *Bauhinia sp.*, *Samanea saman* and *Pithecellobium dulce*. The farmer cooperators were left to make their own decisions regarding feeding, provided that records covering their daily activities were kept for monitoring by researchers. Sheep were weighed monthly by the research team and the live-weight gain (LWG) and average daily gain (ADG) were calculated.

Data analysis

Farmer records were regularly monitored through field visits made by the researchers. These records were organised, assessed and analysed.

Observations

Farmers' records showed that sheep were tethered like local ruminants on rice straw and weeds associated with rice during the rice growing period and supplemented with rice stubbles, standing legumes and crop residues after the rice harvest. Fodder tree species were used for supplementary fodder.

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Results and Discussion

Sheep integration

Raising sheep in this lowland rainfed farming system required at least two hours labour per day during the rice-growing period for cut-and-carry, and one hour per day after the rice harvest for tethering and watering.

The project started in the second quarter of 1994 with four cooperators, increasing to ten in 1995, 12 in 1996 and 13 in 1997 and 1998. Eleven of the farmers treated the sheep like any other ruminants, except for keeping them in semi-confinement. Weeds included in the sheep's diet were predominantly *Echinochloa* spp. and *Cyperus rotundus.*

Benefits

Without raising sheep, farmers would have had to spend much time weeding paddy bunds and fields. Over a four-year period, farmers involved in the project saved a total of 2640 man-days (Table 1).

Table 1. Labour-saving generated from raising sheep.

Year	Number of cooperators	Number of man-days
1994 (Jul–Dec)	4	76
1995	10	647
1996	12	777
1997	13	842
1998	13	298
Total	13	2640

Average daily gain of the supplemented sheep was higher than that for those provided with traditional feed (Table 2). However, overall weight gains of the sheep were lower than those obtained from sheep grazed under coconuts with ADG ranging from 27 to 67 g at different times of the year (Moog 1994). The low ADG obtained from the sheep with the fodder tree supplement was likely owing to inadequate quantity of fodder tree leaves provided to the sheep, averaging only 190 g of fresh leaves per animal per day.

Table 2. Mean liveweight gain of sheep in rice-based farming system (October 1994 to December 1995).

Treatment	Initial weight (kg)	LWG (kg)	ADG (g)
Traditional feeds	11.5	13.2	28
Traditional feeds plus fodder tree supplements	14.1	16.9	36

To demonstrate further the benefits of a fodder tree supplement, an on-site study was conducted during the dry season. Only two farmers volunteered to participate in the five-month trial. Sheep were provided with larger amounts of tree leave supplements, and gained weight at 2.5 to 3 times the rate of the sheep fed with smaller amounts in the earlier trial (Table 3).

Table 3. Average daily gain of sheep supplemented with tree leaves.

Farmer	Supplement	Fresh tree leaves provided (g/hd/day)	ADG (g)
Farmer A (17 sheep)	*Leucaena, S. saman, P. dulce*	230	81
Farmer B (1 ram)	*Leucaena, Bauhinia, Gliricidia*	515	111

Table 4. Benefits to farmers from sheep raised.

Farmer-cooperator	Disposal	Use
M. Valdez	sold (3 sheep)	bought food for the family; bought 4 pieces GI sheets for cow shed
A. Estavillo	sold (3 sheep)	bought food and clothes
W. Manzano	sold (2 sheep)	bought school supplies and food
R. Fabros	slaughtered (1 sheep)	for son's wedding
F. Ganapin	sold (3 sheep)	bought food, fuel oil and fertiliser
	slaughtered (1 sheep)	for brother's death
J. Fabros	sold (1 sheep)	to finance new animal shed
	slaughtered (2 sheep)	birthday and son's graduation
L. Valdez	sold (2 sheep)	bought dining set; domestic expenses
	slaughtered (1 sheep)	brother's visit
C. Salonga	exchanged 1 sheep for 2 goats	bought additional animals to raise
T. Castro	sold (1 sheep)	bought rice
J. Micu	slaughtered (5 sheep)	for special occasions

Development of a Market

Mutton is becoming popular in the village and apparently substitutes for other meat on special occasions (Table 4). It provides an additional source of income for smallholder farming families. In the town market, price has been pegged at PhP 90/kg.

Problems encountered

A farmers field day was conducted to demonstrate opportunities to supplement sheep with fodder trees. All farmers who attended the field day expressed interest in fattening sheep after the rice harvest, from October to June, to take advantage of the available forage biomass in the area.

When farmers were reluctant to adopt supplementary feeding with tree forage it was often due to conflict of use. Some farmers in the village use fodder trees for fuel wood. Some farmers hesitated to feed *Leucaena* for fear that psyllid insects on the foliage might cause death to their animals.

Conclusions

Sheep-raising has good potential for expansion in rice-based cropping system. Mutton is an acceptable and growing alternative to traditional meats and local markets develop quickly.

In small farms, a flock of two or three ewes and a ram is manageable, considering the scarcity of fodder during the rice-growing season. In rice-based systems, the availability of tree fodder can be improved by promoting the planting of tree legumes as living fences. Fattening of sheep during the dry season can be practiced and sheep should be ready for marketing before planting the rice crop.

References

Moog, F.A. 1994. Sheep production on natives pastures under coconuts at different stocking rates. In: Alo, AM. P. and Villar. E.C. ed. Terminal Report of Small Ruminant/Coconut Systems Project — Philippines, 47–54.

Victorio, E.E. and Moog, F.A. 1995. Sheep production in rice-based farming system with fodder tree supplementation. In: Wong, C.C. and Ly, L.V., ed. Enhancing Sustainable Livestock-Crop Production in Smallholder Farming Systems. Proceedings of the Fourth Meeting of Forage Regional Working Group on Grazing and Feed Resources of Southeast Asia, Nha Trang, Vietnam, 20–24 March 1995, FAO, 213–220.

An On-Farm Trial on Integration of Cattle under Coconuts in Albay, the Philippines

F.A. Moog[1], H.E. Diesta[1], A.G. Deocareza[1] and J.H. Losa[2]

COCONUT land in the Philippines is potentially available for the expansion of the livestock industry. With a low national average production of 49 nuts/tree/year, one of the options to increase land productivity is to integrate livestock, particularly cattle, under coconuts. Earlier studies of the Bureau of Animal Industry (BAI) showed that cattle on improved grass pastures like signal grass (*Brachiaria decumbens*) and humidicola (*B. humidicola*) can produce liveweight gains of 300 to 400 kg/ha/year at stocking rates of 2–3 beasts/ha. The majority of coconut farms are small, and these results should be extended to the farm situation.Objectives in this study were to demonstrate the value of integrating cattle under coconuts and to determine the benefits that could be derived by farmers from cattle-coconut integration.

Methodology

Six farmer-cooperators were selected in Barangay Baligang, Camalig, Albay. Farmers' meetings and seminars were conducted. Responsibilities of farmer-cooperators to establish pasture, including land preparation and planting, were emphasised. Planting materials of napier grass (*Pennisetum purpureum*), humidicola and signal grass, and technical assistance, were provided. The forages were planted at staggered intervals from March 1995 to September 1997, with areas ranging from 0.12 to 2.0 ha per farmer. Eleven head of American Brahman cross cattle (five heifers and six steers) were delivered and randomly distributed by drawing lots. Cattle were weighed on 6 December 1996 and at 3-month intervals thereafter, until the final weighing on 10 December 1997.

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Results

Liveweight gains ranged from 22–142 kg/head/year, with an average daily gain of 0.06–0.38 kg/head. From an average of 183.3 kg/head, cattle liveweight soared to 266.5 kg (mean ADG – 0.23 kg) (Table 1).

Liveweight gain of the cattle was directly related to the improved feeding regimes carried out by the farmers. The animals of farmers 1 and 5 performed best as they were provided with supplements such as molasses, corn starch and fodder trees such as *Leucaena leucocephala* and *Gliricidia sepium*. To ensure sufficiency of feed during the dry season, Farmer 5 resorted to gathering rice straw and treating with sugar dissolved in water, to increase palatability. Animals of Farmer 6 performed well as they were supplemented with fodder trees during the dry season. Poor performance of cattle owned by Farmers 3 and 4 was associated with lack of supplementation.

The average annual income of farmers from coconuts is P58 561. Depending on individual farming activities and size of landholding, farmers' incomes range from P17 880 to P104 625 per annum.

The relative income contribution of cattle in integrated livestock systems with coconuts ranged from 1.8–26.3%, depending on farm size, for farmers with two head of cattle. The highest proportion of income from cattle (26.3%) was obtained by Farmer 5, with 1.5 ha of coconut (Table 2). Supplementary income from cattle can increase average family income by 15.1%, from P58 651 to P67 176.

Conclusion

Raising cattle under coconuts provides farmers with additional income and increases the overall productivity of the coconut land. It generates employment for members of the farming family, including women. Development of coconut areas for livestock production will increase the local supply and availability of meat, which will eventually reduce import of meat from overseas.

Table 1. Liveweight gain (LWG) of cattle distributed to farmer-cooperators.

Farmer	Animal no. and sex	Initial weight (kg) 12/6/96	Final weight (kg) 12/10/97	Total LWG (kg)	ADG (kg)
1	1 (M)	165	307	142	0.38
	2 (F)	194	266[1]	72[1]	0.31
2	3 (M)	192	264	72	0.19
	4 (F)	195	272	77	0.20
3	5 (M)	156	211	55	0.15
	6 (F)	187	209	22	0.06
4	7 (F)	163	215	52	0.14
5	8 (M)	164	306	142	0.38
	9 (F)	203	280[2]	77[2]	0.33
6	10 (M)	195	313	118	0.32
		208	289	81	0.22

[1]Until July 31, 1997, animal bred July 1, 1997.
[2]Until July 31, 1997, animal bred July 10, 1997.

Table 2. Income (pesos) of farmers from coconut and cattle in Baligang, Camalig, Albay (December 6, 1996 to December 10, 1997).

Farmer #	Income from Coconut (P) and area (ha)	Income from cattle (P) and no. of head	Total (P)	% Contribution of coconut	% Contribution of cattle
1	51 596 (3.2)	11 532 (2)	63 131	81.7	18.3
2	104 625 (7)	8875 (2)	113 500	92.2	7.8
3	17 880 (2)	5065 (2)	22 945	79.8	20.2
4	77 469 (4)	2635 (1)	80 104	96.7	3.3
5	3377 (1.5)	12 245 (2)	46 622	73.7	26.3
6	65 421 (3)	11 335 (2)	76 756	85.2	14.8

Assessing the Impact of Agricultural Technologies in Smallholder Farming Systems — Results from a Participatory Monitoring and Evaluation Study on Forages in Malitbog, Northern Mindanao, Philippines

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Abstract

In this paper, a participatory approach is used to assess impact of forage technologies recently introduced to Malitbog, the Philippines. Despite the fact that participatory approaches to technology development are designed to ensure that new technologies meet farmers' needs, extent of adoption and the impacts on farm productivity and natural resources have rarely been assessed. Participatory methodologies applied to impact assessment enabled stakeholders to identify, elucidate and rank indicators of potential impact according to their perceived importance by those stakeholder groups. Simple in-field and statistical analysis highlighted important impacts and their relationships to each other. Comparing the two approaches, statistical analysis confirmed the in-field results and indicated that the field technicians could apply in-field analysis with confidence. The results indicated that smallholder farmers are aware of potential benefits of forage technologies to livestock as well as benefits to crops and the environment. Forage technologies were shown to have the potential for significant positive impacts on farming systems provided that they are tailored to individual requirements. In general, cut and carry species had greater appeal (than species for grazing) to farmers from Malitbog since they complement rather than substitute existing pasture and they enable the tethering of livestock closer to home, with a concomitant increase in animal safety.

THERE have been many projects aimed at reducing rural poverty by increasing productivity and maintaining the natural resource base. Despite the fact that participatory approaches to technology development are designed to ensure that new technologies meet farmers' needs, extent of adoption and the impacts on farm productivity and natural resources have rarely been assessed.

Studies of impact have generally focused on key productivity increases at the regional level, but at the farm level there are few 'user-friendly' methods that assess environmental and economic impact during early stages of adoption. Any framework for monitoring progress or assessing impacts of new technologies must be related both to the problems and needs expressed by farmers as well as expected outcomes at different scales (farm, community, region). With this capability, farmers and researchers can modify technology development better to target both local and regional needs.

This monitoring and evaluation project aims to develop a framework to monitor and assess the ongoing and ex-post impacts of new forage technologies developed through farmer participatory research. Specifically, this paper reports on a series of impact indicator assessment workshops held with stakeholders in the Forages for Smallholders Project.

The Forages for Smallholders Project (FSP) has been working with smallholder farmers in Southeast Asia developing suitable forage technologies to help boost livestock productivity. A major question for the FSP was whether the availability and adoption of

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new forage technologies was providing significant positive impact for the smallholder farmers in its project sites.

Two sites where the FSP has been active and where smallholders have adopted improved forage technologies, Malitbog in Bukidnon Province, Philippines, and M'Drak in Dac Lac Province, Vietnam, were chosen to develop this framework of participatory monitoring and evaluation. The basic approach was to work with the stakeholders to identify, order, rank and finally measure indicators of impacts within the context of the overall farming system. The workshops aimed to use participatory techniques to develop and rank indicators of the impact arising from the on-farm development of forage technologies.

In this paper, we present preliminary results from the monitoring and evaluation study of the Malitbog site.

Stakeholder views on impact of new technologies

In developing impact indicators for a particular project, the views of the stakeholders involved in the project are important in defining the potential indicators of impacts. Stakeholders do not necessarily comprise only those people whom the project is designed to help, for example farmers, but all those groups who potentially are going to be affected by the project outcomes (Figure 1). A full assessment of project impacts can only be achieved by identifying all the stakeholders and eliciting their views regarding the potential impacts of the project.

Success can mean different things to different stakeholders. For example, some stakeholders may be interested in increasing aggregate or national production, while other stakeholders may be interested in gender, equity and environmental aspects of the project. Still others may be interested in increasing income and reducing risk. All of these criteria are valid to the particular stakeholder concerned and success therefore depends on the views of the stakeholders involved with the project.

The question of interest to a particular stakeholder is the manner in which the new technology impacts on the system. That system may be an aggregate farming system, or a sub-system like a livestock or cropping system. A new technology impacts on each stakeholder in a different way. At the macro level, a new forage technology might mean that aggregate or national livestock production might increase, or there might be a noticeable improvement in crop yield due to soil erosion control. At a micro level, other stakeholders might be interested in the labour saving aspects of the new technology.

At any one-system level, a new technology will have multiple impacts (Figure 2), which may be immediate, intermediate and long-term in nature. For example, the availability of forages may mean that seasonal shortfalls in feed quality and availability may be alleviated (an immediate impact). This may result in increases in liveweight gain for livestock,

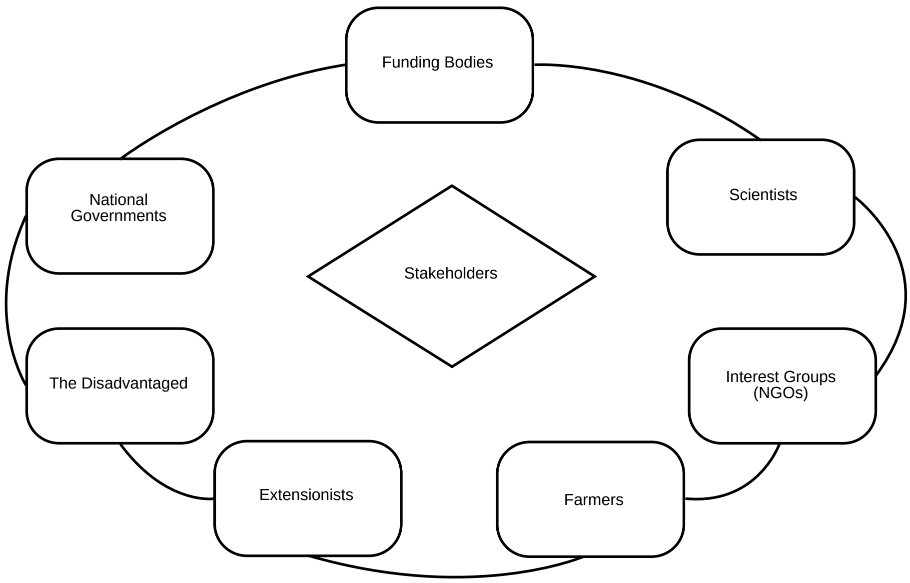

Figure 1. Project stakeholders.

with a resultant improvement in productivity of draught animals and a higher sale price for fattened livestock (a sequence of intermediate impacts). Ultimately these changes may result in higher incomes and improved farmer welfare.

At the same time, the establishment of forages on sloping land may reduce soil erosion (an immediate impact) with consequent benefits for soil fertility and crop yield (intermediate impacts) and, ultimately, beneficial consequences for farmer welfare and downstream resource users (Figure 2).

The multiple effects of a technology may include both positive and negative impacts. For example, while the planting of forage species may result in the reduction of soil erosion from sloping land, as noted above, it may have the adverse effect of reducing the area under cropping, thereby reducing farmer income.

Although a new technology may impact on stakeholders in different ways depending on their relationships to the system in question, impact also depends on the views of the stakeholders. While this topic will be elucidated later, in essence these views can be broadly classified into stakeholders' perceptions, expectations, knowledge and experience of the new technology. For example, stakeholders differing in age or gender may have different perceptions as to how the new technology impacts on their system. In addition, these perceptions are contingent on their own expectations of what this new technology has to offer. Knowledge and experience also changes stakeholders' views, enabling a broader and deeper understanding of the benefits and limitations of the new technology.

Identification of Impact Indicators

Workshops were held with stakeholder groups to elicit indicators of impacts (especially intermediate impacts) that could result from adoption of forage technologies. Workshops were held with the FSP collaborators, comprising representatives from funding bodies, the respective national governments and forage scientists, at the 4th Annual Forages for Smallholders Project Meeting in Nha Trang, Vietnam in January 1999. Further workshops were held with the Malitbog Municipal Agricultural Office personnel, and with seven of the target *sitios* (villages) in the Malitbog Municipality. These were Bilayong, Paitan, Kaluluwayan, San Migara, Santa Inez, Silo-o and Tagmaray.

Each workshop was a two-stage affair. In the first stage, the participants were asked to identify the indicators of impacts, both the positive and negative 'benefits', that they foresaw as likely outcomes from forage adoption. In the second stage, the participants were asked to weight each indicator of impact in order of importance. At all of the sites except Silo-o both the impact assessment and weighting exercises were conducted. The weighting exercise was not carried out at Silo-o due to its remoteness, which meant that it could only be visited once.

In the first stage of the process the participants in the focus groups were asked to identify the likely outcomes of forage adoption on their farming systems and livelihoods. These indicators of impacts were developed by the facilitator and the participants as a flowchart leading from 'forage adoption' to 'well-being' of the stakeholder (see, for example, Figure 3).

The indicators of impacts were differentiated by gender, in that it was noted whether a male or female participant had made that particular comment. It should be noted that this does not mean that the identification of that indicator only applies to one gender, merely that they were the first to mention it; it may well be that other participants (irrespective of gender) agreed with them.

The number and nature of impact indicators differed across focus groups. Groups with a greater (and longer) exposure to forage technologies were able to identify a larger number of indicators, a greater number of multi-stage intermediate and final indicators, and a more complex interaction of indicators in the farming system.

As an example, all focus groups mentioned that forages could fatten livestock and therefore increase their sale price, but only the FSP national coordinators mentioned the reproduction aspect of improved nutrition.

Concentrating on the indicators of impact identified by the farmer focus groups, the groups identified intermediate and final indicators associated with both livestock and non-livestock activities.

Most groups indicated that forages could be used to increase the number of livestock cared for and to fatten livestock already held. These animals could then be sold at a higher price. Some groups indicated that an increase in manure could result from the increase in the number of animals and the change in feeding regime (from an extensive tethering to an intensive cut-and-carry system). The manure subsequently could be collected and either sold or used as fertiliser on-farm. Most groups readily identified linkages between forages and other aspects of their farming systems. For example, forages could be used for soil erosion control.

As mentioned above, stakeholder views on forages were contingent upon their perceptions, expectations, knowledge and experience of how the new forage technology was going to impact on the farming system. As an example, different genders and ages

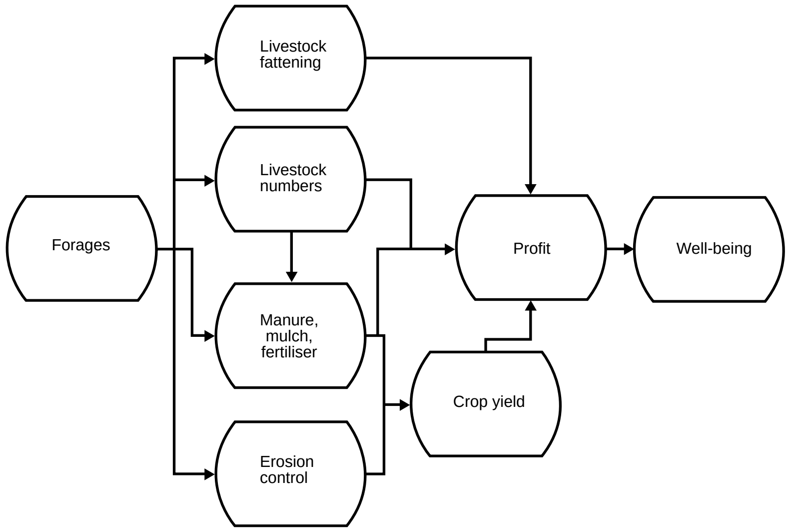

Figure 2. Possible sequences of farm-level impacts arising from introduction of forages.

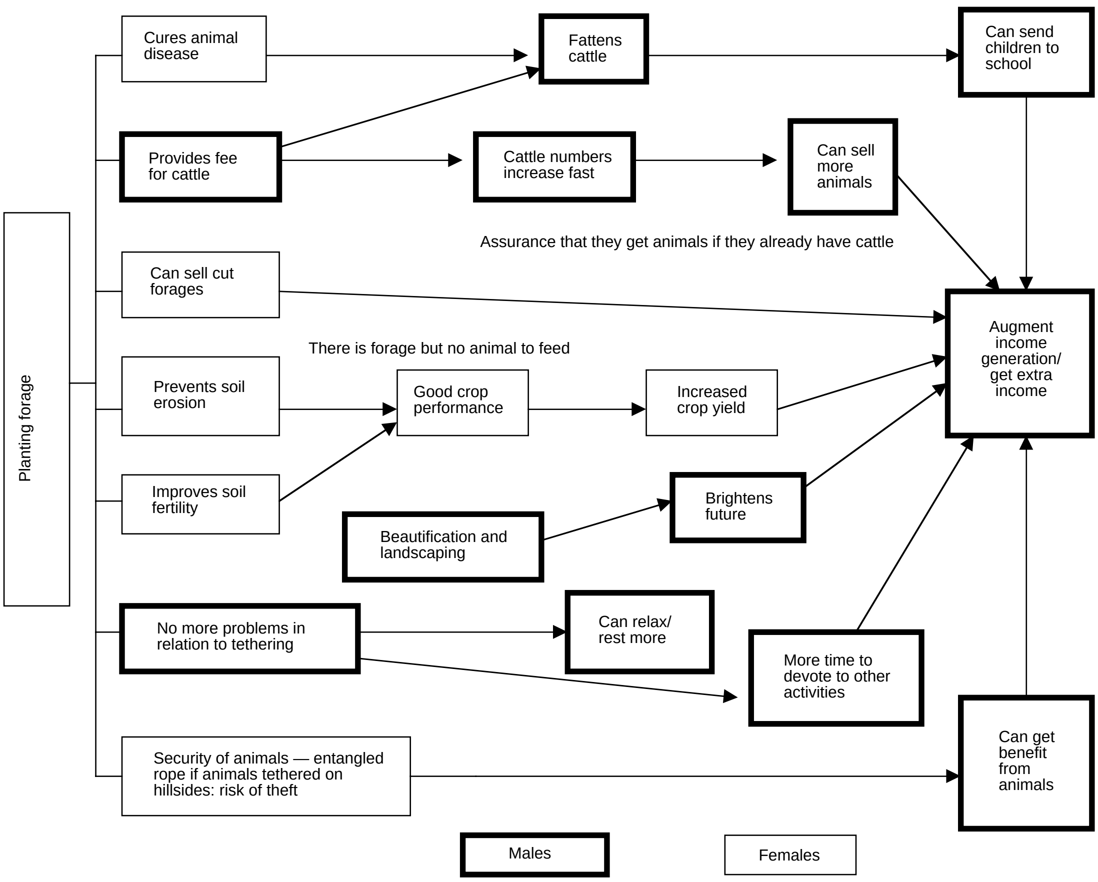

Figure 3. Impact assessment — Sitio Tagmaray.

had different perceptions as to the impact of forages on labour. While some farmers saw that time saved by feeding livestock cut-and-carry forages, rather than tending grazing animals, could be used for rest and relaxation, other farmers saw that the time saved could be used for other farm activities. Some farmers identified the role younger members of the household played in caring for livestock ('even small children can now feed the animals'). The children themselves appreciated the savings in their time which resulted from moving from a purely grazing system to a combined grazing and cut-and-carry system ('Before we had forages it was laborious to feed the animals. Now it is not so laborious').

The expectations of what benefits forage technologies were going to bring to the farming household also played a role. For example, there was a high level of interest shown in forages in some of the villages in the Malitbog area. It transpired that a livestock dispersal program operating in parallel to the Forages for Smallholders Project was requiring qualifying farmers to plant forages. Thus, there was an incentive for non-dispersal recipient farmers to plant forages in order to increase their chances of qualifying for the dispersal program.

Stakeholders with a higher level of knowledge, such as forage scientists and government extension workers, were able to identify likely indicators of impacts such as improved reproduction rates due to improved nutritional status of the animals. Farmers themselves might not have been able to elucidate such concepts, but were well aware of their consequences — increased numbers of livestock.

The amount of experience stakeholders had with forages was directly correlated with the number and range of potential impact indicators identified. Farmers experienced with forage production indicated that they needed forages that could withstand drought and that sometimes the livestock preferred grazing a species in preference to being offered that species as 'cut-and-carry', because they liked to be able to select the palatable leaves and pull the grass from the ground. Experienced farmers also indicated that they now had extra time available for other activities, because they had a readily available source of feed for their livestock.

After all workshops were held, the results were collated into a list of around 70 different indicators of impacts. These were grouped and condensed down to 37 (Table 1).

Weighting of Indicators

The second stage of the process involved collating indicators from each of the stakeholder focus groups and selecting the 24 most mentioned indicators. These were selected under the assumption that the more times it was mentioned the greater was the probable importance. The indicators were written down on a large sheet of paper, which was then used as the weighting board to weight the indicators. Each of the farmer groups was then asked to weight the indicators according to importance.

The farmers were given 10 cards, numbered 1 to 10 and asked to place them upside down (to preserve anonymity) against the impact indicators written on the board in order of importance to them, with 1 being most important and 10 being least important. The remaining 14 indicators were thus classified as 'not important'. This is not to say that the farmers considered them to be totally irrelevant, as they were important enough to mention during the first stage of the impact assessment exercise.

In this stage of the exercise, no differentiation was made between gender responses. In future research it may be necessary to collect information on within-site variability (such as gender and wealth) during the weighting exercise in order to account for the very large variation in responses not attributed to site differences alone.

There was a wide distribution of responses from each site, but several impacts stood out as being most important to all the farmers:

- the ability of forages to fatten animals,
- the ability to provide feed to counter seasonal and overall shortfalls,
- the potential of forages to control soil erosion, and
- the opportunity to ensure the safety of animals against theft and accidents or sickness by tethering closer to home.

In addition, there were indicators of impacts that were considered to be of secondary importance:

- the ability of forages to increase soil fertility by providing fertiliser and manure;
- the time savings generated by a reduction in animal management effort;
- the reduction in social tensions by limiting the need to graze in communal areas and the associated danger of stray animals damaging other peoples' crops[1]; and
- the increased price obtained for fatter livestock.

[1]A system of fines has been introduced in some of the villages which puts pressure on farmers to control movement and grazing of livestock. A P50 fine is levied against farmers who allow their cattle or buffalo to roam free and a P5/damaged plant (typically maize) is levied against farmers who allow their animals to graze on other peoples' plots. Due to the dispersed nature of farm plots in the area the probability of getting *caught in flagrante delicto* is low and hence the continuing social tensions and the interest in new forage technologies.

Interestingly, the livestock dispersal programs operating in the municipality (cattle, carabao and goats) were considered to be less important that the other factors. This was despite informal discussions with the farmer *alayons* (groups) indicating that the dispersal programs were a common factor in decisions to adopt forage technologies. In a subsequent survey, 61% of the 120 farmers growing forages indicated that the dispersal programs played a role in their decision to plant forages. The results indicate that, although the dispersal program did have some importance in farmer decisions to adopt forages, there were also other, more important factors influencing their decisions to adopt.

One of the indicators of impact highlighted by some of the focus groups was the potential for labour savings for women and children in animal management. This was not generally seen by stakeholders as an important enough indicator to mention. In fact, only the national level research scientists identified labour savings by women and children as a likely impact to arise out of forage technology adoption. One of the farmer focus groups actually highlighted that a perceived benefit of forage adoption was that children could now participate more in animal management under a cut-and-carry system than they could with the traditional grazing and tethering systems. Interviews with stakeholders revealed that little importance was attached to the contribution of child labour to the farm household and that the opportunity cost of such labour was considered to be marginal to zero. The contribution of women's labour to

Table 1. Impact indicators identified by stakeholder workshops.

Indicators of impact	Malitbog Agricultural Office	FSP Country Coordinators	All male farmers	All female farmers	TOTAL
Forage little eaten as cut-and-carry but eaten if animals tethered				X	1
Expand establishment of species for grazing			X		1
Planting forage			X		1
Was instructed to plant/given information				X	1
Less drudgery for working animal			X		1
So we could get assistance from MAO				X	1
Livestock dispersal				X	1
Security of animals — preventing theft				X	1
Don't fully own land or animals, so cannot plant forages			X		1
Planting materials were available	X			X	2
Progress for farmers and livestock			X	X	2
Increased sale price		X	X		2
Less work for women and children		X	X		2
Increased work capacity		X	X		2
Have forages but no cattle			X	X	2
Meat quality	X	X			2
No damage to other peoples crops			X	X	2
Send children to school			XX		2
Improve family health/feed animals even if sick	X		X	X	3
Selling feed	X	X		X	3
Relax/rest more	X	X	X		3
Less drudgery for farmer		X	XX		3
Other land uses	X	X		X	3
Helps us with our hardship/financial problems				XXX	3
Fertiliser/manure	X	X		XX	4
Crop yield	X	X		XX	4
More time to devote to other activities	X	X	XX		4
No need to tether far from household			XX	XX	4
Landscaping/clean & green	X	X	XX	X	5
Animals will be healthy	X		XX	XX	5
Improves soil fertility	X	X		XXX	5
Increased number of cattle	X	X	X	XX	5
Additional farm/non-farm income source	X	X	XXX	X	6
To save on labour for caring of animals		X	XX	XXX	6
Soil erosion control	X	X	XX	XX	6
Can fatten their cattle	X	X	XX	XXXX	8
Feed for animals	X	X	XXXX	XXX	9

the farm (as opposed to the household) was likewise considered to be low, by both men and women. This was contrary to observed activities and may reflect a cultural attitude towards female farm labour. When asked how important women's and children's labour savings were, most farmer focus groups attached little to no importance to such an impact. Even one farmer focus group comprised only of women indicated that most thought such labour saving was not important at all. Those that did consider it to be important (compared with 'not important') only ranked it as 'important', rather than 'very important'.

Analysis of Indicator Weightings

An in-field approach to the analysis of indicators

With such a wide range of responses from farmers, it was important to be able to identify patterns and trends within the data. More importantly, it is necessary to be able to develop a methodology that could be applied in the field by extension workers without access to computers or advanced statistical analysis techniques.

Simple bar-charts of farmer responses to each impact indicator at each site were developed (See, for example, Figures 4, 5 and 6). These charts grouped responses into 'very important' (scores 1–3), 'important' (scores 4–6), 'less important' (scores 7–9) and 'least important' (scores 10+).

An ad-hoc ranking scheme was applied, where indicators of impact were ranked by number of responses in the 'very important' class, followed by 'important', 'less important' and 'least important' classes. This is not a very satisfactory ranking scheme, in that indicators with a low score for 'very important' but a high score for 'important' are ranked lower than what casual observation suggests (e.g. the 'fertiliser and manure' indicator compared with the 'crop yield' indicator in Figure 6). However, as part of the study is to compare the-field analysis with rigorous statistical analysis, such *ad hoc* ranking schemes are important benchmarks.

The bar-chart rankings indicate that, for all sites, the top indicators of impact were feed for animals, the safety of the animals and fattening cattle. The bar-chart also indicates that the ad-hoc ranking scheme places the fertiliser and manure and the higher animal price impact indicators lower down the ranking than their 'important' score would suggest is appropriate.

What is interesting to note is that. although farmers were able to identify the indicators which ranked highly, middle ranked indicators were very closely ranked, suggesting that farmers have difficulty in differentiating between these indicators. This can be observed in Figure 7, in which the relative rankings of each impact indicator by each assessment workshop are plotted together. While the indicators which attracted a high ranking are clustered together quite closely, indicators which attracted a middle ranking are spread further apart. This is indicative of participants' difficulty in being able to distinguish between indicators of impact which had little intrinsic difference in outcome.

The bar-charts constructed for each of the sites individually generally coincide with the rankings for all the sites combined. The 'time savings' impact appears out of expected ranking due to the construction of that impact. This impact was a combination of four separate 'time' impact indicators and thus has a higher ranking.

The charts indicate that individual sites have some differences in ranking, due to their particular circumstances. For instance, Tagmaray, a site that is steeply sloping, ranked soil erosion control as the most important impact of forage technology adoption. This can be compared with a site like Paitan, which ranked it as seventeenth out of twenty (Figure 7). Unlike most sites, the farmers at Tagmaray considered the ability of forages to provide feed for animals as very minor, ranking it sixteenth out of twenty. This is due to the relative abundance of grazing land available in a place that has been newly opened for development, compared with other sites with higher population densities.

A Statistical Verification of the In-Field Analysis

While *ad hoc* ranking using bar-charts can give an indication of the relative importance of indicators of impact in assessment exercises, there is always the question of the statistical significance of any perceived difference.

An analysis of variance was carried out on the indicators of impact and the results indicate that there was a highly significant difference ($p<0.01$) between the impact indicators and that there was no significant difference in participants' responses between village of origin. The results are tempered by a low R^2 of 0.18, indicating that only 18% of the variability in rankings can be attributed to either the impact indicator itself or to the site variable. While low R^2s are a common feature of human responses in experimental studies (values of 0.3 are considered to be quite reasonable), an R^2 of 0.18 is probably too low for one to have much faith in the predictive power of the model. A low R^2 combined with a highly significant F-statistic indicates that the problem with the model is under specification and that factors explaining the difference in responses by individuals (in addition to the site variable) need to be incorporated.

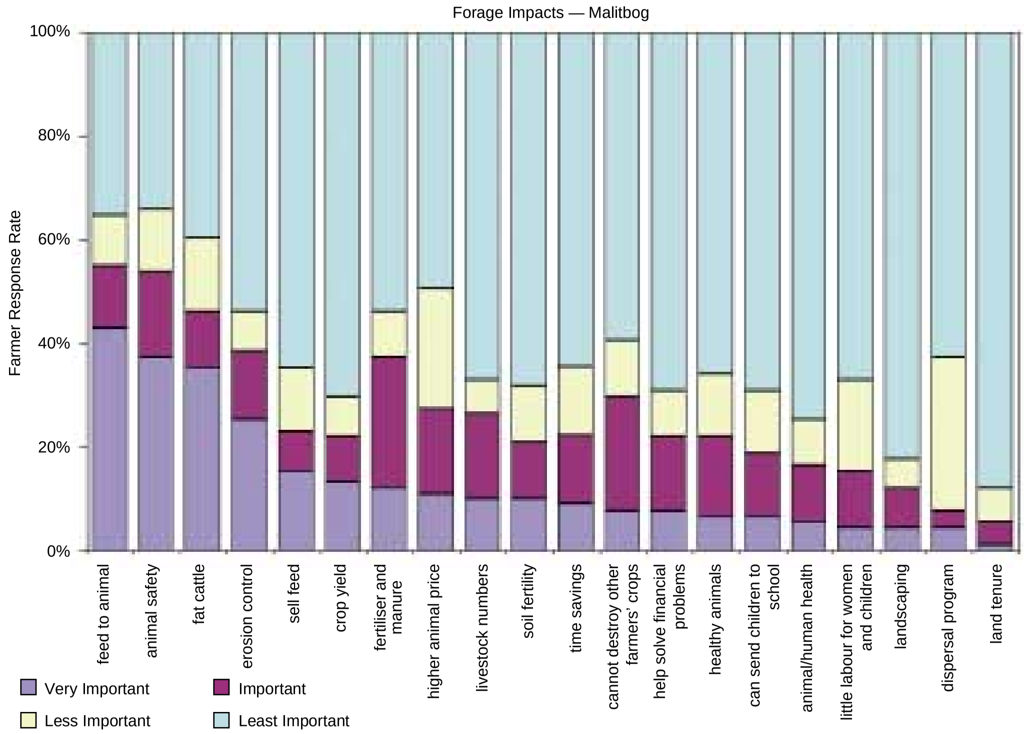

Figure 4. *Ad hoc* ranking schemes — Malitbog (all sites combined).

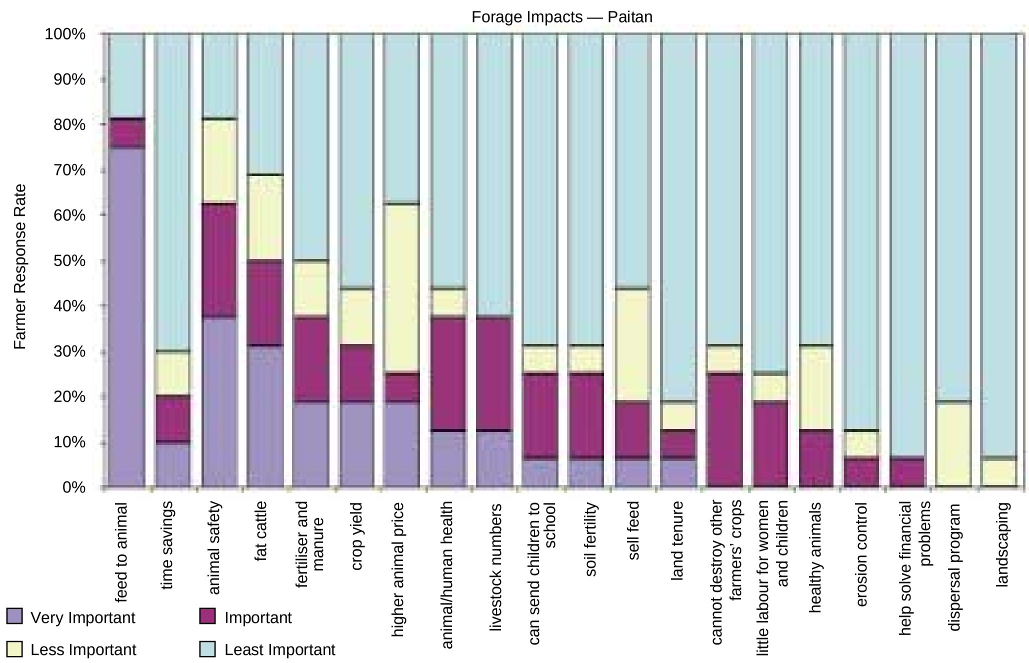

Figure 5. *Ad hoc* ranking schemes — Sitio Paitan.

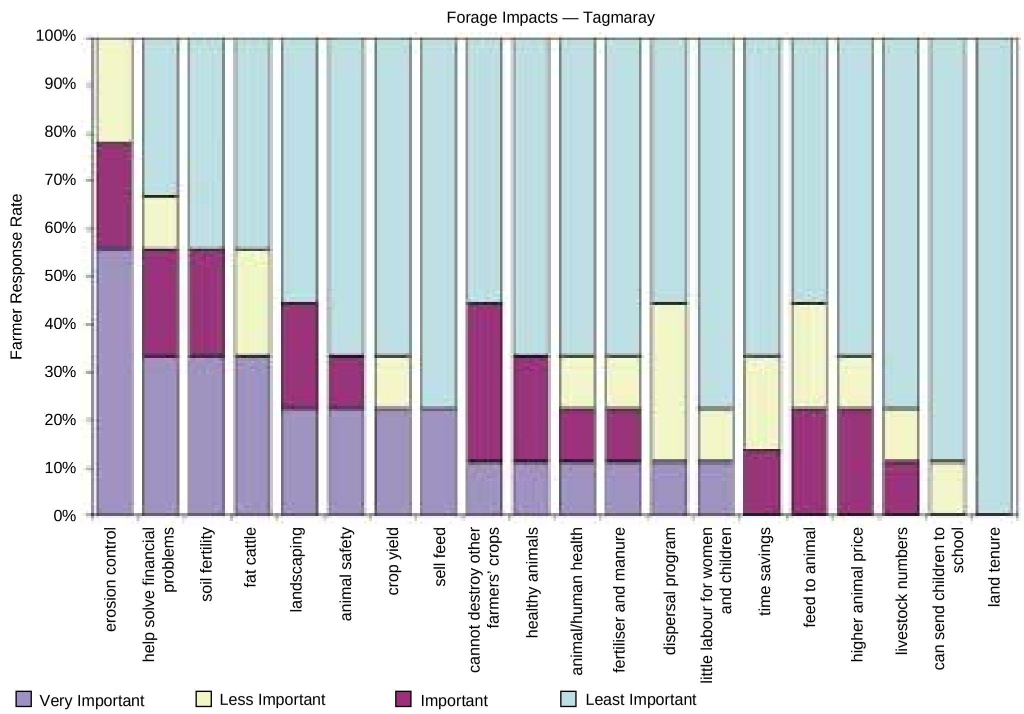

Figure 6. *Ad hoc* ranking schemes — Sitio Tagmaray.

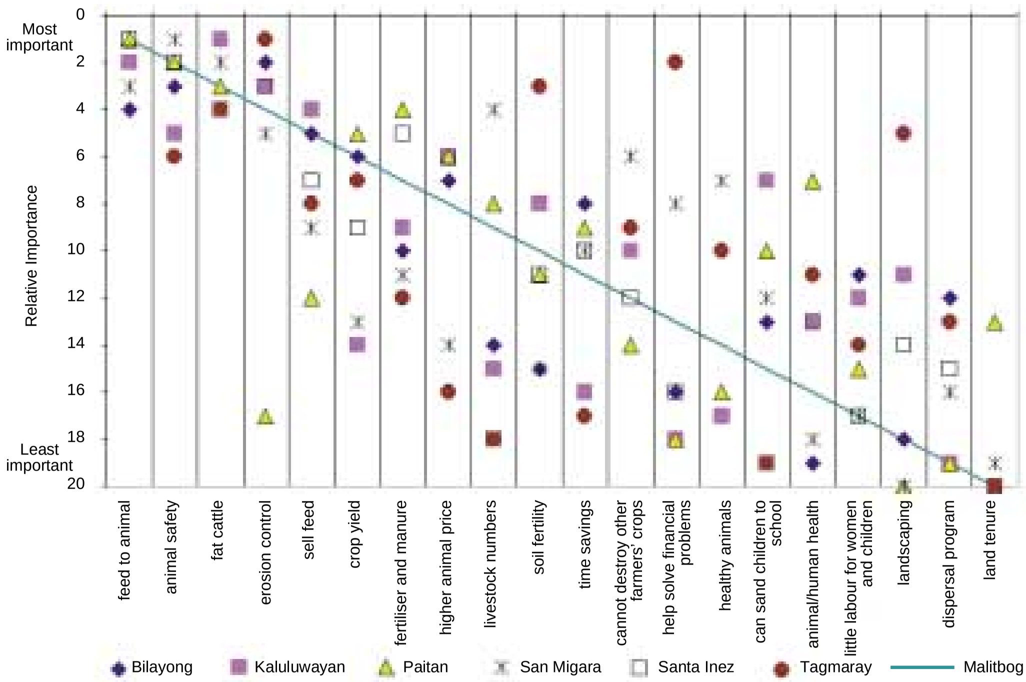

Figure 7. *Ad hoc* ranking scheme — relative rankings of each assessment site.

Regardless of the low R^2, the model results are still valid estimates of the differences between impact indicators in the absence of additional information about individual workshop participants. Multiple range tests were conducted to test for response differences between impact indicators. Fisher's least-significant-difference (LSD) test and the Ryan-Einot-Gabriel-Welsch multiple-range test (REGW) were calculated[2] and the results presented in Table 2.

The multiple range tests give additional information about the significant differences between indicators and suggest that, like the ad hoc ranking scheme results, the ability of forages to provide feed, safety and increased liveweight gain are more important impacts than the other indicators that were suggested. Unlike the ad hoc ranking scheme, the statistical results have the advantage that they are not biased in their ranking of indicators by the allocation of lower 'Very Important' scored but higher 'Important' scored indicators to lower rankings.

The statistical results confirm the ad hoc ranking scheme presented in the bar-charts in that the ranking of impact indicators is qualitatively the same (See Figure 8). There are some minor differences in ranking but these do not appear to be statistically different given the associated increase in variance for indicators of impact scored 'Important'. For most of the indicators of impact the difference between the statistical and the ad hoc ranking schemes was only ± 3 ranks and even the biggest outlier (a difference of 10 rankings for the 'Healthy Animals' indicator of impact for Sitio Kaluluwayan) was within the statistical limits of the multiple range tests. A χ^2 test of independence was carried out and indicated that there was no statistical difference between the ad hoc and the statistical ranking schemes overall.

The multiple range tests also confirm the perception given in the bar-charts of impact indicator rankings that, while the first and last few ranked indicators were statistically different from the rest, there was no statistical difference between the middle ranked indicators. This lack of statistical difference can be attributed to, firstly, the possibility that workshop participants found it difficult to distinguish between indicators that may have held little intrinsic difference. Secondly, the lack of information about the individual participants in the workshops (which led to a low R^2 in the first place) means that variances around the individual estimates are very large, and thus the t-tests of differences between means will reject the null hypothesis of no difference less often.

[2]Fisher's LSD test controls the Type I comparisonwise error rate whereas the Ryan-Einot-Gabriel-Welsch test controls the Type I experimentwise error rate.

Table 2. Analysis of importance of impacts of forages in smallholder farming systems.

Impact indicator	Mean importance (1=Important, 10=Least Important, >11= Not Important)	REGW Multiple Range test (p>0.05)				Fisher's LSD test (p>0.05)			
Provides feed for livestock	5.79	X				X			
Animal safety (theft, accident)	6.15	X				X	X		
Fattens livestock	6.68	X		X			X		
Soil erosion control	7.64		X	X		X			
Provides manure and fertiliser	8.12	X	X			X	X		
Increased livestock price	8.33	X	X			X	X	X	
Cut&carry prevents straying	8.67	X	X	X			X	X	X
Sell feed	8.69	X	X	X			X	X	X
Livestock numbers	8.85	X	X	X		X	X	X	X
Soil fertility	8.97	X	X	X	X	X	X	X	X
Time savings	8.97	X	X	X	X	X	X	X	X
Help with finances	9.09	X	X	X	X	X		X	X
Crop yield	9.11	X	X	X	X	X		X	X
Healthy animals	9.12	X	X	X	X	X	X	X	X
Education and tuition fees	9.29	X		X	X	X	X		X
Labour reduction for women and children	9.37	X		X	X	X	X		X
Livestock dispersal program	9.62	X		X	X	X	X	X	
Animal/human health	9.63	X		X	X	X	X	X	
Landscaping	9.99			X	X		X	X	
Land tenure	10.42				X			X	

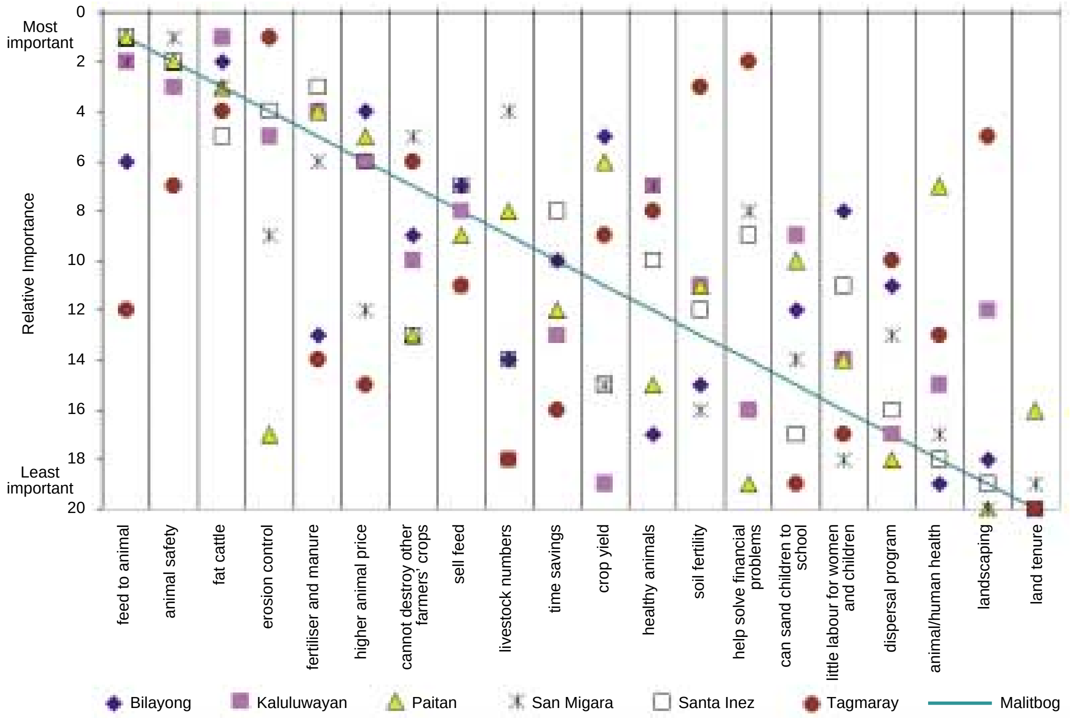

Figure 8. Statistical ranking — relative rankings of each assessment.

Given the results of the ad hoc ranking in the bar-charts, which suggest that there are differences between sites, there is the question of how the results of the statistical analysis (which shows no significant differences between sites) can be reconciled with the results of the ad-hoc ranking scheme.

The number of participants in each of the workshops weights the statistical results, thus differences in rankings in sites with smaller number of participants are diluted by sites with a larger number of participants. This has important implications for policy decisions in reconciling a macro view of rural development with the minutiae of individuals' development in a smallholder farming system. A more detailed dataset, with information on individuals' responses, and their associated demographics, may go part way to identifying critical factors determining how agricultural technologies impact on smallholder farming systems.

Conclusions

Introducing a new agricultural technology into a smallholder farming system can be problematic when trying to reconcile competing interests of the various stakeholder groups. One of the fundamental questions that has to be answered is whether the new technology being introduced has an impact on the farming system and which stakeholder groups benefit (or lose) from that impact. Participatory methodologies applied to impact assessment enable stakeholders to identify, elucidate and rank indicators of potential impact according to their perceived importance by those stakeholder groups.

Not only is it important to have a participatory approach to impact assessment in eliciting the views of all stakeholder groups but it is important to be able to include stakeholder groups in any subsequent analysis of impact. Simple in-field and statistical analysis highlight important impacts and their relationships to each other. Comparing the two approaches, statistical analysis confirms in-field results and indicates that field technicians can apply in-field analysis with confidence.

The results indicate that smallholder farmers are aware of potential benefits of forage technologies to livestock (fattening, feed availability, higher prices) as well as benefits to crops and the environment (fertilizer and manure, soil fertility and reducing erosion). The results also highlight the importance of an inclusive approach to rural development in that the smallholder stakeholders identified benefits not foreseen by scientists and other stakeholder groups (animal safety due to tethering closer to home with a cut-and-carry system, and a reduction in crop damage and associated social tensions).

For Malitbog as a whole the indicators of impact which were perceived to be most important were the ability of forages to provide feed for livestock fattening, and the safety of livestock. In addition, soil erosion control, fertilizer and manure collection, and a higher livestock price were seen as important attributes and outcomes of new forage technologies. The analysis indicates that important impact indicators vary by site; for example, erosion control may not be important for flat areas but is important for steep ones. The analysis also indicates that individual sites and individual farmers have their own characteristics, needs and expectations, and that it is important to get views of all stakeholders.

In conclusion, forage technologies have the potential to have significant positive impacts on farming systems provided that they are tailored to individual requirements. In general, cut and carry species may have greater appeal to farmers from Malitbog since they complement rather than substitute existing pasture and they enable the tethering of livestock closer to home with a concomitant increase in animal safety.

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Monitoring Forage Technology Development – The Adoption Tree

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THE Forages for Smallholders Project (FSP) followed a process of developing forage technologies with smallholder farmers that was based on the principle: 'start small, encourage farmers to innovate and then expand'. During the early stages of this process, when there were only a few farmers testing forages, it was easy to monitor forage development simply by maintaining contact with every farmer (see Figure 1). Very quickly, however, the process became complicated. Each year, new farmers began to evaluate forages for the first time and each year others expanded, maintained or abandoned areas of forages (Figure 2).

This process was made even more complex by the immense diversity that exists between individual households within upland communities, let alone between communities. The opportunities for forages varied greatly between individual households. In the example shown in Figure 2, some farmers planted very large forage areas in the first year and did not need to expand after that. In other cases, they expanded, but only planting small areas each year. Some farmers planted and maintained many forage varieties for different uses, whereas others quickly selected two or three preferred varieties.

Some farmers experimented with new ways of growing the forages and others discovered new uses for forages that they had not initially imagined. The FSP needed to be able not only to monitor these changes but also to try to understand why they were happening and what impacts they were having on farmers' livelihoods.

Simply recording the total numbers of farmers evaluating forages can be very deceiving. The example in Table 1 shows the changes in the total number of farmers working with the FSP in slash-and-burn farming systems. These numbers apparently show an expansion, but it is essential to know how many of the farmers in each year are new farmers and how many dropped out. If the majority of farmers starting to evaluate forages each year were dropping out and being replaced by new farmers, the prospects for forage development would be poor. In this case, 49% of the farmers in 1997 dropped out but only 19% dropped out in 1998. This did not tell us, however, whether any of the farmers whyo were continuing to evaluate forages were planting significant areas. Just measuring the average areas of forage planted, however, can be equally misleading. Often, the variation between farmers was enormous and it was common for a site to have a few farmers growing very large areas while the majority grew forages in small plots.

Table 1. Number of farmers evaluating forages in slash-and-burn farming systems.

Year	Numbers of farmers evaluating forages	Percent of farmers continuing to the next year
1997	83	51%
1998	169	81%
1999	395	–

To be able to offer advice for expanding locally successful forage technologies to new areas, we need a much better understanding of the process of forage technology development, adaptation and adoption in the field so we could answer questions such as:

- what problems was each farmer trying to solve with forages?

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Figure 1. Monitoring forage development in Indonesia by maintaining contact with farmers.

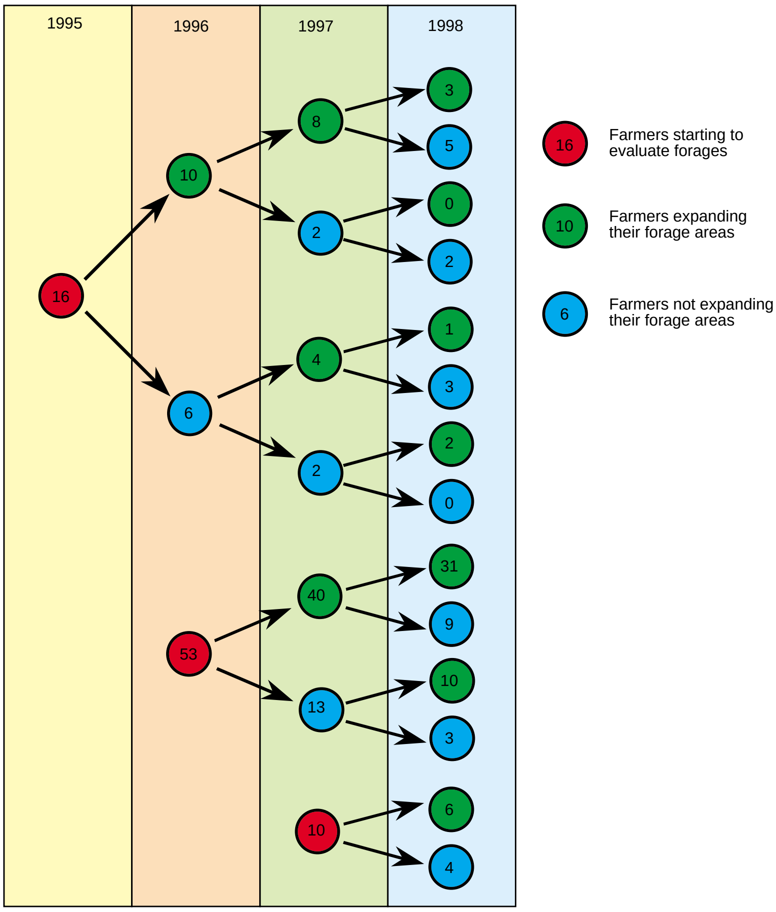

Figure 2. Number of farmers starting to evaluate forages, expanding their areas of forage or maintaining their areas, at Sepaku, East Kalimantan, Indonesia in each of 1995, 1996, 1997 and 1998.

- which forage varieties did each farmer prefer and why?
- which ways of growing and using forages were proving successful and why?
- which farmers were gaining the most benefits from forages and what were these benefits?
- why did some farmers abandon or not expand their forage plots?
- will new farmers more-rapidly adopt integrated forage systems once other farmers in the same area have been using these systems for some time?

What is the 'Adoption Tree'

The 'Adoption Tree' is a survey tool that was developed by the FSP to monitor the changes that occur in forage development for each individual farmer every year. A separate evaluation tool for evaluating farmers' perceptions of forage varieties (participatory evaluation) was often conducted at the same time (for details see Tuhuele et al. 2000). The 'Adoption Tree' is a mixture of survey questions and interactive evaluation tools that gave us information on:

1. Farmers' livelihood activities and forage development:
   - farmers' perceptions on the current and potential future impact of forages;
   - their livelihood (e.g. family members, people working on the farm);
   - their livelihood (e.g. agricultural income, off-farm income, and own consumption);
   - their crop and livestock systems (e.g. farm size, cropping system, livestock types, numbers and purpose, access to grazing land);
   - how important livestock are to them and their major problems with raising livestock;
   - which forages they are developing and how they are being integrated on farms (e.g. varieties, areas, forage system, and utilisation).
2. Impact of forage technologies:
   - farmers' perceptions on the current and potential future impact of forages;
   - how forages are spreading to new farmers in each location;
   - how farmers would like to develop their forage systems (helping the development worker decide what information and planting materials might be required).

The time needed for conducting the 'Adoption Tree' varied from 15 minutes to 1.5 hours depending on the complexity of the farming system and the experience of the recorder. In 1999, the 'Adoption Tree' was conducted with more than 800 farmers at 13 sites in four countries (Table 2).

Table 2. Implementation of the Adoption Tree in 1999.

Systems	Countries	Number of sites	Farmers
Grasslands	Indonesia, Vietnam	2	109
Slash-and-burn	Laos	3	178
Mixed upland cropping	Philippines, Indonesia, Vietnam	6	265
Extensive upland cropping	Indonesia	2	307

The 'Adoption Tree' will be repeated annually (with a sub-sample of farmers representing different wealth, gender and ethnic groups, where necessary) to follow the changes in forage technology development and farmers' perceptions of technologies and impacts.

Conventional economic impact assessment is normally based on collecting detailed economic and farm production data for partial farm budget analysis and other economic indicators. This requires substantial time, highly-skilled staff and is sensitive to the huge variability in basic economic variables that characterise upland farming systems. A separate study has been conducted in collaboration with the FSP to assess alternative approaches to measuring impact on smallholder farms, with the goal of producing a framework for impact assessment that can be implemented by development workers (Purcell et al. 2000).

Understanding the Process of Forage Technology Development

The 'Adoption Tree' has helped us better understand the process of forage development in different farming systems and countries. Apart from monitoring technology development, it has helped quantify the 'intermediate outcomes' (such as adoption and spread of the technologies) that lead towards impacts.

Often these impacts (such as improved household income) are not easy to measure or attribute to particular technological improvements. This is especially the case in smallholder livestock systems where one of the main reasons for keeping livestock is to provide livelihood security. Other impacts are easier to measure, such as where farmers develop forage technologies to reduce the amount of time they spend each day cutting grass for their penned animals.

The results of the 'Adoption Tree' are not presented here, as they have been the basis of many of the papers reporting the experiences of the FSP in these Proceedings (e.g. Nacalaban et al. 2000; Ibrahim et al. 2000). However, several common lessons emerged from the data, across all farming systems and countries. Two of the most important lessons are:

- Regardless of their farming system, almost all farmers started by evaluating forage varieties in small plots. They wanted answers to questions like 'how well do these plants grow in the dry season?', 'how easy are they to manage?' and 'will my animals eat them?'. Only when they were confident with the varieties did farmers experiment with different ways of integrating them on their farms. This may explain why attempts to 'photocopy' technologies from one location to another (for example, hedgerows of tree legumes for erosion control in sloping lands) often fail. That is, the technologies cannot be separated from the process of active farmers' involvement in education, adaptation and adoption.
- Although forages can provide some substantial benefits for natural resource management (e.g. improving soil fertility, controlling erosion and controlling weeds), livestock feeding is normally the entry point for forages into farming systems. The most successful forage developments have occurred at sites where livestock are important to household livelihoods and where feed resources are severely limited.

Some Lessons Learned . . .

The 'Adoption Tree' is being modified from many lessons learned during the first year of field implementation. These include:

- The same people should be involved in field recording, data entry and analysis. Separating these tasks resulted in difficulties in interpreting field recording forms and a feeling among the recorders that data collection was 'just another job' in a process they did not own and which did not provide them any benefits.
- Hands-on training of field recorders is critical to ensure that information collected clearly addresses the question and is an accurate record of farmers' comments. Difficulties often arose from different concepts of what 'accuracy' is required in the answers to the questions. Some field recorders found it difficult to judge the amount of information needed to adequately answer the questions. Active involvement of field recorders in data encoding, inputting and analysis can overcome these problems.
- Different stakeholders (e.g. farmers, extension workers, donors, local government) have different needs for information arising from the project. While some stakeholders are interested mainly in 'intermediate outcomes', others need a clear understanding of the process of technology development and others may not have a need for recording at all. Finding a compromise to address all needs adequately is important in ensuring a feeling of ownership of the results and the process by all stakeholders. Alternatively, different monitoring tools may need to be developed for different needs.
- Monitoring all farmers at the same level of detail was both impossible and unnecessary. In future, all farmers will be monitored at a very basic level and some (based on stratifying farmers according to wealth, gender and ethnic group) will be monitored in more detail.
- Farmers responded very well to active evaluation needs, especially those based on weighting techniques. With weighting, farmers allocate a number of counters to answers which then give not only a ranking but also their relative importance. Farmers had little difficulty in allocating counters in quite complex matrices.
- Qualitative responses from farmers are valuable but must be categorised for entry into the database to be useful.

References

Ibrahim, Truong Tan Khanh and Heriyanto. 2000. Forage technologies for smallholders in grassland areas. In: Stür, W.W., Horne, P.M. Hacker, J.B. and Kerridge, P.C. ed. Working with Smallholders: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Nacalaban, W., Le Van An, Asis, P., Moneva, L. and Balbarino, E. 2000. How do forages fit into smallholder farms in mixed upland cropping systems? In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Smallholders: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Purcell, T., Nacalaban, W., Gabunada, F. Jr. and Cramb, R. 2000. Assessing the impact of agricultural technologies in smallholder farming systems – results from a participatory monitoring and evaluation study on forages in Malitbog, northern Mindanao, Philippines. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Smallholders: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Tuhuele, M., Le Van An, Phengsavanh, P., Ibrahim, Nacalaban, W., Vu Thi Hai Yen, Truong Tan Khanh, Tugiman, Heriyanto, Asis, P., Hutasoit, R., Phimmasan, H., Sukan, Ibrahim, T., Bui Xuan An, Magboo, E. and Horne, P.M. 2000. Working with farmers to develop forage technologies – field experiences from the FSP. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Smallholders: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.

Future Directions

Presentations at this meeting clearly demonstrated that improved forage technologies can contribute significantly to improving smallholder farming systems by increasing animal production, reducing labour requirements for feeding ruminants and reducing soil erosion in sloping agricultural lands. The participatory approach to technology development has been embraced enthusiastically by development workers involved in the FSP and resulted in adoption of forage technologies by poor upland farmers. Involving farmers in technology development is clearly one way forward in helping them to improve their livelihoods and contribute to better management of the natural resources in these areas.

To sustain and accelerate the progress made with participatory approaches, support is needed on several fronts. There are two groups of people who require further nurturing:

- farmers who are still in early stages of developing well-integrated forage technologies into their farming systems; and
- research and extension workers who are adopting participatory approaches in their work but do not have the full support of their organisations which often still follow a conventional supply-driven approach.

We also need to develop practical methodologies for:

- participatory monitoring and impact assessment to provide continuous feedback to researchers and development workers, and
- participatory approaches to scaling-up. There is a danger that extension services and development projects take technologies developed using participatory approaches and try to 'extend' these technologies to other farmers in a conventional supply-driven process. This is doomed to fail as technologies need to be adapted to suit local needs and conditions, and new participatory approaches to extension are needed to scale-up local successes.

These are some of the challenges lying ahead and we invite readers to join the search for lasting solutions to these problems. Two projects have recently been approved to address some of these challenges. The Asian Development Bank (ADB) is funding a 3-year Southeast Asia regional project 'Developing Sustainable Forage Technologies for Resource-Poor Upland Farmers in Asia' which builds on the outcomes of the Forages for Smallholders Project, and AusAID is funding a 5-year bilateral development project, the 'Forages and Livestock Systems Project', with the Lao PDR.

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