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Assessment of Twenty-five ACIAR-supported Projects in the Department of Agriculture of the Philippines

M.C. Mangabat, N.T. Yanson, E. Sanguyo, A. Natividad, N.D.M. Carambas, M.A. Ilagan, E. Esplana, M. Rondon, J. Lantican, N.M. de Leon and E.V. Tepora

Australian Centre for International Agricultural Research

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An Assessment of ACIAR-supported Policy Research in Philippine Agriculture (EFS/1988/038, ANRE1/1989/003, ANRE1/1990/039)

M.C. Mangabat, N.T. Yanson and E. Tepora

Summary

While ACIAR has invested heavily in scientific biological research in agriculture, interest has evolved in other areas of discipline such as in agricultural policy. In the Philippines, in the period 1989–1995, ACIAR funded three research projects dealing on policies in the agriculture sector which were implemented by the Policy and Analysis Division of the Department of Agriculture. Two of these are commodity-specific policy research and one on general equilibrium policy modeling.

EFS/1988/038, entitled 'Technological change in agriculture income distribution and economic policy in the Philippines', developed a general equilibrium model for the agriculture sector known as Agricultural Policy Experiments or APEX. ANRE1/1989/003, entitled 'Economic policies for the Philippine sugar industry', was focused on the development of a partial equilibrium model for sugar supply and demand. ANRE1/1990/039, entitled 'Government policies in the Philippine beef industry', examined the current operational procedures and import policies in the local beef industry and evaluated the economic effects of these policies.

The APEX model is an important tool for policy analysis. Its utilisation and sustainability in the Department of Agriculture's policy and planning is constrained by the lack of trained staff on the computable general equilibrium (CGE) models especially those with academic background. Project staff who were trained with the model have transferred to other employment. CGE modelers in academe have, however, made use of the model. The analytical framework developed for the Philippine sugar industry, on the other hand, has been found to be useful. It provides policy alternatives given the varying environments in the domestic and world sugar markets. ANRE1/1990/039 provided information on the effects of removing the distortions in the domestic beef industry under agricultural trade liberalisation of the Uruguay Round of the GATT–WTO. A more open market policy for the domestic cattle and beef industry resulted in increased imports from Australia.

1 EFS/1988/038: Technical Change in Agriculture Income Distribution and Economic Policy in the Philippines

1.1 Objectives

The project was aimed at constructing a computable general equilibrium (CGE) model that captures the economic relations between the Philippines' agricultural sector and the rest of the economy. Specifically, the model is designed to be capable of analysing the effects on the economy of:

- technical change in agriculture;
- selected domestic economic policy changes (such as changes in manufacturing protection, a change in exchange rate); and
- other exogenous changes (such as changes in international market conditions).

1.2 Project Outputs

The first CGE model of the Philippine economy of the type where percentage changes in equilibrium values of economic variables are solved using linear algebra was developed. This is known as the

Agricultural Policy Experiments or APEX. In the existing full-blown CGE models of the Philippine economy, actual equilibrium levels of economic variables are calculated using an appropriate numerical algorithm for solving non-linear equation systems. Linear models such as APEX have several advantages. They can incorporate much more structured complexity than non-linear models can handle, and they are much more flexible and user friendly.

The APEX model is a valuable tool for policy researchers. The completion of econometric studies to obtain production, consumption and trade price elasticities, as well as the compilation of the data base which was integrated into the effort to build the APEX model, also provide valuable information for academic economists and policy researchers in the Philippines. For the Philippine economy, there is large potential of APEX in influencing policy makers to adopt policy changes which add to economic growth and living standards. For Australia, economic growth in the Philippines implies greater trade opportunities. Through the APEX model, Australia's understanding of how the Philippine economy operates is greatly enhanced. This knowledge could be incorporated into the Australian Government's large regional trading models of Asian, Europe and North American economies.

Under the project, several papers were produced. The first ten papers were presented at the public workshop on APEX held on 14 August 1992. The rest of the papers are working papers presented in various technical workshops held during the course of the project. In addition, a brochure which describes the APEX in non-technical language was produced and disseminated during the third year of the project.

a The Theoretical Structure of the APEX Model of the Philippine Economy by Ramon L. Clarete and Peter G. Warr.

b The General Equilibrium Data Set of the Philippine Agricultural Policy Experiments (APEX) Model by Ramon L. Clarete and Marie Angelique C. Cruz.

c Agricultural Production Parameters Estimates for the APEX General Equilibrium Model for the Philippine Economy by Peter G. Warr.

d Non-Agricultural Production Parameters Estimates for the APEX General Equilibrium Model of the Philippine Economy by Ma. Nimfa F. Mendoza and Peter G. Warr.

e Parameter Estimates of Consumer Demand systems in the Philippines by Arsenio M. Balisacan.

f Estimation of Armington Elasticities for the APEX Computable General Equilibrium Model of the Philippine Economy by Cesar A. Kapuscinki and Peter G. Warr.

g APEX Parameter Files and Closure for Policy Experiments by Peter G. Warr.

h Technical Progress, Income Distribution and Economic Policy in the Philippines by Peter G. Warr and Ian A. Coxhead.

i Equity and Self-sufficiency Effects of Rice Price Support and Fertilizer Subsidy in the Philippines: An APEX CGE Analysis by V. Bruce J. Tolentino and Arsenio M. Balisacan.

j Options for Tariff Protection Policy in the Philippines by Ramon L. Clarete and Beulah C. Dela Peña.

k Environment-specific Rates of Technical Change: A General Equilibrium Analysis for Philippine Agriculture by Ian A. Coxhead and Peter G. Warr.

l Poverty and Welfare Effects of Technical Change: A General Equilibrium Analysis for Philippine Agriculture by Ian A. Coxhead and Peter G. Warr.

m Technical Change, Land Quality and Income Distribution: A General Equilibrium Analysis by Ian A. Coxhead and Peter G. Warr.

n Kaunti: Structural Equations by Hom M. Pant and Peter G. Warr.

o The Linking Matrix by Ramon L. Clarete.

1.3 Institutionalisation and Use of Project Output

To lay the groundwork for institutionalising the use of the APEX, a one-week training program on CGE modeling was conducted for staff of the Department of Agriculture (DA), National Economic and Development Authority (NEDA), and the Department of Finance (DOF) of the Philippines. This training workshop was sponsored by the Food and Agriculture Organization under the Philippine Structural Adjustment Project (project EFS/1988/038 Terminal Report, undated).

A one-day training workshop on running the APEX model on Macintosh computers was conducted for DA and University of the Philippines School of Economics staff. Two staff members of the DA also attended the 1992 ORANI Training Course conducted by the Australian Industry Commission in Canberra.

Three experiments using the APEX to analyse policy issues in agricultural subsidies, technical change and tariff protection were executed. The experiments demonstrated the potential uses of APEX in policy formulation.

The experiment on technical progress concludes that technical progress in the Philippines over the period 1960 to 1984 raised real national income at the estimated average annual rate of 0.8%. Real disposable incomes of all quintile groups increased, but the poorest group benefited proportionately the most. This happens because the general lowering of food prices which technical change brings has a bigger impact on the poor for whom food constitutes a bigger share of expenditures. Technical change thus reduced income inequality in the Philippines.

These results justify increased investments in agricultural research and rural infrastructure.

The results of the experiment on fertiliser subsidies indicate that fertiliser subsidies could indeed increase agricultural production but could also be regressive—reducing the real income of the poor and increasing the real incomes of the higher income groups. This occurs because fertiliser use is highly correlated with good quality (irrigated) land as well as farm size and, therefore, fertiliser subsidies disproportionately benefit the better-off farmers. Real wages of unskilled labour also fall, thereby accentuating the bias of the subsidy against the poorest households. The APEX analysis thus cautions policy makers about the income distribution costs and other inter-sectoral effects of such fertiliser subsidy programs.

The experiment on tariff policy strengthens the arguments for lowering tariffs in the Philippines. The analyses of four options for lowering tariffs indicate that all scenarios offer positive benefits for the country in terms of volume of trade, government revenues, aggregate incomes and consumption. However, the APEX shows that lowering tariffs in such a way as to create equal effective protection rates across industries is the best option.

Overall, the APEX model is a vital tool for policy analysis. At the DA this model is not currently used by the policy and planning staff due to several constraints. First, the model was developed using a Macintosh computer system and the updated version using other computer systems was not installed at the DA.

Second, the personnel turnover rate at the DA is large due to outside higher paying job opportunities. The trained DA technical staff members have moved to a private consulting firm. While there is an interest in using the model at the DA, this requires technical staff trained in CGE modeling and the DA is lacking in this aspect. Refinements to the APEX model which may be required are costly. However, the technology on how to manipulate the model was adopted by CGE modelers in academe.

2 ANRE1/1989/003: Economic Policies for the Philippine Sugar Industry

2.1 Background/Rationale

Sugar is one of the traditional export crops in the Philippines. This commodity has been a major source of exports and foreign exchange earnings for the country, although its contribution has now been declining relative to the other major agricultural commodities. Until 1985, sugar was the second highest foreign exchange earner in the agriculture sector, but it dropped within the range of 5th and 10th annual ranking between 1986 and 1997 period (Mangabat 1998). The declining contribution of sugar to export earnings is partly attributed to inefficiencies in the sugar industry resulting from inappropriate policies which resulted in falling production. Despite production setbacks, it appears that the Philippines has the potential to improve its performance through coherent policies, notwithstanding favourable agronomic conditions.

As sugar exporters, Australia and the Philippines are competitors in the world market for sugar although both countries are price takers. While Australia has the advantage as one of the world's most efficient and largest sugar exporters, both countries face the same problems that could arise from developments in the world sugar trade. Thus, both would benefit from an economic study of the industry with focus on the Philippine sugar industry. Through ACIAR support, a collaborative study on the Philippine sugar industry was undertaken between the Centre for International Economics (CIE) in Canberra, Australia and the

Philippine Department of Agriculture (DA). In the Philippines, in addition to the DA, such study would be in the interests of other government agencies such as the Sugar Regulatory Administration (SRA), an attached DA agency, the Congress, the private sector such as the Philippine Sugar Association and Confederation of Sugar Producers Association, and academia.

2.2 Objectives

The primary aim was to develop a coherent sugar industry policy, so that the industry would contribute fully to the Philippine economy. A secondary aim was related to technology transfer where, in the course of the collaborative effort, Philippine researchers would be equipped with certain analytical tools and approaches while providing challenges to Australian researchers on the problems of a developing country. In detail, the project aimed to:

1. identify the important effects of policies on supply and demand for sugar;
2. build up an understanding of the economic structure of the sugar industry;
3. develop a quantitative model of supply, demand and policy; production; consumption, trade and economic welfare;
4. carefully evaluate developments in the world market and their implications for the Philippines; and
5. prepare a well reasoned public report, based on the analysis above, setting out the best policy option to be pursued.

2.3 Linkages to Other ACIAR Projects

ANRE1/1989/003 is linked to two other policy related ACIAR-supported projects in the Philippines. One of these is ANRE1/1991/009, a study on the 'World Market for Coconut Products: An Economic Analysis from the Perspective of the Philippines'. ANRE1/1989/003 provided analytical methodologies for an export commodity. The other ACIAR related project is EFS/1988/038 which developed the APEX computable general equilibrium model. ANRE1/1989/003 provided inputs to the testing and application of the model specifically in the sugar component of the APEX model.

2.4 Project Outputs

A comprehensive model for sugar supply to be interfaced with a model of sugar demand was developed in the context of partial equilibrium. This was contained in the main output of the project, a monograph entitled 'Philippine Sugar—An Industry Finding Its Feet' which was published by the CIE.

Several types of vital information that can be generated from the project include modeling in policy research, specifically in providing skills in using econometric models, and in the use of input–output framework structure and simultaneous equations. The project also presented policy alternatives under different changes in both domestic and world sugar policy environments.

2.5 Project Impact

The analytical framework for the sugar industry proved to be useful in dealing with situations that require the use of policies as, for example, during the Philippine sugar crisis in 1998 (De la Pena, PATAAS Project, Department of Agriculture, Quezon City, Philippines, pers. comm., 1998).

3 ANRE1/1990/039: Government Policies in the Philippines' Beef Industry

3.1 Background/Rationale

The circumstances that led to the undertaking of ANRE1/1990/039 are described in the following sections. Since this project is already completed, the supporting statistical tables are updated to 1999.

Table 1. Livestock contribution to the farm value of agricultural production

Year	Value of total agriculture (US$'000)	Cattle	Swine	Chicken
		% share		
1987	8,740	1.8	8.1	6.8
1988	9,817	1.9	8.0	8.0
1989	11,085	1.6	10.5	6.0
1990	11,234	1.7	11.1	7.3
1991	11,135	1.7	11.8	8.
1992	13,173	1.8	12.1	10.2
1993	12,896	2.2	11.7	9.8
1994	15,135	2.2	12.0	9.8
1995	16,689	2.0	12.4	8.4
1996	18,092	2.1	13.0	8.4
1997	17,412	2.2	12.9	9.1
1998	20,798	2.2	13.4	9.8
1999	21,789	2.0	13.4	8.6

Source: Bureau of Agricultural Statistics, Department of Agriculture.

Compared with other livestock such as chicken and swine, the contribution of cattle to total farm value of production is small, with minimal increase from less than 2% in 1987 to slightly more than 2% at the beginning of 1993 (Table 1).

Partly due to constraints of suitable land for grazing, cattle raising in the Philippines is largely backyard (less than 20 head). Commercial operation is small and decreasing, from a 23% share of the total cattle population in 1980, to below 20% in 1984 and less than 10% from 1992 (Table 2). The downward trend in large scale operations such as ranching and large feedlots can be attributed to several factors such as law and order problems, marketing problems, the Comprehensive Agrarian Land Conversion, and high investment costs and inputs (Pempengco 1997). Also, policy changes in agriculture discouraged investment in the beef industry which contributed to the closure of many commercial farms and thus reduction of the cattle inventory in large operations.

Table 2. Cattle population, the Philippines, 1980–1999

Year	Cattle population, 1 January ('000 head)		
	Total	Backyard	Commercial
1980	1,912	1,473	438
1981	1,940	1,477	463
1982	1,942	1,477	465
1983	1,937	1,507	431
1984	1,849	1,512	337
1985	1,789	1,493	294
1986	1,814	1,504	310
1987	1,747	1,496	251
1988	1,700	1,489	211
1989	1,682	1,503	179
1990	1,630	1,441	189
1991	1,677	1,485	192
1992	1,731	1,577	153
1993	1,915	1,755	160
1994	1,936	1,769	167
1995	2,021	1,835	186
1996	2,128	1,929	199
1997	2,266	2,056	210
1998	2,377	2,168	209
1999	2,437	2,242	195

Source: Bureau of Agricultural Statistics, Department of Agriculture.

Beginning in 1993, however, there was a sudden increase in cattle stock, then a continuous rise at an annual rate of 2.87% from 1993 to 1999. This situation can be explained by the trade reforms in the country. From a restrictive trade policy dominated by import and exchange controls, unilateral trade reforms were seriously considered in the 1980s. A Tariff Reform Program (TRP) and an Import Liberalization Program (ILP) were pursued which continued into the early 1990s. Between 1990–1993, most food commodities were subjected to lower tariffs. This included live animal imports, in particular cattle for breeding and fattening. In the 1992–1994 period before the GATT–UR agreement, heavy imports of live cattle for fattening and breeding had already started (Table 3).

Table 3. Live cattle imports (no. of head), the Philippines, 1990–1999

Year	Total	Breeder	Fattener
1990	23,022	1,709	21,313
1991	15,773	3,099	12,674
1992	49,237	15,875	33,362
1993	82,130	7,458	74,672
1994	115,916	6,430	109,486
1995	168,679	6,299	162,470
1996	167,235	2,645	164,790
1997	156,719	1,269	155,450
1998	186,835	704	186,131
1999	236,909	752	236,157

Source: Bureau of Animal Industry, Department of Agriculture.

In the early 1990s, while cattle inventory and hence beef production was declining, the demand for beef was increasing. This indicated good prospects for beef, as future incomes were foreseen to increase as the economy continued to develop. This situation raised several issues: source of additional supply; extent of government intervention in terms of policies designed to increase supply; and closed versus open economy with regards to the beef market. While government policies were already geared towards increasing the productive capacity of the domestic beef industry with the related objectives of creation of employment in the feedlot and processing sectors, increased farmer incomes, and more value adding in the domestic beef industry, there was still uncertainty whether the domestic beef industry was able to meet increasing domestic demand. Before the government could pursue alternative courses of action, it was deemed

necessary that existing regulations and operational procedures in the industry be examined.

It was in the environment described above that ACIAR ANRE1/1990/039 was conceptualised. The project was undertaken during the pre-GATT–WTO period 1992–1995, which was timely since the Philippines is a potential market for Australian beef given the prospects for a global open economy. Australia is one of the major trading partners of the Philippines in terms of cattle and beef.

The general objective of ANRE1/1990/039 was to resolve the issues on the international competitiveness of the Philippine beef industry and how it was influenced by different agricultural policies. Its specific objectives were as follows:

1. to describe the economic, institutional and social features of the Philippine beef industry;
2. to examine the current operational procedures and policy arrangements in the beef industry, focusing on those affecting imports of live cattle and beef;
3. to evaluate the economic effects of the policies described in objective (2); and
4. to propose alternative procedures and policies and to evaluate the economic effects of these which may be new or modified versions of existing policies with emphasis on import policies for beef and live cattle.

3.2 Research Outputs

The first and second objectives of ANRE1/1990/039 were accomplished through research on the existing literature on the Philippine beef industry and interviews with knowledgeable persons from both the government and private sectors. As a result, five discussion papers were written, such as those on the salient features of the Philippine agriculture sector; the dynamics and prospects of the domestic beef industry; and European country dumping, customs surveillance and the domestic beef industry. The third objective was addressed by preparing an ex-ante economic assessment of the potential benefits (i.e. annual discounted benefits) of an open market policy for the domestic beef industry.

3.3 Project Linkages and Impact

The livestock sector is one of the 49 sectors included in the general equilibrium model known as Agricultural Policy Experiments or APEX developed under ACIAR EFS/1988/038. According to a former DA staff member involved in ANRE1/1990/039, results of this project were later used in testing the livestock component of the APEX model. The work was also related to non-ACIAR policy projects at the DA such as the AAPP and APRAAP which were funded by the USAID. These projects also dealt mainly on trade liberalisation aspects in feedlot cattle as part of the opening up of Philippine agricultural trade under multilateral trading agreements such as the GATT–WTO. The studies on the productivity and competitiveness of the agriculture sector with respect to beef, and a review of the government programs and policies in relation to the performance of the domestic beef industry (ANRE1/1990/039) were part of the reference material for these projects, especially for those DA staff involved with the project. Similarly with ANRE1/1990/039, these USAID-funded projects were also implemented with the heavy involvement of the Planning and Analysis Division of the DA.

Overall, ANRE1/1990/039 provided information on the effects of removing the distortions in the beef industry in relation to liberalised agricultural trade under the Uruguay Round of the GATT–WTO that affect domestic cattle producers and beef consumers. This information also provided important inputs to policy makers and program implementors in the DA and its attached agencies involved in livestock development. The extent to which this information was used has been limited because it was not disseminated partly due to institutional constraints at the DA. Based on an interview of one of the key staff at the DA who had knowledge of the project, the collaborative undertaking between Australia and the Philippine Government under ANRE1/1990/039 provided many opportunities for the latter including training for policy analysis for two of the DA staff involved with the project. Moreover, it was averred that there was flexibility in decisions with regards to technical matters and funding (B. Tolentino, PATAAS Project, Department of Agriculture, Quezon City, Philippines, pers. comm., 1998). However, the sustainability of the project was not addressed after its termination. The dissemination of the results of the project was limited. Accordingly, there was only one workshop held attended by staff of the DA and its attached agencies. It was suggested that in future projects of this type, the dissemination of results should be incorporated to ensure the utility of the information generated.

As can be gleaned from the preceding Tables 1 to 3, the adoption of an open market policy in Philippine agriculture, in particular the domestic cattle and beef industries, resulted in continuous acceleration of imported beef products and cattle fatteners, but with a slackening of breeder imports. This may imply that, with the reduced breeding operations of commercial farms and feedlots, there has been a shift in focus to small and medium-sized operations rather than large-scale operations. The Philippines sources a significant portion of its beef requirements from Australia and the latter's share to total beef imports has increased significantly since 1993 (Table 4).

Table 4. Free-on-board (f.o.b.) value (US$'000) of meat bovine (beef) imports by source, the Philippines, 1988–1999.

Year	Total	Australia	% share	Other	% share
1988	7,485	700	9.4	6,785	90.6
1989	13,958	1,110	8.0	12,848	92.0
1990	16,880	1,173	6.9	15,707	93.1
1991	15,359	1,014	6.6	14,345	93.4
1992	20,715	1,910	9.2	18,805	90.8
1993	26,075	11,758	45.1	14,317	54.9
1994	46,998	10,535	22.4	36,463	77.6
1995	57,323	22,314	38.9	35,008	61.1
1996	75,845	28,532	37.6	47,313	62.4
1997	96,977	36,592	37.7	60,385	62.3
1998	64,789	26,288	40.6	38,501	59.4
1999	60,529	12,093	20.0	48,436	80.0

Source: Bureau of Agricultural Statistics based on data from the National Statistics Office.

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An Assessment of Research on Chicken Diseases in the Philippines (AS1/1987/017, AS2/1991/016)

N.T. Yanson, A. Natividad and M.C. Mangabat[1]

Summary

The Philippines is not isolated from the perennial outbreak of a highly virulent disease in chickens called Newcastle disease (NCD). From 1987–1991, ACIAR invested around A$400,000 under project AS1/1987/017 which was aimed at identifying and isolating a prevalent strain of virus suitable for vaccine production and adaptable to the climate of tropical countries like the Philippines. HRV_4 or V_4, a heat resistant vaccine orally administered by coating it onto feeds was developed in previous ACIAR supported research in Australia and Malaysia. The Philippine counterpart under AS1/1987/017 was focused mainly on efficacy trials conducted in one of the villages in the northern part of the country. Field trials proved that V_4 vaccine can provide protection, giving survival rates of 65–85% when applied correctly and at the right time.

While the efficacy trials proved successful, the reproduction and commercialisation of the vaccine in the Philippines was not pushed through primarily due to resource and bureaucratic constraints. Also, commercialisation was constrained by economies of scale since the vaccine can be made available at low prices only when produced in large quantities. In this case, developing countries can hardly cope without government support or subsidy. An ex-ante evaluation was conducted in light of the large potential benefits that could have accrued to the country because of a growing broiler industry. Using a discount rate of 8%, the net present value of the research is estimated at A$117.66 million over the period 2000–2015. One of the major bottlenecks in attaining this potential benefit is the lack of government advocacy in supporting private sector initiative to commercialise the vaccine.

A sequel to AS1/1987/017, AS2/1991/016 was undertaken in 1992 and aimed to isolate strains of bacteria for the fowl cholera vaccine. ACIAR provided about $52,000 to support bacterial strain isolation, vaccine reproduction and efficacy trials. The project has successfully isolated and identified the bacterial strains. The reproduction of the vaccine was, however, suspended, largely attributed to the persistent and long-term power outages experienced in the country at that time.

1 Introduction

In the Philippines, like most Southeast Asian countries, village chickens are an important component of smallholder livestock enterprise. It is the cheapest source of protein among animal meat.

As of 1 January 1999, the Bureau of Agricultural Statistics estimated a total 115.8 million chickens distributed as follows (Table 1): village chickens (57%), commercial broilers (35%), and commercial layers (8%). Of the total chicken meat output, broilers account for 80%; village chickens, 15%; and culled layers, 5%. Eggs from village chickens contribute between 50 and 60%, the rest are sourced from the commercial layers (Table 2). These figures suggest the resource potential of village chickens in the Philippines. Any factor that may affect their number or productivity, such as diseases, becomes a concern. One of these is Newcastle disease (NCD). Although the reported occurrence of this disease has not been so

1 Project Staff and Project Leader, respectively, Economic Evaluation of Non-UPLB ACIAR Supported Projects.

widespread as to cause alarm in the Philippines, research on this disease has been deemed important. As an offshoot of AS1/1987/017 another ACIAR project on chicken disease was developed: AS2/1991/016, 'Fowl Cholera. Vaccines for Asia'.

Table 1. Chicken population ('000 birds), Philippines, 1990–1999

Year	Chicken population, 1 January			
	Total	Broiler*	Layer*	Native and/ or imported
1990	81,303	26,565	9,814	45,924
1991	78,240	24,529	9,330	45,391
1992	81,525	27,356	7,406	46,763
1993	87,157	31,173	8,601	47,783
1994	93,109	34,771	8,342	49,996
1995	96,215	27,885	9,364	58,966
1996	115,782	39,312	10,796	65,675
1997	134,963	46,558	11,466	76,939
1998	138,521	46,386	13,170	78,965
1999	115,839	34,770	13,366	67,703

* Broilers and layers are by-products of purebred grand parent stock (GSP) or parent stock (PS).
Source: Bureau of Agricultural Statistics, Department of Agriculture, Philippines.

1.1 Objectives of the Present Paper

This paper is a project-level assessment of the impact of research in AS1/1987/017 on 'Newcastle disease in the Philippines' and AS2/1991/016 on 'fowl cholera. vaccines for Asia'. The assessment is focused on the adoption of technology arising from research, if any, barriers to adoption, other forms of research impact, and in the case of AS1/1987/017, a quantitative measurement of research benefits on NCD as an update of work done previously by the Centre for International Economics in July 1998.

2 AS1/1987/017, Control of Newcastle Disease in Village Chickens with Oral V_4 Vaccine

2.1 Overview

Newcastle disease is caused by a highly infectious paramyxovirus called V_4 which can cause great loss in the productivity of village poultry in Southeast Asia. The disease was first described in Indonesia by Kranveld in 1926 and the virus was isolated by Doyle in 1927 in the United Kingdom (Copland 1992). As early as 1983 ACIAR has embarked on research aimed at developing a vaccine that could provide protection from NCD in chickens particularly applicable to the village environment of developing countries in Asia and Africa. A heat-resistant vaccine called HRV_4 was developed from these research undertakings. The vaccine thrives in tropical climates. It is orally administered by coating it on chicken feed, which is very applicable and practical for the conditions under which village chickens are raised in developing countries.

In the 1980s and up to 1996, ACIAR NCD related research focused on the efficacy trials of HRV_4 vaccine in controlling the disease in village chickens in Southeast Asia (Copland 1992). The first test was conducted in Malaysia in association with Arthur Webster Pty Ltd, a vaccine-producing company, under the auspices of the first ACIAR NCD related research, AS1/1983/034. Another study was conducted by Bell et al. (1991), the results of which further confirmed previous findings and supported the role of V_4 vaccine as an effective control and eradication strategy for NCD cases. The Philippine counterpart of NCD research, AS1/1987/017 (1988–1992) was another ACIAR research project in recognition of the importance of village chicken in the economy of developing countries. This project was undertaken in collaboration with the other Asian countries of Malaysia, Thailand, Sri Lanka and Vietnam. The commercialisation process for HRV_4 vaccine, which did not push through in the Philippines, was constrained by economies of scale—it could only be made available at low price when purchased in large quantities. Many small raisers of village chicken were then unable to afford the vaccine. Such constraints led to the third ACIAR NCD Project AS1/1993/222 (1993–1996) which aimed to develop a new avirulent vaccine, I_2, which could be produced locally at very minimal cost. As at this writing, the I_2 vaccine would have been developed in Vietnam and trials were conducted in several African countries (CIE, July 1998).

Because of the successful efficacy trials of HRV_4 reported from other countries, NCD research effort was extended in the Philippines, focusing on field trials. Specifically, the project was aimed at conducting efficacy and pilot village trials with the aim of demonstrating that HRV_4 NCD vaccine confers protection against the indigenous velogenic strain of the NCD virus under Philippine conditions. The implementing agency was the Bureau of Animal Industry (BAI) of the Department of Agriculture (DA).

Table 2. Native and commercial chicken: production of meat and egg in the Philippines, 1987–1998

ITEM	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Poultry meat production ('000 metric tons)												
Total	278.52	294.02	315.89	347.41	372.55	462.84	473.34	489.09	518.89	591.02	645.05	637.00
Broiler	217.72	231.75	249.50	274.39	275.95	370.23	388.52	390.20	409.72	466.79	515.78	523.00
Native chicken	43.48	45.22	48.04	52.63	65.23	68.50	67.26	70.38	76.90	89.54	94.63	84.00
Layer/culled	17.32	17.05	18.35	20.39	31.37	24.11	17.56	28.51	32.27	34.69	34.64	30.00
Share (%)												
Broiler	78.17	78.82	78.98	78.98	74.07	79.99	82.08	79.78	78.96	78.98	79.96	81.97
Native chicken	15.61	15.38	15.21	15.15	17.51	14.80	14.21	14.39	14.82	15.15	14.67	13.19
Layer/culled	6.22	5.80	5.81	5.87	8.42	5.21	3.71	5.83	6.22	5.87	5.37	4.83
Egg production (million pieces)												
Total	3,014.0	3,557.0	3,828.0	3,480.0	3,587.0	3,791.0	4,244.0	4,117.0	4,198.0	4,317.0	4,680.0	4,768.0
Native	1,754.0	2,066.0	2,228.0	2,026.0	2,079.0	2,211.0	2,173.0	2,059.0	2,034.0	1,918.0	1,691.0	1,614.0
Commercial	1,260.0	1,491.0	1,600.0	1,454.0	1,508.0	1,579.0	2,071.0	2,058.0	2,164.0	2,399.0	2,989.0	3,153.0
Share (%)												
Native	58.2	58.1	58.2	58.2	58.0	58.3	51.2	50.0	48.5	44.4	36.1	33.9
Commercial	41.8	41.9	41.8	41.8	42.0	41.7	48.8	50.0	51.5	55.6	63.9	66.1

Source: Bureau of Agricultural Statistics, Department of Agriculture, Philippines.

HRV_4 efficacy trials were conducted in five villages in the municipality of Rosario, a province of La Union in the northern part of the Philippines. Some 165 farmer-cooperators were oriented on the expected benefits from the experiment and the relevance of the project to the national economy.

Blood samples were randomly collected to determine the benchmark HI titres (immune level) of the chickens in the five village project sites. The samples were subject to serology testing at the National Animal Disease Diagnostic Laboratory (NADDL) of the BAI.

A control group of caged chickens was fed with HRV_4 vaccine-coated feed. Collection of blood samples was done to determine the immunity level of chickens administered with feed coated with the vaccine. A series of trials was undertaken which determined the immunity rate of survival. This was done by mixing the control group with the commercial strain, white leghorn, without any form of vaccination and infecting them with a virulent strain of locally isolated NCD virus through their eyes and nostrils. All survivors were recorded and yielded results of 65% survival during the first trial, 70% during the second trial and 85% during the last trial. The highest survival rate of 85% further confirmed the efficiency of HRV_4 vaccine.

2.2 Impact Assessment

2.2.1 Adoption of the HRV_4 vaccine

The efficacy trials of the HRV_4, or V_4 vaccine for short, proved successful under Philippine conditions, denoting the vaccine's potential in protecting village chicken from Newcastle disease. After the completion of the ACIAR Project AS1/ 1987/017 in 1991, a proposal from the project leader was submitted to the management of the BAI for the massive reproduction and introduction of the V_4 vaccine. However, it was not pursued due to resource and bureaucratic constraints (B.C. Fontanilla, Bureau of Animal Industry, Department of Agriculture, Quezon City, Philippines, pers. comm., 1997, 1998).

The project assessment team conducted a survey in the villages of the municipality of Rosario, La Union province, where the field trials were conducted, and in nearby villages. Data on costs and returns and possible adoption rates were obtained from the survey. This information will be used in quantifying the expected benefits from the project. Several of the respondents were cooperators during the field trials and, hence, they were aware of the V_4 technology. Since they were witnesses of the efficacy trials during the project implementation, cooperators indicated their willingness to adopt as long as the vaccines are made available. Moreover, the farmers and rural folk in the nearby villages and municipalities were fully aware of the V_4 vaccine and its proven effectiveness. Such awareness was the result of the information dissemination through word of mouth by the project cooperators of ACIAR AS1/1987/017. Due to the unavailability of the V_4 vaccine, adoption has not taken place so far.

Tropical Biological Philippines, a local distributor of Websters Pty Ltd, showed interest in commercially manufacturing and distributing for sale the V_4 vaccine. In 1997, a proposal was submitted by the company to the BAI for the production of the V_4 vaccine and the initiation of mass vaccination of village chicken nationwide locally called 'Oplan Alis Peste'.[1] Funding support from Australia in the form of a grant was proposed for the 'Oplan Alis Peste'. However, there is no development yet as to the status of the proposal (J. Limcumpao, Tropical Biological Philippines, a local distributor of Webster Pty Ltd, pers. comm., 1998, 1999).

2.2.2 Barriers to adoption

There are two major factors that have constrained the adoption of the V_4 vaccine in the Philippines:

a. Weak institutional support. The alleged in-house bureaucratic problems in the agency tasked to carry out the results of the research have completely jeopardised the socioeconomic justification of sustaining the technology developed by the research team.

b. Long delays in commercialisation. Since the government itself did not take the initiative to introduce the V_4 vaccine, the private sector was somewhat hesitant in taking over the venture.

It was perceived that if there had been logistical support from the Philippine Government and even from the research-funding institution for initial production and introduction of the vaccine to target users, adoption may have likely occurred. From there, private sector participation would have been encouraged.

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[1] Literally translated as 'operation plan for the removal of the pest disease (Newcastle)'.

2.2.3 Other impacts of NCD research

The project staff comprised 5 regular employees of the BAI including the primary scientist and project leader who was then the Assistant Chief of the Philippine Animal Health Center of the BAI, and one regular employee from the Bureau of Agricultural Research (BAR) who coordinated and monitored the research work. Moreover, four contractual field staff were hired who assisted in the conduct of field trails in La Union province. The BAI staff in particular were trained on the conduct of research and their skills in laboratory work were enhanced. The provision of one vehicle and one computer, respectively, to BAI and BAR have enhanced the capacity of the proponent agencies, especially their mobility in the conduct of field work and in the storage and retrieval of data in the case of the computer. The success of field trials was not sustained because there were no efforts for the mass production of vaccine by the BAI due to resource limitations.

2.2.4 Measurement of benefits to NCD research

Several economic evaluations have already been conducted on NCD research such as those of Johnston, Fontanilla et al. (1991) and Hafi et al. (1995). The latest impact assessment made for ACIAR's Newcastle disease projects was conducted in 1998 by the Centre for International Economics (CIE). The focus was on two projects, AS1/1983/034[2] and AS1/1987/017, and subsequently AS1/1993/222.[3] The latter project is the latest on NCD research which developed an alternative vaccine called I_2. This vaccine is less costly and could be made available in small quantities. It could be more effective when administered as eye drops.

The present study utilises updated cost of production data based on interviews of raisers of village chicken by the project assessment team and also updated chicken population numbers from the Bureau of Agricultural Statistics. Unlike the previous studies, including the recent CIE study which focused mainly on village chickens, the present study covers research impacts on three markets in the Philippines—meat from village chickens and commercial broilers, and eggs. A comparison of the parameters used in the measurement of benefits to NCD research between the present assessment and that of the CIE study is summarised in Table 3. Commercial producers of layers are potential adopters of the V_4 vaccine, and hence were considered in the present study. Incorporating the broiler sector in this study gains its merit from a Malaysian study on the application of V_4 vaccine for commercial broiler and layer (Latif Ibrahim et al. 1991). The Malaysian study proved further that V_4 oral food-based vaccine is an effective booster vaccine for commercial chickens that have received primary vaccination with lentogenic virus in commercial hatcheries. Also, its ease of application by mixing it in the feeds will reduce the labour time that would have been spent in administering vaccine through injection.

The results of the quantitative assessment, including the conceptual framework, are presented in Appendix A of this paper.

Table 3. Comparison of parameters and assumptions used by the present assessment and Centre for International Economics (CIE) assessment on Newcastle disease

Assumptions/ parameters	CIE	Present study
Village chicken		
meat	included	included
egg	included	included
Commercial broilers	excluded	included
Supply elasticity	less than 1 (perfectly inelastic)	0.90*
Demand elasticity	1.5	–1.44*
Price (kg)		
meat (village chicken)	A$3.50 (live)	A$3.11
egg (village chicken)	–	A$3.09
broiler meat	–	A$2.75
Exchange rate	19.856	21.93

* Estrada and Bantilan 1991.

3 AS2/1991/016, Fowl Cholera Vaccines for Asia

3.1 Overview

The ACIAR-funded project on fowl cholera in the Philippines followed on from AS1/1987/017 which dealt with the control of Newcastle disease in village chickens using oral V_4 vaccine. During the field trials that tested the efficacy of V_4 vaccine, it was discovered that fowl cholera was also causing massive deaths of village chickens in the research

[2] AS1/1983/034 is entitled, 'Vaccination of Malaysian Village Poultry with an avirulent Australian vaccine NCD Virus.'

[3] AS1/1993/222 is entitled, 'Development of New Strain Thermostable NCD Virus I_2'.

sites and in nearby provinces. Hence, in 1992 after the completion of AS1/1987/017, AS2/1991/016 commenced with a proposed duration of 3 years. The proposed budget was A$52,585. The confirmed reports of widespread outbreaks of fowl cholera in almost all regions of the country were not confirmed through laboratory tests. As such, the project aimed primarily to isolate and identify the existing or prevalent serotype or strain of bacteria called *Pasteurella multocida* that is suitable for vaccine production for the control of fowl cholera.

Laboratory work was conducted and proved successful because seven strains of *Pasteurella multocida* type A were isolated. Unfortunately, the planned field trials which could have tested the efficacy of these strains were not pursued. The reason for this was that the bacteria were destroyed due to frequent blackouts experienced in the country which affected most government and private sectors. This made the process of identification and isolation even more costly and strenuous. This led to the suspension of AS2/1991/016 (R. Azul, pers. comm., 1998).

During the short period of the project, a project workshop was, however, conducted followed by a one week training on vaccine production.

When the problem of constant power outages was finally resolved in the late 1993, the project never resumed.

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Appendix A

1 Evaluation Framework

1.1 Conceptual Framework

The assessment of the economic impact of ACIAR research on Newcastle disease focuses on two markets—the markets for village chickens and broilers. The disease control technology, V_4 oral vaccine, minimises production losses accruing to village chicken raisers through reduction of labour costs and costs of supplies to broiler raisers due its ease of applicability. Figure 1 depicts a cost-reducing effect of the use of oral vaccine. The initial supply curve depicts a situation of disease outbreak without oral V_4. The after research supply curve represents a situation where oral V_4 is used. The aggregate welfare benefits or surplus is the summation of the welfare benefits from the two markets—village chickens and broilers.

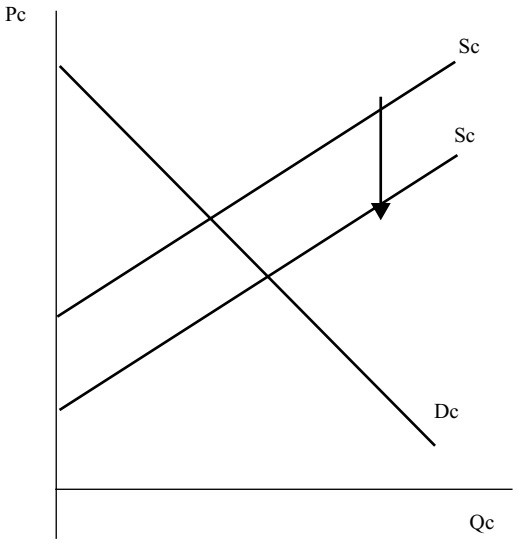

Figure 1. A shift of the chicken supply curve due to research in oral vaccine V_4

1.2 Other Assumptions

a. The supply and demand curves are linear and shifts are parallel.

b. The measurement of benefits is dynamic, i.e. the annual flows of research benefits are measured. The cost of research is included in the estimates of benefits and the net benefits are discounted to determine their present values.

c. The analysis is partial equilibrium.

d. The measurement of research benefits uses the ex-ante approach because the vaccines are yet to reproduced and made available in the market.

e. There is no substitution in production and consumption between village chickens and broilers.

f. The whole framework is that of a closed economy.

2 Measurement of Parameters

2.1 Production, Consumption, Prices and Elasticities

Production of chicken meat and egg is the equivalent meat product of standing stocks of village chicken and broilers and the egg by-product of village chicken. Production of meat from village chicken and from broilers is derived using their respective shares from the total chicken dressed which includes culled layers. Egg produced from village chicken on the other hand are primary data obtained from the household surveys of the Bureau of Agricultural Statistics. Consumption data are total food use from domestic production and imports. Consumption for village chicken, broilers and eggs of village chicken were also derived using their ratios of production to total production of meat and egg. The base data for production and consumption for the 1987–1997 period were used as bases in projecting data from 1998 to year 2016.

Prices are at the farmgate level. The available price elasticity of chicken was substituted for egg and chicken meat for both village chicken and broiler (Table 4).

2.2 Costs and Returns and Adoption Rates

The costs and returns data used in the assessment were obtained from the survey in La Union province in Region I conducted by the team. The cost structure represents the 'before research scenario' where mortality due to disease outbreak ranges from a low of 50% to as high as 100%. The ratio of households that use vaccine (terramycin) is 2 out 5 respondents or 40%. Commonly used types of feeds were maize grits, milled maize, rice bran and paddy grains. The survey captured few respondents who were recipients of V_4 vaccine during the project field trials in 1991. These households served as the vehicle for information dissemination in the area, hence almost all

respondents in the locality were aware of the technology and have recognised the importance of controlling the devastation brought by the disease outbreak. Since potential users are already aware of the technology, adoption would likely occur. Drug distributors interviewed felt that if the government would welcome the proposal, year 2002 would be the latest occurrence of adoption. However. a low initial rate of 1% is assumed in the initial year of 2002 and a maximum of 50% in year 2015.

3 Results and Implications

A summary of the results of the quantitative assessments of the benefits to NCD research can be found on Table 4. The gross benefits accruing to the Newcastle disease research over a 15-year period is estimated at A$683.51 million. Benefits accruing to the village chicken sector comprise almost 99% of the total benefits. Village chicken captures almost one hundred percent of the benefits because this assessment assumed that the disease becomes endemic across the whole country (one of the assumptions cited by Hafi et al. 1995). Producer benefits are greater than the consumer benefits for both commodities.

After the cost of research is accounted for, the net returns to research is A$564.14 million and the present value is A$171.66 million using a discount rate of 8%. The research pay-off to Newcastle disease is 60%.

The results indicate substantial potential benefits to raisers and consumers of village chicken meat and eggs. A major constraint in attaining these potential benefits is the lack of government advocacy to support the private sector's initiative for the reproduction of the vaccine.

Table 4. Summary of benefits, net present values and internal rate of return (IRR) V_4 vaccine for Newcastle disease in poultry

ITEM	Unit ($A/t)	Cost reduction (%)	Producer benefits (A$m)	Consumer benefits (A$m)	Total benefits (A$m)
Native chicken	2,418.50	56.48	363.96	310.54	674.50
Meat	2,022.30	56.48			
Eggs	396.21	56.48			
Broiler chicken (meat)	7.410	0.54	4.91	4.11	9.02
Gross total					683.51
Research costs*					0.03
Net benefit					564.14
Present values					
Benefit					171.71
Cost					0.52
Net benefit					171.66
IRR (%)					60
Discount rate (%)					8

* ACIAR funds.

An Evaluation of ACIAR Project LWR1/1994/014: Management of Phosphorus for Sustainable Food Crop Production on Acid Upland Soils in Australia, the Philippines and Vietnam

N.T. Yanson and M.C. Mangabat

Summary

LWR1/1994/014, which deals with the management of acid upland soils, commenced in June 1996 and was expected to wind up in June 2000. With almost 90% of the project completed, field experiments indicated that the application of lime and inorganic P—triple superphosphate (TSP) in combination with organic —tricho-compost, in acid upland soils is viable in terms of increasing productivity and thereby profitability. Farmer adoption of this technology would depend to a large extent on the availability and prices of these types of fertiliser. The other tangible impacts of the project, particularly to the implementing agencies in the Philippines—Bureau of Soils and Water Management of the Department of Agriculture and Central Mindanao State University—are the upgrading of laboratory facilities, introduction of new methods and standards of soil and plant tissue analysis in consonance with the Australian Soil and Plant Analysis Council (ASPAC), and the enhancement of knowledge and skills of the research staff. Moreover, the project paved the way for the enlistment of the country to the South-East Asian Laboratory Network (SEALNET).

1 Introduction

ACIAR-sponsored research on land resource management, particularly the management of acid soils or on problem systems such as steep lands or upland farming, has been vigorously pursued in tropical countries such as the Philippines, Vietnam and Australia. The most recent research is the current project LWR1/1994/014 which deals with the management of phosphorus on acid upland soils. This project serves as a sequel to a recently completed project SWL/1989/004, 'Management of acid soils for sustainable food crops production in the humid tropics of Asia'. LWR1/1994/014 information on nutrient limitation to plant growth will provide a sound basis for the establishment of appropriate treatments and in the design of agronomic field experiments.

In the Philippines, LWR1/1994/014 is implemented by the Soil and Water Resources Division of the Bureau of Soils and Water Management (BSWM) of the Department of Agriculture (DA), and Central Mindanao University (CMU) located in the southern part of the Philippines. The collaborating institution in Australia is the Resource Management Institute in Queensland. However, there are two collaborating external agencies which also link this project with other non-ACIAR related projects, namely the Philippines Council for Agricultural Research and Resource Management (PCARRD), Farm Resources and Systems Research Division at Los Baños, Laguna, and the International Board for Soil Research and Management (IBSRAM): ASIALAND Management of Acid Soils Network in Bangkok, Thailand.

LWR1/1994/014 had a four-year duration, from June 1996 to May 2000 with a total project cost of A$705,123. It had three components: a) establishment of methodologies—laboratories and methods, b) determination of the effects of organic matter, lime and P fertilisers on the efficiency of utilisation of soil and fertiliser P in acid upland soils, and c) economic evaluation of P fertiliser management and

technologies. These were simultaneously undertaken by both agency collaborators—BSWM and CMU.

2 Overview of LWR1/1994/014

Acid upland soils make up a large percentage of arable land in the tropics. In humid tropical Asia, it is estimated that these soils occupy about 212 million ha or 4% of the land area. Of these, 17 million ha are in the Philippines and 25 million ha in Vietnam. These soil types are similarly widespread throughout tropical and subtropical eastern Australia.

With continued use for food crop production, these acid upland soils degrade rapidly. Moreover, many acid upland soils have a high capacity to transform phosphorus into a plant-unavailable form (P fixation) resulting in its low utilisation by crops. This affects crop yields and eventually farm revenues. Phosphorus fertilisers are a key component in sustainable, profitable farming systems because of their nutrient value and contribution to cost of production. In the Philippines, the low productivity of acid upland soils is attributed to a combination of soil fertility related factors which are commonly phosphorus deficiency and phosphorus fixation, and nitrogen as well as calcium and magnesium deficiencies. Aluminium toxicity was also observed in some upland farms in the municipality of Lantapan, Bukidnon (C.M. Duque, pers. comm., 1999).

This project addressed the management of phosphorus for better crop yields. It attempted further to measure the economic viability of these management practices against farm income and sustainability.

The project was implemented at two sites. One project site was in the southern part of the Philippines, specifically in the municipality of Lantapan, Bukidnon which is about 20 km north of the CMU, the collaborating agency. The second project site was in the northern part of the country, in the village of San Isidro, about 9 km from the municipality of Ilagan, province of Isabela. The experiments in the second site were spearheaded by the BSWM with a project site in the village of San Isidro, about 9 km from the municipality of Ilagan, province of Isabela. Research in both project sites was focused on yellow maize.

2.1 Objectives

The project aimed specifically to:

1. evaluate appropriate technologies for the amelioration of acid soil infertility effects, especially low P supply, under a range of upland soil conditions with identified limitations to plant growth;
2. improve the efficiency of soil and fertiliser P utilisation by crops through the application of selected materials or through cropping practices that supply P or improve P availability;
3. identify and test farmer-acceptable practices that will match P availability with plant demand through the management of organic matter in acid upland soils of the tropics and subtropics; and
4. evaluate the socioeconomic benefits of farming practices for the improvement of P utilisation by crops.

2.2 Initial Results and Assessment

In the two project sites of Isabela and Bukidnon, the three components were pursued simultaneously. The following is a brief discussion on implementing strategies of the different components, the preliminary results of each component and the initial assessment as to the prospective impact of the technology.

2.2.1 Establishment of methodologies—laboratories and methods

This sub-project dealt mainly on the preparatory stage of laboratory analyses, particularly on soil analysis and plant tissue tests. This component was necessary to ensure quality standards and analytical procedures for the soil and plant laboratory, for the purpose of getting accurate and consistent data. The project provided to both CMU and BSWM new laboratory equipment and apparatus which upgraded their existing laboratory methodologies, thus increasing their efficiency and accuracy.

The following activities and laboratory procedures were undertaken as part of this project's component:

a) Training on soil and plant tissue analysis. Training lasting almost a month was conducted at the University of Queensland. It aimed to standardise the methods to be used for the three

collaborating countries, to upgrade the capability of the technicians on laboratory methods, and to ensure that the chemical analyses of soil and plant tissue samples were accurate and reliable, especially the fractions of P in soils. Such laboratory methods and analyses are in consonance with the quality assurance program of the Australian Soil and Plant Analysis Council (ASPAC).

b) Tutorial services. These were provided by ASPAC in several rounds to the project staff of each collaborating agency. However, Dr Dean Biddle supplemented the course by giving out training materials and questionnaires to be completed by the participants. Moreover, tutorials were also conducted through computer-aided materials and methods of analyses.

c) Seminars. 'Echo-seminars' conducted by the project staff were attended by other laboratory staff, particularly in the Soil Chemistry Laboratory. One aspect of the in-house seminar is the transfer of skill on the use and operation of newly acquired equipment.

d) Enlistment of the Philippines to the South-East Asian Laboratory Network (SEALNET). A forum conducted in Thailand in 1998 aimed to promote quality laboratory analyses in regional agricultural and environmental laboratories.

Due to the establishment of methodology component, the institutionalisation of the laboratory methods and standards is now being considered in the existing laboratory procedures in both the BSWM and CMU. These standards are as follows:

a) Quality control standards. These include the internal and external standards in consonance with the ASPAC standards. Moreover, analytical results were submitted to ASPAC for accreditation; and

b) Use of blanks. These are an excellent medium to monitor quality control of reagents, analytical processes, and proficiency.

2.2.2 Determination of the effects of organic matter, lime and P fertilisers on the efficiency of utilisation of soil and fertiliser P in acid upland soils

This component aimed to measure the magnitude of yield responses of maize to the different methods of P fertiliser application. Comparison of maize yield, plant tissue analysis and changes in the chemical properties of the soil in response to rates of lime application, organic and inorganic P sources and combinations were determined.

The results of the above component of the project are summarised below.

a) The soil analysis revealed pH ranges from 4.0 to 5.0 (strongly acidic) and an extractable P range from 0.13 to 0.23 mg/kg which is below the level of P sufficiency.

b) As to the nutritional limitations of the soil, the analysis showed that liming is needed (application of 1.16 g $Ca(OH)_2$ per kg) to raise the pH of the soil from 4.7 to 5.5. Higher yield responses of maize were also observed when other nutrients were applied with lime, such as P, N and K fertilisers.

c) Maize yield responses were also observed using the two types of inorganic P sources—triple superphosphate (TSP) and rock phosphate (RP). Maize yield was higher when treated with TSP. Moreover, yield response was also observed when inorganic P sources were applied in combination with organic P sources, such as tricho-compost and chicken dung. Maize yield was higher when either TSP and RP were applied in combination with organic tricho-compost compared with tricho-compost alone. There was no significant change in yield when chicken dung was applied.

2.3.3 Economic evaluation of P fertiliser management and technologies

This component aimed to determine the economic viability for the various types of soil amendments applied. The economic analysis was based on partial budgeting and marginal analysis methods.

The application of triple superphosphate (TSP) in combination with lime was found necessary so as to increase productivity and profitability. A TSP rate of 40 kg/ha was found to be economically optimal.

3 Preliminary Assessment

Considering that acid upland soils in the Philippines constitute about 58% of the total land area and that most of such lands are planted to maize, the economic viability of the technology developed in this project is an important consideration. However, at the time of writing, the results discussed in the previous sections are not yet conclusive and need to be reviewed and verified. Nonetheless, maize productivity, particularly the yield response to the

application of P fertiliser and the utilisation of soil and fertiliser P, had undoubtedly yielded good results. The critical consideration, however, is the application of lime because these chemicals are not readily available at the locality. Furthermore, the issue of what form of P fertiliser–TSP that will be made available, whether in pure form which is much expensive or in a form combined with other inorganic fertiliser, are still open for further verification.

In order to get an initial response from the farmers and other agricultural entrepreneurs, the BSWM project team sponsored a 'farmers' field day' at the project site where participants and visitors had a first-hand view of the response of the maize plant to the P application and other nutrients at the site.

4 Status and Directions

On 15–19 November 1999 an annual meeting was held wherein the project status and results were presented. The presentation was a prelude to the culminating round which was to be held after the project completion in May 2000 (see previous discussion of the results). Further field experiments and laboratory analyses were to be undertaken during the remaining six months of the project, which is about two (2) croppings, in order to confirm the preliminary results. Scientists signify their reservations on the issue of the availability and pricing of superphosphate or TSP and lime. They expressed the idea of having the issue discussed in the policy level forum because this will involve the participation of an institution in charge of fertiliser regulation and distribution—the Fertilizer and Pesticides Authority (FPA) (R.B. Cagmat, pers. comm., 1999).

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Assessment of Rainfed Lowland Farming Systems Projects in the Philippines (EFS/1983/030 and EFS/1983/069)

M.C. Mangabat, N.T. Yanson and M. Rondon

Summary

Three municipalities in Antique province were selected as project sites due their wide range of agro-environmental conditions. In EFS/1983/069, researchers studied the environmental or agronomic constraints to increased productivity in rice-based lowland rainfed areas. Field trials were undertaken based on recommended management practices and inputs. Yield of crops grown in sequence were compared with those in adjacent farmer-managed fields. A complementary project, EFS/1983/030, determined the socioeconomic factors that affected the difference between potential (those achievable through field trials) and actual productivity through the frontier production function approach. This approach measures the allocative and technical efficiencies of farms.

The results of EFS/1983/069 showed higher yields from researcher-managed fields compared with farmer-managed fields, on average, by 0.55 t/ha for rice and by 2% for second crops (mungbean, cowpea). The yield gaps were attributed to lower use of some fertiliser nutrients (P, K, Zn and S) rather than their inefficient usage and also to unmeasured environmental and/or management factors. Dry-seeded rice (DSR) or wet-seeded rice (WSR) for the first crop or WSR and transplanted rice (TPR) second crop were the recommended cropping pattern which can be modified according to farmers' preferences.

Results of EFS/1983/030 indicated that the variations in technical efficiencies of farms were mostly explained by management practices, particularly in the timing and method of establishment, use of herbicides and pesticides, other factors such as landscape position, rainfall pattern, and unmeasured environmental factors and management practices. The measured allocative efficiencies showed the importance of farmers' technical know-how and their resources in the adoption of modern farm technology.

The results of both projects have important implications to a responsive agricultural extension system. However, these results have not been integrated in the extension system in the province. As in most other projects, there were no follow-up activities for wide dissemination of important findings, nor mechanism for monitoring project impacts. Several technical papers were written which contributed to the pool of literature on rainfed farming systems in both agronomic and socioeconomic aspects. The projects also provided training opportunities and research linkages between institutions.

1 Introduction

As part of the technical assistance from ACIAR on farming systems in the Philippines and Sri Lanka, two complementary projects were undertaken in these countries from July 1984 to June 1987. The project on the performance of rice-based farming systems (EFS/1983/030) dealt with the socioeconomic factors affecting the difference between potential productivity and actual farm performance in rainfed lowland rice-based areas. EFS/1983/069 studied the environmental constraints to increased productivity of rainfed rice-based farming systems in lowland areas. This project was popularly known as the Philippine

Australian Rainfed Lowland Antique Project or PHARLAP. The lead agency was the former Agricultural Research Office (ARO), the forerunner of the present Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA). The principal research collaborators from Australia were from the Economics Department of the Research School of Pacific Studies (RSPS) of the Australian National University (ANU) for EFS/1983/030 and the Division of Land and Water Resources of the Commonwealth and Scientific Industrial Research Organisation (CSIRO) for EFS/1983/069. With the help of the DA regional staff, several sites for the agronomic projects were identified but the lead and collaborating agencies finally selected Antique province in the Western Visayas region because of its wide range of agro-environmental conditions, characteristic of many rainfed lowlands in the Philippines. At the local level, project coordination was also provided by the DA regional office in the Western Visayas and by the Municipal Agricultural Office in Antique province.

1.1 The Study Areas

Three municipalities that extend from the northern to the southern part of Antique province—Tobias Fornier, Patnongon and Pandan—served as study areas. In these municipalities, as in most rainfed areas in the province, the prolonged period of rains (April–June to October–January) and the introduction of short-duration rice varieties in the mid-1970s allow double cropping of rice within a year despite the lack of large national and small communal irrigation systems (Angus 1988). The isolation from irrigation systems partly explains the limited availability of other production inputs and services such as fertiliser, pesticides, planting material, hand tractors for rent, credit and extension.

2 EFS/1983/069

2.1 Project Management

A project staff was formed in Antique province headed by a regional DA agronomist on detail to the project, with support from project hired contractual staff. A rented house in one of the three project areas—Patnongon—served as the main office. Two other local DA staff were assigned to the project to oversee the field trials in Tobias Fornier and Pandan, also supported by contractual staff. The project staff in the three sites were mainly responsible for the conduct and monitoring of field trials and recording of data. The CSIRO principal scientist who regularly visited, provided the main directions, and supervised in the conduct of the field trials. Agronomists from ARO, the local DA office in Antique, and two agronomists from the University of the Philippines at Los Baños (UPLB) who worked part time with ARO also gave advice. One of the UPLB agronomists worked with the crop simulation model with the CSIRO scientist. During the planning stages of the project, a principal scientist from the International Rice Research Institute (IRRI), who also worked for ARO, provided assistance. Another two ARO staff assigned to EFS/1983/069 and EFS/1983/030 visited regularly the project sites to provide administrative support.

In addition to field trial equipment in the three sites, the project acquired a utility vehicle based in Patnongon which facilitated mobility to the field experiments and to the other two project sites. The vehicle was also utilised in the procurement of supplies, most of which had to be bought in Iloilo City in another province. Motorcycles were provided to the project staff in Tobias Fornier and Pandan.

2.2 Objectives and Methodology

EFS/1983/069 addressed the general issue of increasing farm productivity on rainfed lowland areas through improved yield, double cropping, and identification of off-farm factors that affect efficient farm production. The project adopted the farming systems approach and the technology developed and tested by IRRI, Bureau of Plant Industry (BPI), and the Rainfed Agriculture Development Project (RDP) of the DA.

Using a set of recommended inputs and management practices, experiments were established by researchers on farmers' fields in the three project sites during the crop years 1984–1985 and 1985–1986. Within each researcher-managed field, a replicated component technology trial tested the components of the recommendations. Yields of crops (paddy and second crops such as mungbean and cowpea) were sampled and measured. The yield per crop was tested with a series of conventional field trials on researcher-managed farms vis-à-vis the yield on adjacent farmer-managed fields with similar soil landscape position where possible. The project agronomists did not provide any advice on the farmer-managed fields. The farmers on the latter fields also normally operated the researcher-managed fields.

Experiments in the researcher-managed fields also involved the testing and measurement of yield responses to changes in the recommended input levels in order to determine the most efficient set of inputs for growing rainfed rice in the project sites.

The measurement of yields in researcher-managed fields also served as linkage to the socioeconomic project.

In field trials with identical experimental field designs, yield data for each cropping season were combined and subjected to statistical analyses using the GENSTAT package of 1983.

Also, a similar simulation model was used in the field trials which determined the effects of weather conditions on the growth of rainfed crops and in identifying the most appropriate cropping patterns for various climatic conditions in the project sites.

2.3 Relevant Information and Conclusions of the Project

It was found from the field trials that the mean yield gap of rice grown between farmers and researchers using the recommended technology was 0.55 t/ha; and the yield of other crops grown by farmers were 98% of the researcher-managed crops (Tasic et al. 1987). Most of these gaps have been attributed to responses to phosphorus and potassium which were not used intensively by the farmers. Nitrogen was applied by most farmers and hence it did not contribute much to the yield gap. The application of Zn together with the recommended inputs will increase yield by another 0.3 t/ha and the additional application of S could result in a small increment to yield.

The very large between-field variability in rice yield response to P, K, Zn and S indicates severe deficiencies as these nutrients were not widely used by most of the farmers in the project sites. The researchers of the project feel, however, that this finding warrants further research before a blanket recommendation of the use of fertiliser containing these nutrients (Tasic et al. 1987).

From the statistical analyses of the results of the field trials, it was found that the large variability of yields was attributable to unmeasured environmental and/or management factors associated with each individual field.

From the findings of the field experiments, several fertiliser practices were recommended that would increase the efficiency of rice production (Tasic et al. 1987). One of these is the increased use of potassium through strengthened extension and marketing. It was found that for some fertiliser nutrients, the yield gaps between researcher- and farmer-managed fields is attributable more to the lack of supply of some fertiliser rather than their inefficient use. Second, the project confirmed the possibility of double cropping at the project sites and recommended the following cropping patterns: dry-seeded (DSR) or wet-seeded (WSR) first crop or WSR and transplanted (TPR) second crop which can be modified based on farmer's preference and the availability of draught-power.

The project also enhanced an existing crop simulation model of rice growth which was fitted and tested against the field experiment data.

3 EFS/1983/030

3.1 Project Management

Directions for the socioeconomic component mainly came from the principal scientist of the RSPS from ANU who served as project leader. Two other economists also from the RSPS were also involved; one was assigned to the development of the production frontier analysis and the other to data analysis. The socioeconomic surveys were led by one ARO economic staff and assisted by one contractual researcher hired by the project. All of the survey data were processed at the Economics Department of the RSPS of ANU with the ARO economic staff regularly visiting the University for data organisation and to participate in running the production frontier model.

3.2 Objectives and Methodology

EFS/1983/030 aimed to determine the range of performance of farmers within complex farming systems within the project areas. It compared the yields of rice and other crops grown by farmers with those of the field trials; identified and quantified the factors that contributed to the yield gaps between the farmers and those achievable under the field trials; evaluated the technical efficiency of the technology transfer mechanism; derived policy implications for research/extension and for improving farm productivity; and assessed implications for research systems and priorities in developing countries and for their research

collaboration with research institutions, e.g. ACIAR and aid agencies, e.g. AusAID (Shand 1988).

In meeting the above objectives, the project focused on two activities. First was the development of a methodology of analysing farm performance in a holistic manner in the context of farming system and multidisciplinary approach—the frontier production function (Shand 1988). This framework measures both technical and allocative efficiency which determine farm performance. It gives the 'farm frontier' or best practice performance for any given set of input levels. Farms are ranked by their performances. The factors determining the performance below the frontier (less technically efficient) are explained, and form the basis for policy implications. Second was the conduct of socioeconomic surveys of farmers in the three project sites during the crop year periods 1984–1985, 1985–1986 and 1986–1987. For each crop season, two surveys were conducted—immediately after the wet and dry seasons. These surveys involved 603 farms randomly selected from lists of rainfed farms in each of the municipalities of Patnongon, Tobias Fornier and Pandan (Mangabat 1988). The first survey provided the benchmark information for the farmers' households and basic farm information etc. For each season, three sets of questionnaires were used in generating data for a) socioeconomic and demographic details of all household members including their sources of incomes, assets, access to inputs and credit, and input and less detailed output data on non-rice crops; b) details of input–output data on each lowland rice plot (a farm map was drawn to identify each farm plot over the whole survey); and c) all incomes generated from each farming activity (crops, livestock) and their disposition and non-farm income. In order to obtain more accurate data on farmers' assessments of the physical description of their farm plots (soil texture, fertility etc.), an intensive close monitoring survey of a subsample of 150 farmers was undertaken in the first season of crop year 1986–1987 with the help of agronomists.

3.3 Relevant Information and Conclusion of the Project

The estimated technical efficiencies of individual farms have wide variations by season, within the same location and across locations. These were largely attributed to management practices, human capital variables and farm/farmer attributes (EFS/1983/030 termination report). Among these three factors, management practices were the most significant, in particular, the timing and method of establishment, crop variety and date of harvesting. This information indicates the importance of soil, landscape position and rainfall pattern on crop growth. Yield response to herbicides and pesticides was significant and mostly positive. In general, the human capital variables were not a major factor, although the most important of these variables were age of household and motivation in farming. Farm/farmer attributes have minor effects and among these, tenurial status and non-farm income have the greater influence on farm efficiency. Part of the unexplained variability was attributed to unmeasured environmental factors and management practices.

Measured allocative efficiencies indicated that farmers' technical know-how is a major factor in their decisions on the use of production inputs. Non-farm income was found to be positively correlated with allocative efficiency, while farm size and higher interest rates were negatively related in most of the cropping seasons.

The above information demonstrated how important it is that the adoption of modern farm technology be supported by technical knowledge and resources to finetune this technology to their farm environment in order to achieve efficiency from this technology. This in turn implies a responsive agricultural extension system.

4 Impact of the Projects

The results of the two projects were presented in a workshop with a wide range of participants from policy makers in the DA national office; agronomists in region 6 and in the municipalities of the projects sites; economists and agronomists from the research and agricultural universities; and farmer representatives. There were no follow-up activities, however, after the completion of the project, such as verifying further the results of the field trials on certain types of fertiliser that would warrant blanket recommendation; no integration of the results of the agronomic project into the extension system in the province where the three project sites were located; nor was there a coordination with the private sector towards marketing of the recommended fertiliser nutrients in short supply in the project areas. The latter may be attributed to the lack of demand for these nutrients. As is common with most project implementation, there was no monitoring mechanism of the adoption of conclusive recommendations arising from the

field trials and the constraints for non-adoption, even for the farmers in the adjacent researcher-managed fields.

Nevertheless, the results of the projects provided relevant information and contributed to the pool of literature on the different agronomic and economic factors affecting the productivity in the cropping pattern of rainfed lowland farms, in particular to the project sites and in general to areas with similar conditions in other regions of the country. Several technical papers were written from the project results. The projects demonstrated the importance of a holistic approach to rainfed farming systems. The projects also provided linkages between research institutions and training opportunities for project staff.

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The Contribution of ACIAR to Research on Cadang-cadang Disease of Coconut in the Philippines (CS1/1984/002, CS1/1988/031)

M. C. Mangabat and E. B. Sanguyo[1]

Summary

In the absence of a technology for the direct control of coconut cadang-cadang disease, the Philippine Coconut Authority (PCA) recommends to farmers an interim method of burning and cutting down infected trees. Due to the perennial nature of coconut, research on the commodity requires long-term observation and monitoring. Cadang-cadang research in the Philippines has focused on the nature, origin and epidemiology of the disease. The Food and Agriculture Organization of the United Nations/United Nations Development Programme (FAO/UNDP) provided support during the 1950s to 1985 in collaboration with the Bureau of Plant Industry, the University of the Philippines at Los Baños (UPLB) and the PCA-Albay Research Center (ARC). ACIAR research funding ensued in the late 1980s with project CS1/1984/002, 'Studies on Cadang-cadang Disease of Coconut in the Philippines and Micronesia' (July 1986–June 1989). This project was extended through CS1/1988/031, 'Virus-like Diseases of Coconut Palm' (January 1990–December 1993).

The main objective of the ACIAR-funded research on cadang-cadang was to generate information regarding the nature of the disease and its causal agent. The research studies provided evidence of CCVd transmission via pollen and seeds. One of the major contributions of CS1/1984/002 was the development of an assay—polyacrylamide gel electrophoresis (PAGE)—used in detecting the presence of the causal pathogen, coconut cadang-cadang viroid, or CCCVd, in coconut palms. The PCA–ARC through their mobile diagnostic laboratory, used the PAGE assay in monitoring disease boundaries and in determining the rate, range and pattern of spread of the disease in the field. The findings of CS1/1988/031 are relevant in coconut-growing countries where the information on the existence of viroid-like disease aids scientists in the development of coconut genetic breeding programs. Also, the results of both studies were used as bases in the development of a disease indexing protocol which, in conjunction with the development of the PAGE assay, is important in the formulation of appropriate quarantine guidelines in the Philippines, such as in the safe transfer of germplasm, and in prohibiting the transfer of seedlings from the disease-prone areas.

1 Introduction

Cadang-cadang[2] is a viroid disease in coconuts. The disease progresses through three well-defined stages (Table 1). The time between the appearance of the first symptoms and death of the palm ranges from 3 to more than 15 years, with an average of 10 years (Zelazny and Niven 1980). The symptoms of the disease appear in coconut palms at the average age of 30 years. Its spread is dependent on the age of palms, rarely affecting less than 10-year-old palms but incidence increases linearly up to 40-year-old palms, then appears constant for older palms (Zelazny et al. 1982).

In the Philippines, cadang-cadang is endemic in the Bicol region and adjacent areas. Many research

1 The authors would like to thank Dr Maria Judith Rodriguez and Mrs Esther Pacumbaba of the Philippine Coconut Authority–Albay Research Center (PCA–ARC) for their invaluable comments and suggestions and to Ms Joy Ragpa for clerical support.

2 The term is derived from the Bicol term *gadan-gadan* meaning dead or dying (Carpio 1985).

specialists believe that the disease originated in San Miguel Island in Albay province, where an outbreak in 1927 wiped out a plantation owned by the Agusan Coconut Company. It spread in the Bicol region and in some provinces in Eastern Visayas. Isolated cases of the disease were found in Quezon province in region IV in 1960 (Bigornia et al. 1960; Zelazny et al. 1982). The incidences in these areas varied from low to high, while some areas are disease-free. The spread of the disease has been confined to these coconut-producing areas, from the northernmost boundary of Quezon province to the southernmost portion of Eastern Samar province (Figure 1).

Table 1. Stages and characteristics of cadang-cadang disease

Stage	Duration	Characteristics
First stage	2–4 years	More rounded, smaller, scarified nuts; leaves developing yellow spots, appearing water-soaked in reflected light
Mid stage	2 years	Numerous larger yellow spots; inflorescence with necrotic tips; very few nuts; slowing of new fronds
Advanced stage	5 years	Confluent leaf spots; distinctly yellowish or bronze-colored crown; absence of nuts; absence or lesser fronds

Sources: Zelazny et al. 1982; PCA–ARC 1997.

The epidemic in the early 1950s caused the largest losses: more than one million palms per year (Bigornia et al. 1960). It subsided in the early 1980s, the estimated yearly loss ranged from 500 to 100 thousand palms valued at US$1.8 million (Anon. 1982; Zelazny et al. 1982; Carpio 1985). The extent of incidence in disease-prone areas is shown in Table 2 as reported by the Philippine Coconut Authority-Albay Research Center (PCA–ARC).

2 Cadang-cadang Research in the Philippines

Research on cadang-cadang in the Philippines is relevant for several reasons. In spite of having a declining share in the world trade for copra and coconut oil, the Philippines remains the principal producer and the biggest source of these products in the world market. Coconut products continue to be the number one agricultural export of the country; the industry employs about 6% of the country's total population and utilises one-fourth of the total agricultural land. Moreover, there are no coconut varieties that have been found resistant to cadang-cadang. Research on cadang-cadang started in the early 1950s and intensified to the 1980s with substantial support from international agencies such as the FAO/UNDP in collaboration with the Bureau of Plant Industry (BPI) of the Department of Agriculture (DA), the University of the Philippines at Los Baños, and the PCA–ARC (E. Pacumbaba, personal interview, 1997). The discovery by Randles in 1973 that cadang-cadang is caused by a viroid served as the basis for further research on the nature, origin and epidemiology of the coconut disease. When the UNDP funding support ended in late 1984, a proposal was submitted to ACIAR which brought about ACIAR CS1/1984/002. This was followed by CS1/1988/031 as there was a need to conduct further tests. The International Plant Genetic Research Institute–Philippine Coconut Authority (IPGRI–PCA) concentrated on the survey and testing of the pathogens of CCCVd related and viroid-like RNAs in coconut in the Philippines (M.J. Rodriguez, written communication, 2000).

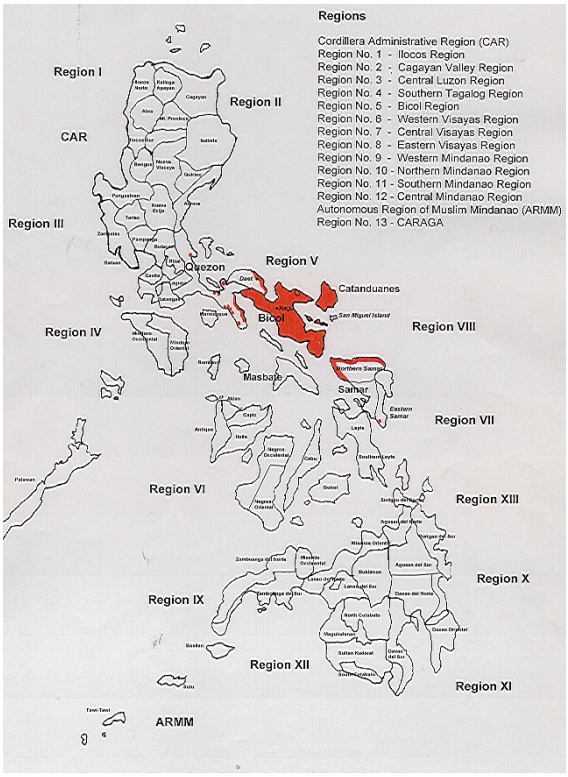

Figure 1. Map of the Philippines and the distribution of cadang-cadang occurrence (shaded areas)

Table 2. Cadang-cadang incidence in the Philippines, various years

Province	Average age of palms (years)	Palms in early stage of disease (%)	Estimated new cases ('000 palms)
Camarines Norte			
1978	30.2	2.45	41
1980	30.9	1.44	24
1990	36.9	1.20	101
1993	34.4	1.75	147
Camarines Sur			
1978	24.2	4.61	248
1980	26.5	2.04	110
1986	26.9	0.80	171
1990	24.0	0.98	209
1993	31.0	1.50	321
Albay			
1978	20.3	1.09	27
1980	21.9	0.58	15
1986	24.3	0.18	14
1990	27.1	0.34	28
1993	28.4	1.28	106
Sorsogon			
1978	27.2	0,81	21
1980	29.0	0.96	25
1986	29.6	0.32	27
1990	32.0	0.48	43
1993	32.0	0.82	73
Masbate			
1978	34.0	0.91	19
1980	33.6	0.47	10
1986	40.5	0.17	24
1990	36.0	0.41	58
1993	38.0	0.24	35
Catanduanes			
1978	23.7	2.71	13
1980	24.9	2.40	12
1986	20.7	2.00	18
1990	33.0	2.31	21
1993	28.0	1.24	11
Northern Samar			
1978	27.1	0.67	22
1980	28.6	0.39	13
1986	37.0	0.22	16
1990	32.8	0.50	37
1993	34.0	0.28	21

Source: PCA–ARC 1997.

2.1 ACIAR Research on Cadang-cadang

ACIAR invested in two cadang-cadang research projects (CS1/1984/002 and CS1/1988/031) which contributed to and extended the information on the epidemiology of the coconut disease (Table 3).

These projects were undertaken by the Albay Research Center, at present under the Philippine Coconut Authority, in the Bicol Region. For these projects, ACIAR commissioned the Waite Agricultural Research Institute (WARI) in Adelaide, Australia to work with the PCA–ARC research staff.

Table 3. ACIAR and some non-ACIAR research on cadang-cadang in the Philippines

Fund source	Project title/description
I. ACIAR (1986–1993)	
CS1/1984/002 (July 1986–June 1989): Studies on cadang-cadang disease on coconut in the Philippines and Micronesia	Started investigation on the spread and distribution pattern of cadang-cadang. Some of the objectives of this study were continued under CS1/1988/031 in the Philippines. Mobile laboratory was established and CCCVd extraction technique through PAGE assay was developed.
CS1/1988/031 (January 1990–December 1993): Virus-like diseases of coconut palm	An extension of CS1/1984/002, it continued the study on the nature, origin and epidemiology of cadang-cadang.
II. Non-ACIAR	
FAO–UNDP (1972–1984)	Discovery of the coconut cadang-cadang viroid (CCCVd) leading to further studies on its nature, origin and epidemiology
IPGRI–PCA (1995–1996)	Survey and pathogenicity testing of CCCVd related and viroid-like RNAs in coconut in the Philippines

Sources: personal interviews from the PCA–ARC staff in 1997 and ACIAR project documents; M.J. Rodriguez, written communication, 2000.

Expenditure data on cadang-cadang research by funding agency are not readily available. ACIAR expenditure for cadang-cadang research based on available project documents is given in Table 4.

Table 4. ACIAR expenditure on cadang-cadang research, Philippines, 1986–1993

Period	Amount (A$)
Total	477,195
1986–1987	114,692
1990–1992	301,478
1993	61,025

Sources: ACIAR project documents.

2.2 Control of Cadang-cadang

There is no chemical treatment for the disease, and no other any method of direct control has been developed yet. The technical information on the use of the PAGE assay (see below) in determining the presence of cadang-cadang can be followed by an interim method of controlling the spread of the disease by cutting down and burning infected trees at all stages, especially at the early stage, and immediate replanting with early bearing dwarfs and hybrids (Zelazny et al. 1982). This has been recommended by the ARC since the 1980s. Replanting of coconut palms destroyed by cadang-cadang has been successful in Albay province. The cutting of affected palms mostly in the advanced stages of cadang-cadang is a common practice in the Bicol region. Infected palms at the early stage are very difficult to recognise by symptoms alone and usually cadang-cadang is mistaken with other coconut disorders, and sometimes the farmers are reluctant to cut because the palms are still bearing (Zelazny et al. 1982).

2.3 Impact of ACIAR Research on Cadang-cadang

Several contributions of CS1/1984/002 and CS1/1988/031 can be identified (E. Pacumbaba, personal interviews, 1997, 1999; M.J. Rodriguez, personal interview, 1999; and written communication 2000).

- The provision of evidence of CCCVd transmission via pollen and seeds.
- The development of a molecular hybridisation assay (MHA)[1] and the mobile diagnostic laboratory using the technique polyacrylamide gel electrophoresis (PAGE) assay (Rodriguez et al. 1993). Using a mobile laboratory, the procedure for normal laboratory testing was shortened into three steps. First, the sap is extracted from the coconut leaf tissue and deproteinised. Second, nucleic acid is recovered by cold ethanol precipitation. Lastly, detection of viroid is achieved by fractionation of nucleic acid using polyacrylamide gel electrophoresis. The PAGE assay is rapid, cost-efficient and reliable, particularly in field diagnosis of cadang-cadang. The mobile laboratory facilitated intensive monitoring of viroid spread and distribution in remote survey sites.

  From 1985 to 1993, the technology was widely used in detecting and identifying new areas of the disease and its distribution in the Bicol region and other endemic areas. However, the mobile laboratory stopped upon the completion of CS1/1988/031 in 1993 and there were no local funds to sustain its operation. In spite of budget constraints, PCA technicians try to accommodate requests of coconut farmers for cadang-cadang testing.

  In 1997, the cost of chemicals needed for the PAGE assay was P19.21 per sample and it was estimated at P25 per sample from 1997 to 1999 levels (M.J. Rodriguez, personal interview 1999). From 60 samples to be assayed in 1.5 days, 80 samples could be processed under field conditions within 4 hours using the new technique by changing the ratio of acrylamide to bisacrylamide from 99:1 to 32.3:1. The duration of the PAGE run was shortened from 15 hours at 125 volts to 6 hours at 175 volts.
- The development of a disease-indexing protocol which, in conjunction with the development of the PAGE assay, is important in the formulation of appropriate quarantine guidelines, such as in the safe transfer of germplasm and in prohibiting the transfer of seedlings from the disease-prone areas.
- The findings of ACIAR CS1/1988/031 have relevance in Australia and coconut-growing countries around the world. The information on the existence of viroid-like disease in other countries is useful in terms of the development of coconut genetic breeding programs.
- Another impact of the research projects is the enhancement of research skills of the five project staff at the PCA–ARC.
- The projects have contributed to the literature on cadang-cadang disease comprising 5 papers published in scientific journals, and 19 papers presented in conferences and workshops.

1. Nucleic acids extracted from coconut leaves are assayed for the presence of cadang-cadang. PAGE is less expensive than molecular hybridisation assay (MHA) technique, which uses radioactive probes. The use of the latter technique is constrained by the supply of the materials required, special laboratory facilities, and personnel training.

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Assessment of ACIAR-funded Research on Forage in the Philippines

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Summary

ACIAR has continuously supported forage research in the Asia–Pacific region, initially with FOG/1985/027 which focused on the development and updating of a database on forage research and the exchange of information and access to the database between country coordinators. A larger project, FST/1994/033, was aimed at developing a new high quality leucaena provenance to be used in tropical farming systems. In the Philippines, the project focused on the identification of species and/or hybrids that are psyllid resistant and adaptable to different agronomic conditions. A new and superior leucaena provenance or KX_2 hybrid, a cross between *Leucaena pallida* and *Leucaena leucocephala*, has been successfully identified. It has the following characteristics: adaptable to varied climates and soil conditions in the Philippines, highly resistant to psyllids, and higher biomass—four times the giant *ipil-ipil* (leucaena) in the country. The findings of the project are timely because psyllid infestation in the mid-1980s devastated leucaena in a country where it is used as forage, especially in village cattle fattening, and also used as leaf meal ingredient.

Following the promising results of FST/1994/033, the Bureau of Animal Industry (BAI) and the National Dairy Authority (NDA), and later ACIAR, collaborated on the development of techniques of propagation, ensuring uptake of the technology by conducting on-farm managed evaluation, and publicising the work through LEUCNET news. A 2-day training course on vegetative propagation of the new leucaena was initially conducted in three cattle-producing villages in the municipality of Mabini, Batangas province. The current propagation project was due to be completed in June 2001.

An ex-ante cost–benefit evaluation for FST/1994/033 and the succeeding projects on propagation was undertaken, taking into consideration prospects for adoption of the new leucaena as forage for village cattle and goats, as leaf meal ingredient for hogs and for broilers and layers. The stream of annual net benefits over the period 2001–2025 accruing from the project is A$313,527. Of the total benefits, the majority (86%) is contributed by adoption in the ruminant sector, 7.3% from the hog sector, 7.4% from the poultry sector.

1 Introduction

During the period 1985 to1991, ACIAR provided funds to Southeast Asian and Pacific countries through ACIAR Project FOG/1985/027. The support was aimed at building up and compiling a database on forage research from Indonesia, Malaysia, Thailand, Philippines and Fiji Islands. Forage researchers from these countries seemed isolated from each other such that the compilation of a database would be a very useful and valuable information resource for researchers in the region. The projects facilitated exchange of information and access to the database. It strengthened the relationships between country coordinators and researchers. Moreover, under the auspices of these projects, one researcher from the

1 Project Staff and Project Leader, respectively of the economic evaluation of non-UPLB (DA) ACIAR supported projects in the Philippines. The authors would like to thank Dr Alex Castillo of the Bureau of Animal Industry for project information, Dr Josefina Susbilla of the Livestock Department of the Philippine Council for Agriculture Resource Research and Development (PCARRD) and Ms Mimi of Lipa City Quality Control Co. for information on animal nutrition, and Ms Ligaya Vergara for clerical support.

Philippines was able to pursue a post-graduate course in forage research. It paved the way for continuing research on forage in the Philippines, in particular the 'New Leucaena' research from July1995 to June1998 with a total cost of A$90,091.

1.1 The Significance of Leucaena

Leucaena leucocephala or colloquially known as 'leucaena' in tropical countries has been one of the most productive and versatile multi-purpose tree legumes available. It has demonstrated wide environmental adaptation and great variety of uses. Among tropical tree legumes it is the premier forage species. In tropical Australia, it has been widely used as broadacre grazing species, while it is a cut and carry fodder species for smallholder agriculture in Southeast Asia. Moreover, leucaena is a good material for reforestation, alley cropping and other agroforestry and landscape stabilisation practices.

The varied uses of leucaena are hampered by several limitations of the existing species used. The germplasm is genetically limited, with only one species available, *Leucaena leucocephala*, a self-fertilised polyploid with low genetic diversity. This species represents only a fraction of the genetic resources available in the leucaena genus. Moreover, the potentials of this existing species pose some limitations, foremost of which is its susceptibility to psyllid insect pests *(Heteropsylla urbana*). Other limitations include poor seedling vigour (thus making the plant very susceptible to weed competition), lack of tolerance to strongly acid or waterlogged soils, and high seed production causing weed problems.

1.2 Background of the New Leucaena Research

By the late 1980s there was a growing desire for selecting and breeding of psyllid-resistant leucaena. In response to this, ACIAR took the lead by sponsoring an international workshop on leucaena in 1994. The offshoot of this workshop was the ACIAR Project FST/1994/033, 'New Leucaena' for Southeast Asian Pacific and Australian Agriculture. There were four collaborating countries: Philippines, Papua New Guinea, Vietnam and Australia.

a. Objectives

The goals of this project were:

- to develop new high-quality leucaena provenances for use in tropical farming systems of Southeast Asian, Pacific and Australian regions;
- to extend the provenances as widely as possible; and
- to communicate information on their production and use.

In the Philippines, the major research objectives of the project were:

- to identify leucaena species and/or hybrids that possess wide adaptive characteristics;
- to identify highly psyllid-resistant lines with good growth potential and producing high quality fodder;
- to compare the relative acceptability of the new leucaena species to ruminants; and
- to compare and evaluate the liveweight response of cattle glazing on new leucaena species.

In the Philippines, leucaena (locally called *ipil-ipil*) has long been a vital and integral part of smallholder agriculture, where it is traditionally used as forage for ruminant animals, a leaf meal ingredient (particularly in the Visayas region) for monogastric animals like chickens and hogs, paper pulp, wood and charcoal production, and as a source of organic fertiliser for food production. However, since the mid-1980s, psyllid insects have caused widespread devastation of leucaena in the country, resulting in erratic supply and contributing to the shutdown of a leucaena leaf meal operation in the Visayas. It has also affected cattle operations in major cattle- producing provinces due to limited supply and fears of using psyllid-infested leucaena. The psyllid devastation stimulated research for an alternative multi-purpose tree (MPT) species and gave impetus to conduct studies on biological control of psyllid. Thus, the arrival of this New Leucaena research in the Philippines was very much needed to recover the rapidly diminishing potential of *ipil-ipil*.

1.3 Research Strategies

The project started in July 1995 and was completed in June 1998. The objectives of the project were realised through the following strategies. A number

of these activities were simultaneously undertaken in Vietnam, Papua New Guinea and Queensland.

- Evaluation sites were established simultaneously in Queensland and at IRRI Los Baños a leucaena collection was evaluated. There was a complete collection of 116 lines of leucaena established at IRRI, Los Baños, Laguna. The collection of more than 100 varieties of leucaena as foundation seeds was provided by CIAT–IRRI under the Forage for Smallholder Project. Three evaluation sites were established, namely: Lipa City, Batangas; Tanay, Rizal; and Palayan, Masbate.
- Evaluation sites at Lipa City and Tanay were established and monitored to evaluate the effects of genotype and environment on the tannin content of leucaena. Simultaneously, the same study was being undertaken at Queensland to examine the effect of soil fertility and water stress on tannin levels.
- Large grazing trials were undertaken in Palayan, Masbate and Papua New Guinea to assess animal production from the new leucaenas. Palatability trials at these sites were also assessed as to animal acceptance of the leucaena species.
- Lastly, strategies on the initial propagation of the identified superior or hybrid germplasm and the dissemination of information on New Leucaena production and use to potential users were undertaken before the termination of the project. However, initial propagation activities were underway in collaboration with the National Dairy Authority, particularly developing the technology of vegetative propagation of the hybrid provenance for dairy farmers.

2 Objectives of the Present Paper

This paper is a qualitative and quantitative assessment of the impact of 'New Leucaena' research in the Philippines. Since the first phase of the project, the identification of a superior provenance has been completed, and the second phase is under way, the expansion of vegetative propagation. Basically, the paper will focus on documenting the project's accomplishments and outputs and the initial response of potential users in selected areas.

3 Research Outputs

3.1 Identification of Elite Leucaena Germplasm

Among the four species which were identified as promising cultivars for broadscale adaptation, the cross between *L. pallida* and *L. leucocephala,* called KX_2 F_1 hybrids, was the most promising. This so-called elite germplasm exhibited outstanding agronomic performance, such as wider adaptation to the varied climate and soil conditions in the Philippines; high resistance to psyllid infestation; and higher biomass yield (4 times higher than the 'giant ipil-ipil')—hence it has a higher production potential as livestock feed and firewood. Moreover, it has a faster rate of establishment, thus minimising weed competition and reducing maintenance costs.

3.2 Initial Propagation Activities

The propagation work was initiated under the auspices of the project but was continued after the project's termination with support from the National Dairy Authority (a government institution which is in charge of dairy industry development, particularly on organisation and technical assistance to dairy cooperatives) which collaboratively joined hands to further develop the technology of vegetative propagation. The collaboration aimed to come up with an improved technology on vegetative propagation and to disseminate the technology to dairy farmers. The following outputs were accomplished under the BAI–NDA collaboration:

- A 2-day training course on 'Vegetative Propagation of the KX_2 F1 Leucaena Hybrid' was conducted in three barangays (villages) in Mabini, Batangas. A total of 26 farmers attended the three separate sessions held in Malimatoc 1, Malimatoc 11 and Lauren.
- There were three methods of propagation introduced in the training course: cuttings, grafting and marcotting. There were 70 rooted cuttings currently growing at STIARC Centre at Lipa City, while in Malimatoc about 200 plants derived from rooted cuttings were distributed to farmers and are currently doing well in the farmers' fields. Using the grafting method, on the other hand, there were approximately 40 plants that have been successfully grafted at Malimatoc largely from 'local' leucaena rootstock. Marcotting, however, has yet to prove as successful because the technique is rather slow. Based on the field

trials conducted, grafting showed a great deal of promise as an alternative method of vegetative propagation.

- There was an initial distribution of 30 pieces of live cuttings (mother plant) to each farmer's dairy cooperative in six areas of the country, namely: Batac, Ilocos Norte, Cebu, Central Luzon State University (CLSU) Albay, Sorsogon and Sariaya, Quezon.

4 The Project's Short-term Direction

The goal of the first phase of FST/1994/033 was successfully carried out, hence ACIAR favourably approved the recommendation of follow-up work to capitalise on the initial investment (Miller et al. 1998). The project's extension was to commence July 1999 and was expected to be completed in June 2001. This two-year extension was to incur an additional cost of about A$88,879. The objectives and expected outcomes were the following:

- To develop techniques of propagation through vegetative cuttings considered appropriate to Southeast Asian smallholders.
- To train collaborators on vegetative propagation. In order to ensure uptake of the technology, an on-farm, farmer-managed evaluation was undertaken. The expected participants were nursery staff, farmers, foresters and livestock extension agents.
- To ensure that the KX_2 F_1 hybrid is palatable to ruminants. It was expected that the project could gather conclusive evidence of the long-term acceptability of KX_2 F_1 hybrid to cattle and goats.
- To publicise the work through the Leucnet News, a forum for information exchange concerned with leucaena research and development.

With the project's extended work and funding, the BAI planned to disseminate the KX_2 hybrid in three regions of the country, namely, southern Tagalog, eastern Visayas and northern Mindanao (Castillo, personal interview, 1998). A module comprising 30 to 50 mother plants was to be set up in each of the three regions and propagation would be in the form of cuttings. From twenty mother plants, about 500 to 700 cuttings can be produced. The use of the KX_2 leucaena variety will be popularised by the BAI through the regional field units (RFUs) of the Department of Agriculture (DA) and the local government units (LGUs).[1]

5 Impact Assessment

This section is a descriptive and quantitative assessment of ACIAR FST/1994/033

5.1 A Qualitative Assessment

The project's first phase has been highlighted by its successful development of a hybrid leucaena, KX_2 F_1, with superior agronomic performance, particularly highly resistant to psyllid infestation. The success of the trial as to the resistance of KX_2 to psyllid pests conducted in one of the evaluation sites established was confirmed during the farmers' on-farm trial conducted in village Malimatoc, municipality of Mabini, Batangas province (Gutteridge et al. 1999) wherein the farmers themselves saw the large difference in the productivity of the local and hybrid leucaena when both were severely attacked by psyllid.

The project leader of EST/1994/033 in the Philippines perceives a high potential of adoption, especially as forage for beef and dairy cattle. This was supported by the fact that a sole institution for dairy cattle development in the country has moved to endorse and encourage dairy farmers to use hybrid leucaena as a cheap alternative forage to napier grass. Moreover, in one of the trainings conducted in village Malimatoc in Batangas province, smallholder cattle farmers showed great interest and enthusiasm as they participated in the practical sessions of the training (Gutteridge et al. 1999).

In support of the adoption presentation of hybrid leucaena, during the survey of cattle raisers in Rosario, Batangas and in Laoag, Ilocos Norte, more than 50% of the farmers interviewed expressed their willingness to adopt the new hybrid as they are currently users of 'local' leucaena. Also, based on interviews of local feedmillers and animal nutritionists, leucaena as leaf meal is a welcome technology especially if it comes in cheap and pulverised form. The only reservation of these feedmillers and nutritionists is the sustainability of supply.

Farmers also signified their eagerness for the introduction of the leucaena hybrid because leucaena can also be used as erosion control,

1. The provinces and municipalities.

firewood, fertiliser or mulch and shade (Guteridge et al. 1999).

As forage, the KX_2 hybrid reduces the production costs of feedlot and dairy operators in terms of lower feed costs for ruminant animals (cattle fatteners, dairy cattle, goat fatteners). Another potential linkage is in the leaf meal industry, in the use of KX_2 hybrid as an alternative source of protein in feed formulation for monogastric animals (hog fatteners, chicken broilers and layers). According to animal nutritionists, leucaena can be substituted for yellow maize for its xanthophyll content which gives a deep yellow colour in egg yolk and skin pigment of poultry meat. It is hypothesised that the use of KX_2 has a cost-reducing effect in feed formulation which is translated as a reduction in the production cost of hog fatteners and eggs.

5.2 Quantitative (Ex-ante Quantification of Welfare Benefits)

The ex-ante economic evaluation which appears in Appendix A of this paper complements the qualitative assessment. It gives an insight into the welfare benefits of ACIAR research investments in New Leucaena in the Philippines. Research investment considers only the cost of the first phase of FST/1994/033 and the BAI–NDA project cost.

Reference

Gutteridge, R.C. et al. 1999. New leucaenas for Southeast Asian, Pacific and Australian agriculture, Annual Report.

Appendix

Quantitative Evaluation of FST/1994/033

1 Evaluation Framework

1.1 Conceptual Framework

It has been observed that, for most types of research, such as plant breeding and pest and disease control, the impact of research can be identified directly on the commodity where research is focused (Davis 1994). In the case of forage research such as in the ACIAR-funded research on new leucaena, it has a wide impact or linkage (Table A1). The assessment of the economic impact of the new leucaena or KX_2 hybrid variety focuses on its linkage with the livestock industry.

The economic assessment employs the concept of economic surplus in measuring the changes in the welfare gains of the adopters of the KX_2 hybrid resulting from research (producer surplus, PS) and the welfare to the end users of KX_2 (consumer surplus, CS). The multimarket approach in assessing research (Alston et al. 1995) is hereby extended in assessing the impact of new leucaena research in the Philippines. The impact of the KX_2 hybrid is analysed in terms of the individual markets for cattle, hogs, goats and poultry as depicted in Figure A1.

As forage, the KX_2 hybrid reduces the production costs of feedlot and dairy operators in terms of lower feed costs for ruminant animals (cattle fatteners, dairy cattle, goat fatteners). Another potential linkage is in the leaf meal industry wherein the use of KX_2 hybrid is an alternative source of protein in feed formulation for monogastric animals (hog fatteners, chicken broilers and layers). According to animal nutritionists, leucaena can be substituted for yellow maize for its xanthophyll content which gives a deep yellow colour in egg yolk and skin pigment of poultry meat. It is hypothesised that the use of KX_2 has a cost-reducing effect in feed formulation which is translated as a reduction in the production cost of hog fatteners and eggs. The cost-reducing effect of the use of the KX_2 hybrid is depicted in Figure 1 as a downward shift of the individual supply curves of the above ruminants and monogastric animals. The effects of KX_2 hybrid in dairy cattle and chicken layers represent vertical market relationships wherein the cost reduction in these animals are translated into corresponding shifts in the supply curves of their final products, milk and eggs, respectively. The aggregate welfare benefits or surplus (total surplus, TS) is the summation of the welfare benefits from the individual livestock markets. The change in research benefits or surpluses can be depicted as follows:

$$\Delta CS = \Sigma\Delta CS_{rj} + \Sigma\Delta CS_{ml}$$

$$\Delta PS = \Sigma\Delta PS_{ri} + \Sigma\Delta PS_{mj}$$

$$\Delta TS = \Delta CS + \Delta PS$$

where:

$\Sigma\Delta CS_{rj}$ is the sum of the changes in consumer surpluses from the markets for ruminants (cattle fatteners, dairy cattle, goat fatteners) in the i^{th} region.

$\Sigma\Delta CS_{ml}$ is the sum of the changes in consumer surpluses from the market for monogastric animals

Table A1. New leucaena research and its linkages

Research output	Usage	Linkage	Nature of impact
New leucaena or KX_2 hybrid	Forage	Cattle fatteners	Reduced cost of feeds.
		Cattle dairy	Reduced cost of feeds.
		Goat fatteners	Reduced cost of feeds.
	Leaf meal	Hog fatteners	Low-price leaf meal ingredients for feedmillers resulting in reduced cost of feeds for hog fattening and egg production.
		Broilers	
		Layers	Improved quality of chicken meat and egg.
	Crop rotation	Farming systems	Weed control and provides moisture.
	Forestry material	Environment	Prevents soil erosion.
	Wood/charcoal	Rural households	Additional income.

(hog fatteners, chicken broilers, layers) in the i^{th} region.

$\Sigma\Delta PS_{rj}$ is the sum of the producer surpluses from the market for ruminants (cattle fatteners, dairy cattle, goat fatteners) in the i^{th} region.

$\Sigma\Delta PS_{mj}$ is the sum of the producer surpluses from the market for monogastric animals (hog fatteners, chicken broilers, layers) in the i^{th} region.

1.2 Other Assumptions

The following assumptions also apply in the above conceptual framework. These are adopted in order to simplify the theoretical framework.

First, the supply and demand curves are linear and downward shifts are parallel. The parallel shift implies a uniform rate of adoption of the new leucaena variety and equal cost reductions across all producers in an individual sector.

Second, the measurement of benefits is dynamic, i.e. annual flows of research benefits are measured. The annual benefits accrue from the cost reductions as a result of research. The cost of research is included in the estimates of benefits and the net benefits are discounted to determine their present values.

Third, the analysis is partial equilibrium since the effects of new leucaena research are concentrated within the livestock industry.

Fourth, the measurement of research benefits uses the ex-ante approach since the vegetative propagation of the new leucaena or KX_2 hybrid has been recent, starting only in mid-1998 under a one-

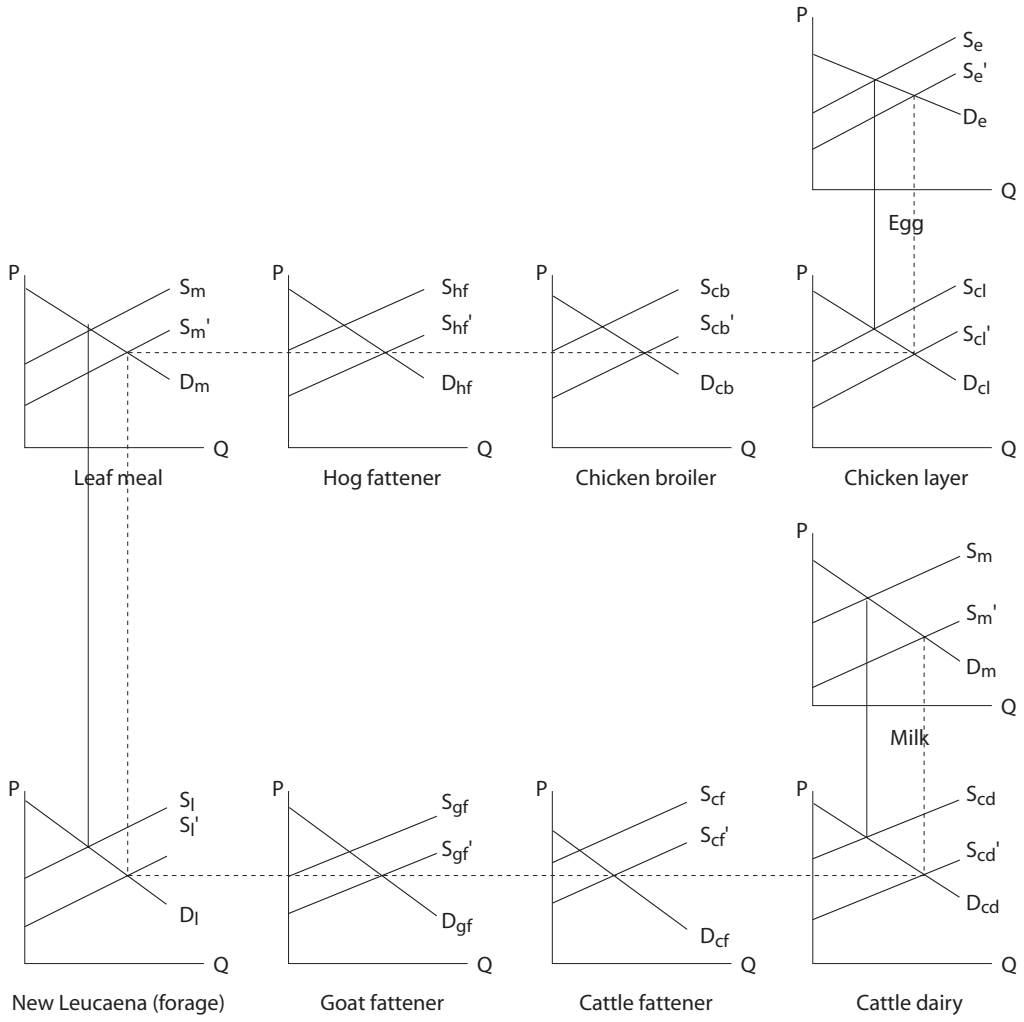

Figure A1. New leucaena research and its multimarket impact in a closed economy

year collaborative project between the Bureau of Animal Industry (BAI) and the NDA.

Fifth, there is no substitution in production and consumption between the different types of livestock.

Sixth, the whole framework is that of a closed economy.

2 Measurement of Parameters

A description of the basic parameters used in the conceptual framework—production, consumption, price, elasticities, adoption rate—for each type of livestock are summarised in Table A2. Except for adoption rate, the data for the rest of the parameters were culled from secondary sources.

2.1 Production and Consumption

Production data refer to the meat equivalent of standing stocks for cattle, swine, goat and chicken broiler, and final products such as milk for dairy cattle and egg for chicken layers. Broiler meat production composed of native or village chicken, broilers, culled commercial layers and breeders. Egg production from commercial layers was extracted from the total chicken egg production which includes eggs of native chicken. Consumption data for beef, milk, chevon swine and broiler are the total food use from domestic production and imports. Consumption for broiler meat and commercial table egg were derived using their ratios of production to total production of meat and egg. The base data for production and consumption for the 1987–1997 period were used as bases in projecting data from 1998 to year 2016.

2.2 Prices

Prices are at farmgate level or prices received by farmers from the first point of sale. In the case of the cattle, the cost of transporting live animal from the farm to the auction market and other handling costs were deducted from prices at the auction markets.

2.3 Price Elasticities

The price elasticities of demand and supply for beef, swine and chicken broiler were derived from secondary sources. Due to the unavailability of data, the price elasticities of supply and demand for beef cattle were substituted for goat fatteners and milk.

Table A2. Parameters in the assessment of leucaena research

Item	Production/Consumption	Price	Adoption (%)		Elasticities	
			Min.	Max.	η (demand)	e (supply)
1. Cattle a. Beef	meat equivalent of slaughtered animals base year: 1987–1997 projection: 1998–2016	farmgate	6	45	0.70	0.48
b. Dairy	Milk base year: 1995–1997 projection: 1998–2016	farmgate	6	46	0.70	0.48
2. Goat fattener	meat equivalent of slaughtered animals base year: 1987–1997 projection: 1998–2016	farmgate	5	35	0.70	0.48
3. Swine a. Fattener	meat equivalent of slaughtered animals base year: 1987–1997 projection year: 1998–2016	farmgate	2	47	0.60	0.70
4. Chicken a. Broiler	meat equivalent of slaughtered animals base year: 1987–1997 Projection: 1998–2016	farmgate	3	55	0.72	0.90
5. Chicken layer a. Egg	Eggs Base year: 1987–1997 Projection: 1998–2016	farmgate (medium size)	3	63	0.72	0.90

Sources: Field interviews for adoption rates. BAS for production, consumption and prices. Estrada, J. and C. Bantilan (1991) for elasticities.

The elasticities for chicken were adopted for eggs. As the secondary data show, the supply and demand elasticities of ruminants are both inelastic (Table A2). However, the demand for ruminants is more elastic than supply. This indicates that consumers of beef, chevon and dairy are more responsive to price changes in these products, suggesting some degree of shifting to substitutes of these products.

On the other hand, for monogastric animals and their products (eggs for layer), the price elasticity of demand is less elastic than their supply. The price elasticity of supply of producers of monogastric animals is more elastic than the supply elasticity of producers of ruminants. This can be attributed partly to the longer gestation period of the latter type of animal such that producers respond less quickly to price changes.

3.4 Adoption Rates

Animal specialists and nutritionists interviewed foresee that the introduction of KX_2 hybrid to livestock producers, farmers and feedmillers would meet less resistance. Accordingly, the major hindrance to its adoption is its availability and sustainability of supply. Moreover, small and medium-scale feedmillers who do not have pulverising equipment would require leucaena in dried or pulverised form.

As forage, there is a high potential of adopting the KX_2 hybrid in the Philippines because leucaena has been used traditionally as forage for cattle and goats. It would replace from 20% to as much as 100% of the feed ration for ruminants. In Batangas, a major cattle-producing province in Region IV, an interview of cattle fattener producers indicated that 80% to 100% of animal feed ration consists of traditional leucaena variety, as cut-and-carry or prepared into a concoction (local term is *supak)* which is fed to cattle. In La Union and Ilocos Norte in Region I, the practice of feeding leucaena is more of the cut-and-carry system. It is estimated that it would take one year after planting before an initial commercial quantity of leucaena will be produced and hence, initial adoption will also occur. Information on the level of regional adoption rates of leucaena for cattle fattening were determined based on field interviews in the provinces of Batangas, La Union, Ilocos Norte, and Nueva Ecija; elicitation of the possible minimum and maximum adoption rate and corresponding year since the introduction of the KX_2 hybrid (2001 for cattle, 2002 for dairy and goat fattening) from the Regional Agricultural Statistical Officers (RASOs) of the Bureau of Agricultural Statistics (BAS); and the proportionate shares of regional livestock production to total production. For each type of livestock, progressive adoption rates which are weighted averages based on the regional proportionate shares to total livestock production, are used over the period 2001 to 2016 (Annex A).

Adoption rate is assumed constant from the year of maximum level of adoption to year 2015. The initial adoption rate for cattle for fattening or dairy is at 6% each and goat at 5% (Table A2). Among the three ruminants, the maximum level of adoption is highest for dairy which starts after the eighth year. The National Dairy Authority (NDA) has been pushing for organised dairying in the Philippines, although under the cattle credit program napier grass cultivation is required for the loan recipients. In spite of this policy, animal scientists are optimistic that, with a continuous supply of the new leucaena, cattle dairy producers will shift gradually from napier grass because leucaena can be managed and cultivated easily. The new leucaena has also good prospects as forage for goat fattening because of the successful food acceptance test conducted with sheep, considered as having the most discriminating taste in ruminants. For goats, scientists perceive that leucaena can replace commercial feed mix by 5% or more.

Based on animal nutrition, leucaena can replace only 3% to a maximum of 5% protein source ingredient in feed formulation for monogastric animals such as swine and chicken. It is assumed that there is a 2-year adoption lag for the KX_2 variety. From the time that the joint BAI–NDA project on new leucaena cultivation and dissemination starts, it would take 2 years to be able to propagate a commercial quantity for the feedmilling industry. The minimum level of adoption is lower for hogs, 2% compared with 3% for broiler and layer producers. The maximum level of adoption for layer producers would be more than 50% and for hog producers, less than 50%.

4 Costs and Returns Structure

The following discussions deal with the cost structure of the different types of livestock before and after the introduction of the new leucaena or KX_2 hybrid.

4.1 Leucaena as Forage

Except for cattle fattening, the costs and returns data for ruminants are largely sourced from the Bureau

of Animal Industry (BAI). The costs and returns data on goat was sourced from a study made by Asia Specialist Kompanie, Inc. Table A3 presents a summary and some details on the cost structure of different ruminants, particularly the changes in feed costs and labour costs.

4.1.1 Cattle fattening

A survey of the costs and returns structure of smallholder cattle fattening was conducted in four provinces in three smallholder cattle producing regions (I, II, IV) in the country. Sample respondents include users and non-users of native leucaena. The 'without research' cost scenario depicts the traditional practice of small raisers of cattle fatteners utilising native leucaena variety. The 'after research' scenario shows an increase in labour cost of A$34.19 due to additional labour-days required in more intensive use of new leucaena. That is, more time is spent in cultivation, gathering and preparing the leucaena feed concoction or s*upak*. In spite of additional labour cost, feed cost was reduced by about A$33.06 because of substantial reduction in the quantity of higher priced commercial feeds despite the imputed cost of new leucaena being A$0.08 per kg. The ratio of leucaena in the feed mix after research increased by 20%. The resulting unit cost reduction is A$516.19 per tonne or 15.8% (Annex B). The KX_2 variety has a high protein content which serves as meat enhancer for ruminants, resulting in more rapid weight gain.

4.2.2 Cattle dairy

Based on the available cost and return data (Dairy Commodity Investment Profile, PSA, 1996), feed cost is about 60% of the total cash costs or about 40% of the total operating costs. The introduction of new leucaena into the feed ration of dairy animals results in feed cost being reduced by 21%. The proportion of leucaena in feeds increased from 65% to 80%. Labour costs, however, increase by A$25.53 because of additional time needed for feed preparation and leucaena cultivation. The unit cost reduction is only A$15.09 or 6.7% (Annex C).

4.3.3 Goat fattening

Scientists perceive that the use of new leucaena can replace commercial feed mix by 50% or more. The reduction in feed cost is only 10%. This is due to a lower commercial feed ratio of leucaena to total feed ration for goats. As a result of the use of new

Table A3. Feed ration and labour costs in ruminants before and after research

Type of feeds	Before research			Model-based			Reduction/ increase in value (A$)
	Qty (kg)	A$/kg	Total value	Qty (kg)	A$/kg	Total value	
1. Cattle beef (12 mos. cycle)							
a. Feed	1260.00		196.80	1260.00		132.30	(64.50)
Comm'l feed	384.00	0.33	126.72	126.00	0.33	41.58	
Hay/leucaena	876.00	0.08	70.08	1134.00	0.08	90.72	
Ratio	30:70			10:90			
b. Labor (mandays)	71.00	4.56	323.77	78.50	4.56	357.96	34.19
2. Cattle dairy (12 mos. cycle)							
a. Feed	1343.00		285.01	1350.00		225.72	(59.29)
Comm'l feed	467.00	0.46	214.92	310.00	0.46	142.50	
Hay/leucaena	876.00	0.08	70.08	1040.30	0.08	83.22	
Ratio	35:65			20:80			
b. Labor (mandays)	30.20	4.56	137.26	35.70	4.56	162.79	25.53
3. Goat (8 mos. cycle)							
a. Feed	90.50		8.77	88.50		7.85	(0.92)
Comm'l feed	4.00	0.46	1.84	2.00	0.46	0.92	
Mineral lide	1.00	0.09	0.09	1.00	0.09	0.09	
Hay/leucaena	85.50	0.08	6.84	85.50	0.08	6.840	
Ratio	5:95			3:97			
b. Labour (mandays)	79.00	4.56	360.25	85.50	4.56	389.89	29.64

leucaena, the unit cost reduction is A$150.9 or 6% (Annex D).

4.2 Leucaena as Leaf Meal

Two animal nutritionists were interviewed by the project team in order to assess the potential of new leucaena as leaf meal in feed formulation for monogastric animals. A least-cost simulation model at the Livestock Division of PCARRD was used in determining the cost of feed formulation with leucaena as one component. This model is an optimum combination of feed ingredients that gives the standard nutrient requirement of an animal at least cost. The model assumes a 2–3% mixture of leucaena leaf meal at A$0.18 per kg in dried form.

In using leucaena as feed mix in growing monogastric animals, the cost reduction is primarily in the reduced value of commercial feeds as illustrated in Table A4.

The impacts of new leucaena leaf meal on the cost structure of the following types of livestock are given below.

4.2.1 Hog fatteners

The cost of feed concentrates without leucaena leaf meal is A$60.57 per head of fattener per fattening cycle (one cycle = 4.5 months). After research, that is, with new leucaena leaf meal in the feed formulation of hogs, cost of feed decreased by A$0.98 or 1.6% per kg. (Annex E). This results in a very minimal cost reduction of about A$11.55 per tonne or 0.62%.

4.2.2 Broiler

In a 45-day broiler operation cycle, the use of leucaena in the formulation of finisher mash for broilers reduces the value of a kilo of feed by A$0.03 cents per head per cycle or about 2%. which translates into a A$15.20 or 1.1% unit cost reduction per metric ton of broiler produced (Annex F).

4.2.3 Layer

After research, that is using new leucaena as leaf meal ingredient, feed cost is reduced by A$0.73 or 2.6% per layer per laying cycle (1 cycle = 22.6 months). This translates into a unit cost reduction of A$1.83 or 2.1% per tonne of egg produced (Annex G).

5 Discussion of Results

Given the framework and assumptions adopted in this study, the gross benefits accruing to the new leucaena research over a 29-year period is A$799.8 million. Of these benefits, A$737.2 million are derived from ruminants and A$113.7 million from monogastric animals (Table A5).

Table A4. Feed mix in monogastric animals before and after research

Type of feed	Proportion		Price (A$)		Total value (A$)	
	%	kg	Without leucaena	With leucaena	Without leucaena	With leucaena
1. Hog fattener						
Starter	17	24	0.49	0.46	11.79	10.94
Grower *	55	78	0.42	0.42[a]	32.79	32.79
Finisher *	28	39	0.41	0.41[a]	15.99	15.85
Total/weighted price	100	141	0.43	0.43	60.57	59.58
2. Broiler						
Booster/starter	86	2.57	0.48		1.24	1.24
Finisher *	14	0.43	0.45	0.39[a]	0.19	0.17
Total/weighted price	100	3.00	0.48	0.47	1.44	1.41
3. Layer						
Booster	3.2	2	0.46	0.46	0.92	0.92
Starter mash	9.2	5	0.42	0.42	2.38	2.38
Layer mash *	87.6	54	0.45	0.43[a]	24.13	23.42
Total/weighted price	100	61.7	1.33	1.31	27.43	26.73

Hog fattener: Growing = 60 days or 2 mos. Fattening = 75 days or 2.5 mos. Fattening cycle = 135 days or 4.5 mos.
Broiler: Growing cycle = 45 days. Layer: Growing = 4.6 mos. Laying = 18 mos. Laying cycle = 22.6 mos.

[a] Simulated prices of a kilo of feed with new leucaena leaf meal.
* Type of feeds with leaf meal ingredient.

Table A5. Benefit-cost analysis of research on leucaena (A$)

	YEAR	BENEFITS							COSTS			NET BENEFITS	PRESENT VALUES			COSTS (P)		
		Beef Cattle	Beef Dairy	Hog	Broiler	Layer	Goat	Total	ACIAR	non-ACIAR	Total		Benefits	Costs	Net Benefits	ACIAR	non-ACIAR	Total
–1	1996	0	0	0	0	0	0	0	40,226	0	40,226	(40,226)	–	43,445	(43,445)	823,500		
0	1997	0	0	0	0	0	0	0	37,552	0	37,552	(37,552)	–	37,552	(37,552)	823,500		
1	1998	0	0	0	0	0	0	0	12,312	2,280	14,592	(14,592)	–	13,511	(13,511)	270,000	50,000	
2	1999	0	0	0	0	0	0	0	–	2,280	2,280	(2,280)	–	1,955	(1,955)		50,000	
3	2000	0	0	0	0	0	0	0				–	–	–	–			
4	2001	6,640,757	0	0	0	0	0	6,640,757				6,640,757	4,881,155	–	4,881,155			
5	2002	12,084,858	16,108	308,110	170,305	154,471	545,496	13,279,349				13,279,349	9,037,702	–	9,037,702			
6	2003	18,403,549	30,447	745,198	403,833	365,522	996,722	20,945,270				20,945,270	13,199,073	–	13,199,073			
7	2004	27,664,334	56,220	1,197,988	630,708	565,167	1,616,608	31,731,025				31,731,025	18,514,749	–	18,514,749			
8	2005	37,235,148	83,191	2,262,982	1,160,587	1,029,976	2,411,726	44,183,609				44,183,609	23,871,029	–	23,871,029			
9	2006	44,281,327	107,431	3,344,644	1,671,749	1,484,356	3,053,773	53,943,281				53,943,281	26,985,071	–	26,985,071			
10	2007	50,873,166	122,039	4,132,436	2,014,642	1,776,673	3,593,503	62,512,458				62,512,458	28,955,364	–	28,955,364			
11	2008	54,978,394	135,220	4,969,204	2,495,339	2,219,995	3,895,228	68,693,380				68,693,380	29,461,413	–	29,461,413			
12	2009	54,978,394	136,839	5,543,655	2,881,427	2,631,154	3,926,810	70,098,278				70,098,278	27,836,991	–	27,836,991			
13	2010	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	26,214,424	–	26,214,424			
14	2011	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	24,272,615	–	24,272,615			
15	2012	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	22,474,643	–	22,474,643			
16	2013	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	20,809,855	–	20,809,855			
17	2014	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	19,268,384	–	19,268,384			
18	2015	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	17,841,096	–	17,841,096			
19	2016	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	16,519,534	–	16,519,534			
20	2017	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	15,295,864	–	15,295,864			
21	2018	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	14,162,837	–	14,162,837			
22	2019	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	13,113,738	–	13,113,738			
23	2020	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	12,142,350	–	12,142,350			
24	2021	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	11,242,917	–	11,242,917			
25	2022	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	10,410,108	–	10,410,108			
26	2023	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	9,638,989	–	9,638,989			
27	2024	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	8,924,990	–	8,924,990			
28	2025	54,978,394	136,839	5,998,290	3,239,343	3,013,694	3,926,810	71,293,369				71,293,369	8,263,880	–	8,263,880			
	Total	691,988,681	1,645,364	58,493,958	30,864,646	28,309,478	43,600,725	799,787,620	90,091	4,560	94,651	799,692,969	313,623,562	96,463	313,527,099			
	Net present value		313,527,099															
	Internal rate of return		208%															
	Discount rate		0.08															
	IRR guess		0.5															

YEAR	CPI (1996=100)		Exchange rate
	Australia	Philippines	(P/A$)
1996	1.00	0.95	20.52
1997	1.00	1.00	21.93
1998	1.00	1.00	21.93
1999	1.00	1.00	21.93

Considering all types of livestock included in this study, the adoption of leucaena as forage in beef cattle or cattle fattening yields the highest benefit of A$692 million, followed by goat. Losses are incurred in hog fattening which may be partly due to the biological limitations of monogastric animals in their intake of leucaena.

If the cost of research is accounted for, the net return is A$799.7 million and the net present value is A$313.6 million, using an 8% discount rate. The research pay-off to new leucaena is 208% (Table A6).

Table A6. Summary of benefits, net present values and internal rate of return base case scenarios ($A'000)

	Unit cost ($A/t)	Reduction (%)	Benefits total
A. Forage			
Cattle beef	516.19	15.85	691,988.7
Cattle dairy	15.09	6.68	1,645.4
Goat fattener	139.03	5.83	43,600.7
B. Leaf meal			
Hog (fattener)	–4.45	0.24	58,494.0
Chicken broiler	15.11	1.10	30,864.6
Chicken layer	1.83	2.13	28,309.5
Gross total			799,797.6
Research costs			94.6
Net benefit			799,693.0
Present values			
Benefit			313,623.6
Cost			96.5
Net benefit			313,527.1
IRR (%)			208
Discount rate (%)			8.00

There are other important yet unquantifiable gains to the new leucaena research—fuelwood, some organic fertiliser, charcoal, and soil erosion control.

If the contribution to research investment is accounted for, 95% of the benefits is attributed to ACIAR and 5% to BAI-NDA. This attribution is based on the proportional share of ACIAR and BAI-NDA to total investment in new leucaena research in the Philippines (Table A7).

Table A7. New leucaena research expenditure by source

Agency	Amount (A$)	%
ACIAR	90,091	95
BAI–NDA	4,560	5
Total	94,651	100

6 Conclusions

Given the substantial high pay-off of new leucaena research, it is imperative to continue on with the extensive propagation of the new leucaena hybrid, KX2, under the present BAI–NDA project. The problem is not so much in the adoption of producers of forage animals as in the case of ruminants where continuous supply of large volume is required by feedmillers for processing into leaf meal. Most of the feedmillers are on the island of Luzon but the larger physical area for new leucaena cultivation is on Mindanao island. If a bigger volume of the new leucaena is sourced from Mindanao, pricing of new leucaena can be a constraint to its adoption as leaf meal ingredient. The marketing aspects should also be considered if the new leucaena is to be widely propagated.

Annex A Adoption rates of new leucaena (KX_2) by type of livestock, Philippines

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Forage																
Cattle fatteners	0.06	0.10	0.15	0.23	0.31	0.36	0.41	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Dairy cattle		0.06	0.10	0.19	0.28	0.36	0.41	0.45	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Goat fatteners		0.05	0.09	0.14	0.21	0.27	0.32	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Leaf meal																
Hogs		0.02	0.06	0.09	0.18	0.26	0.32	0.39	0.44	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Broilers		0.03	0.07	0.11	0.19	0.28	0.34	0.42	0.48	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Layers		0.03	0.08	0.12	0.22	0.31	0.37	0.47	0.55	0.63	0.63	0.63	0.63	0.63	0.63	0.63

Annex B Comparative cost analysis of producing beef cattle, before and after research, 1997[1]

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH		AFTER RESEARCH	
			Quantity	Value	Quantity	Value
COST OF PRODUCTION						
LABOUR COST			71	323.77	79	357.97
Planting	A$/day	4.56	–	–	1	2.28
Cutting and propagation	A$/day	4.56	–	–	2	9.12
Cultivation and weeding	A$/day	4.56	–	–	3	13.68
Cut and carry	A$/day	4.56	19	86.64	20	91.20
Feed preparation	A$/day	4.56	10	45.60	11	50.16
Feeding	A$/day	4.56	7	31.92	7	31.92
Bathing	A$/day	4.56	5	22.80	5	22.80
Pasturing	A$/day	4.56	25	114.00	25	114.00
Shed/Barn cleaning	A$/day	4.56	5	22.80	5	22.80
FEEDS[2]				431.38		398.32
Commercial feeds	A$/kg	0.33	500	165.30	400	132.24
Cogon grass/hay/leucaena	A$/kg	0.23	1,167	266.08	1,167	266.08
PURCHASES				476.35		476.35
Acquisition cost	A$/head	476.35	1	476.35	1	476.35
TOTAL VARIABLE COST	A$/head			1,231.50		1,232.64
FIXED COSTS				5.93		5.93
Land rental	A$/head			–		–
Depreciation	A$/head			5.93		5.93
Management cost	A$/head			–		–
TOTAL COST	A$/head			1,237.43		1,238.57
TOTAL COST PER UNIT	A$/mt			3,256.39		2,740.19
UNIT COST REDUCTION	A$/mt					516.19
TOTAL REVENUE	A$/mt	2,745.18	0.380	1,043.17	0.452	1,240.82
Increase in yield						18.95%
Unit cost reduction						–15.85%

ASSUMPTIONS:
1 On per head basis unless stated otherwise.
2 Commercial feed consumption after research is 20% lower; roughes consist of leucaena, cogon, and other grasses.
Exchange rate 21.93

Cost reduction (summary)	k	P(S)	K
PHILIPPINES			
CAR	516.19	1.00	516.19
Ilocos	516.19	1.00	516.19
Cagayan Valley	516.19	1.00	516.19
Central Luzon	516.19	1.00	516.19
Southern Tagalog	516.19	1.00	516.19
Bicol	516.19	1.00	516.19
Western Visayas	516.19	1.00	516.19
Central Visayas	516.19	1.00	516.19
Eastern Visayas	516.19	1.00	516.19
Western Mindanao	516.19	1.00	516.19
Northern Mindanao	516.19	1.00	516.19
Southern Mindanao	516.19	1.00	516.19
Central Mindanao	516.19	1.00	516.19
ARMM	516.19	1.00	516.19
CARAGA	516.19	1.00	516.19
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

Annex C Comparative cost analysis of producing dairy milk, before and after research, 1997[1]

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH		AFTER RESEARCH	
			Quantity	Value	Quantity	Value
COST OF PRODUCTION						
LABOUR COST			30.1	137.26	35.6	162.34
Planting	A$/day	4.56	–	–	0.50	2.28
Cutting and cultivation	A$/day	4.56	–	–	0.50	2.28
Cultivation and weeding	A$/day	4.56	–	–	3.00	13.68
Cut-and-Carry	A$/day	4.56	7.53	34.34	7.53	34.34
Feed preparation	A$/day	4.56	3.96	18.06	3.96	18.06
Feeding/pasturing	A$/day	4.56	12.67	57.78	12.67	57.78
Bathing/barn cleaning	A$/day	4.56	1.98	9.03	1.98	9.03
Milking	A$/day	4.56	3.96	18.06	3.96	18.06
FEEDS				285.01		225.72
Commercial feeds	$/head			285.01		142.50
Grass/hay/leucaena	$/head			–		83.22
PURCHASES				–		–
Acquisition cost	$/head			–		–
OTHER COSTS				75.70		75.70
Power, light and water	$/head			1.82		1.82
Medicines	$/head			20.52		–
Housing	$/head			–		9.12
Miscellaneous (tools, supplies, etc.)	$/head			9.12		44.23
Coop dues/interest on capital	$/head			44.23		463.76
TOTAL VARIABLE COST	$/head					
FIXED COSTS				13.68		13.68
Land rental	$/head			–		–
Depreciation	$/head			13.68		13.68
Management cost	$/head			–		–
TOTAL COST	$/head			511.64		477.44
TOTAL COST PER UNIT	$/mt			225.79		210.70
UNIT COST REDUCTION	$/mt					15.09
TOTAL REVENUE	$/mt	433.20	2.266	981.63	2.266	981.63
Increase in yield						0.00%
Unit cost reduction						–6.68%

ASSUMPTIONS:
1 On per head basis unless stated otherwise.
2 Commercial feed consumption after research is 20% lower; roughes consist of leucaena, cogon, and other grasses.
Exchange rate 21.93

Cost reduction (summary)	k	P(S)	K
PHILIPPINES			
CAR	15.09	1.00	15.09
Ilocos	15.09	1.00	15.09
Cagayan Valley	15.09	1.00	15.09
Central Luzon	15.09	1.00	15.09
Southern Tagalog	15.09	1.00	15.09
Bicol	15.09	1.00	15.09
Western Visayas	15.09	1.00	15.09
Central Visayas	15.09	1.00	15.09
Eastern Visayas	15.09	1.00	15.09
Western Mindanao	15.09	1.00	15.09
Northern Mindanao	15.09	1.00	15.09
Southern Mindanao	15.09	1.00	15.09
Central Mindanao	15.09	1.00	15.09
ARMM	15.09	1.00	15.09
CARAGA	15.09	1.00	15.09
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

Annex D Comparative cost analysis of producing goat, before and after research, 1997[1]

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH		AFTER RESEARCH	
			Quantity	Value	Quantity	Value
COST OF PRODUCTION[1]			79	360.25	85.5	389.89
Planting	A$/day	4.56	–	–	1	2.28
Cutting and propagation	A$/day	4.56	–	–	2	9.12
Cultivation/weeding	A$/day	4.56	–	–	3	13.68
Cut-and-carry	A$/day	4.56	19	86.64	20	91.20
Feed preparation	A$/day	4.56	10	45.60	10	45.60
Feeding/pasturing	A$/day	4.56	40	182.40	40	182.40
Bathing	A$/day	4.56	5	22.80	5	22.80
Shed/barn cleaning	A$/day	4.56	5	22.80	5	22.80
FEEDS[2]				210.22		188.33
Commercial feeds	A$/kg	0.46	96	43.78	48	21.89
Mineral lick	A$/24 heads			2		2
Grass/dayami/leucaena	A$/24 heads			164		164
PURCHASES	A$/24 heads	44.27	24	1,062.50		1,062.50
Aquisition Cost				1,062.50	24	1,062.50
OTHER COSTS				154.27		154.27
Power, light and water	A$/24 heads			74		74
Medicines	A$/24 heads			34		34
Housing	A$/24 heads			36		36
Miscellaneous (rope, etc)	A$/24 heads			9		9
TOTAL VARIABLE COST	A$/24 heads			1,787.24		1,794.99
FIXED COSTS				0.05		0.05
Land rental	A$/24 heads			–		–
Depreciation	A$/24 heads			–		–
Management cost	A$/24 heads			0.05		0.05
TOTAL COST	A$/24 heads			1,787.28		1,795.04
TOTAL COST PER UNIT	A$/mt			2,482.34		2,331.46
UNIT COST REDUCTION	A$/m					150.88
TOTAL REVENUE[3]	A$/mt	3,420.07	0.72	2,462.45	0.77	2,633.18
Increase in yield						6.93%
Unit cost reduction						–6.08%

ASSUMPTIONS:
1 Production costs and returns based on estimates for a 24-head goat fattening farm of Asia Specialist Kompanie, Inc.
2 Commercial feed consumption decreases 50% after research; forage includes leucaena valued at same cost.
3 Average weight per head before research is 30.0 kg. After research, average weight is 2.08 kg heavier, a gain of 260 g/month.
Exchange rate 21.93

Cost Reduction (Summary)	k	P(S)	K
PHILIPPINES			
CAR	150.88	1.00	150.88
Ilocos	150.88	1.00	150.88
Cagayan Valley	150.88	1.00	150.88
Central Luzon	150.88	1.00	150.88
Southern Tagalog	150.88	1.00	150.88
Bicol	150.88	1.00	150.88
Western Visayas	150.88	1.00	150.88
Central Visayas	150.88	1.00	150.88
Eastern Visayas	150.88	1.00	150.88
Western Mindanao	150.88	1.00	150.88
Northern Mindanao	150.88	1.00	150.88
Southern Mindanao	150.88	1.00	150.88
Central Mindanao	150.88	1.00	150.88
ARMM	150.88	1.00	150.88
CARAGA	150.88	1.00	150.88
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

Annex E Comparative cost analysis of growing hog, before and after research, 1997[1]

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH		AFTER RESEARCH	
			Quantity	Value	Quantity	Value
COST OF PRODUCTION						
LABOUR COST			17.3	9.85	17.3	9.85
Feed preparation	A$/hour	0.57	3.46	1.97	3.46	1.97
Feeding	A$/hour	0.57	8.64	4.92	8.64	4.92
Bathing	A$/hour	0.57	3.46	1.97	3.46	1.97
Shed/Barn cleaning	A$/hour	0.57	1.73	0.98	1.73	0.98
FEEDS[2]				60.57		59.59
Before research						
Starter	A$/kg	0.49	24	11.79		
Grower	A$/kg	0.42	78	32.79		
Finisher	A$/kg	0.41	39	15.99		
After research						
Starter	A$/kg	0.46			24	10.94
Grower	A$/kg	0.42			78	32.79
Finisher	A$/kg	0.41			39	15.85
PURCHASES	A$/head	72.96		72.96		72.96
Acquisition cost			1	72.96	1	72.96
OTHER COSTS						
Power, light and water	A$/head			15.28		15.28
Medicines	A$/head			5.70		5.70
Repair and maintenance	A$/head			2.74		2.74
Miscellaneous	A$/head			2.28		2.28
				4.56		4.56
TOTAL VARIABLE COST				158.66		157.68
FIXED COSTS				0.05		0.05
Land rental						
Depreciation						
Management cost				0.05		0.05
TOTAL COST				158.70		157.72
TOTAL COST PER UNIT	A$/mt			1,867.09		1,855.54
UNIT COST REDUCTION	A$/mt					11.55
TOTAL REVENUE	A$/mt	2,959.50	0.085	251.56	0.085	251.56
Increase in yield						0.00%
Unit cost reduction						–0.62%

ASSUMPTIONS:
1 Costs are based on farm cost of production and income as of July 1997 from the Bureau of Animal Industry (BAI).
2 Commercial feed concentrates. Feed cost after research is based on feed formulation with leucaena.
Exchange rate 21.93

Cost Reduction (Summary)	k	P(S)	K
PHILIPPINES	11.55	1.00	11.55
CAR	11.55	1.00	11.55
Ilocos	11.55	1.00	11.55
Cagayan Valley	11.55	1.00	11.55
Central Luzon	11.55	1.00	11.55
Southern Tagalog	11.55	1.00	11.55
Bicol	11.55	1.00	11.55
Western Visayas	11.55	1.00	11.55
Central Visayas	11.55	1.00	11.55
Eastern Visayas	11.55	1.00	11.55
Western Mindanao	11.55	1.00	11.55
Northern Mindanao	11.55	1.00	11.55
Southern Mindanao	11.55	1.00	11.55
Central Mindanao	11.55	1.00	11.55
ARMM	11.55	1.00	11.55
CARAGA			

Cost Reduction (Summary)	k	P(S)	K
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

Annex F Comparative cost analysis of growing broiler chicken, before and after research, 1997[1]

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH		AFTER RESEARCH	
			Quantity	Value	Quantity	Value
COST OF PRODUCTION						
LABOUR COST			0.11	0.06	0.1	0.06
Feed preparation	A$/hour	0.57	0.02	0.01	0.02	0.01
Feeding	A$/hour	0.57	0.05	0.03	0.05	0.03
Bathing	A$/hour	0.57	0.02	0.01	0.02	0.01
Shed/Barn cleaning	A$/hour	0.57	0.01	0.01	0.01	0.01
FEEDS[2]			3.00	1.44	3.00	1.41
Before research						
Booster/starter/grower	A$/kg	0.48	2.57	1.24		
Finisher	A$/kg	0.45	0.43	0.19		
After research						
Booster/starter/grower	A$/kg	0.48			2.57	1.24
Finisher	A$/kg	0.39			0.43	0.17
PURCHASES				0.55		0.55
Acquisition cost	A$/head	0.55	1	0.55	1	0.55
OTHER COSTS				0.11		0.11
Power, light and water	A$/head			0.02		0.02
Medicines	A$/head			0.08		0.08
Repair and maintenance	A$/head			0.00		0.00
Miscellaneous	A$/head			0.01		0.01
TOTAL VARIABLE COST				2.16		2.13
FIXED COSTS				0.05		0.05
Land rental				–		–
Depreciation				0.00		0.00
Management cost				0.05		0.05
TOTAL COST	A$/head			2.20		2.18
TOTAL COST PER UNIT	A$/mt			1,378.05		1,362.86
UNIT COST REDUCTION	A$/mt					15.20
TOTAL REVENUE	A$/mt	1,721.44	0.0016	2.75	0.0016	2.75
Increase in yield						0.00%
Unit cost reduction						–1.10%

ASSUMPTIONS:
1 On per head basis unless stated otherwise.
2 Commercial feed concentrates. Feed cost after research is based on feed formulation with leucaena.
Exchange rate 21.93

Cost reduction (Summary)	k	P(S)	K
PHILIPPINES			
CAR	15.20	1.00	15.20
Ilocos	15.20	1.00	15.20
Cagayan Valley	15.20	1.00	15.20
Central Luzon	15.20	1.00	15.20
Southern Tagalog	15.20	1.00	15.20
Bicol	15.20	1.00	15.20
Western Visayas	15.20	1.00	15.20
Central Visayas	15.20	1.00	15.20
Eastern Visayas	15.20	1.00	15.20
Western Mindanao	15.20	1.00	15.20
Northern Mindanao	15.20	1.00	15.20
Southern Mindanao	15.20	1.00	15.20
Central Mindanao	15.20	1.00	15.20
ARMM	15.20	1.00	15.20
CARAGA	15.20	1.00	15.20

Cost reduction (Summary)	k	P(S)	K
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

Annex G Comparative cost analysis of producing chicken eggs, before and after research, 1997

ITEMS	UNIT	UNIT PRICE	BEFORE RESEARCH				AFTER RESEARCH			
			Quantity		Value		Quantity		Value	
			Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
COST OF PRODUCTION										
LABOUR COST					1.64	1.64			1.64	1.64
Feeding	A$/head				0.05	0.05			0.05	0.05
Bathing	A$/head				0.15	0.15			0.05	0.05
Shed/Barn cleaning	A$/head				1.44	1.44			1.44	1.44
FEEDS[1]					3.31	24.13			3.31	23.42
Before research										
Booster	A$/kg	0.46	2.00	–	0.92					
Starter mash	A$/kg	0.42	5.70	–	2.38					
Layer mash	A$/kg	0.45	–	54.00		24.13				
After research										
Booster	A$/kg	0.46					2.00	–	0.92	
Starter mash	A$/kg	0.42					5.70	–	2.38	
Layer mash	A$/kg	0.43					–	54.00		23.42
PURCHASES			1		1.14				1.14	
Acquisition cost	A$/head	1.14			1.14		1		1.14	
OTHER COSTS					0.81	0.81			0.81	0.81
Power, light and water	A$/head				0.05	0.05			0.05	0.05
Medicines	A$/head				0.67	0.67			0.67	0.67
Repair and maintenance	A$/head				0.09	0.09			0.09	0.09
TOTAL VARIABLE COST					6.90	26.59			6.90	25.87
FIXED COSTS					0.01	0.01			0.01	0.01
Land rental	A$/head				–	–			–	–
Depreciation	A$/head				0.01	0.01			0.01	0.01
Management cost	A$/head				–	–			–	–
TOTAL COST	A$/head				6.91	26.59			6.91	25.88
TOTAL COST PER UNIT	A$/1000 pcs.					85.9				84.06
UNIT COST REDUCTION	A$/1000 pcs.									1.83
TOTAL REVENUE	A$/1000 pcs.	105.79	0.13	0.26	13.75	27.51	0.13	0.26	13.75	27.51
Increase in yield										0.00%
Unit cost reduction										2.13%
ASSUMPTION:										

1 Commercial feed concentrates. Feed cost after research is based on feed formulation with luecaena.
Exchange rate 21.93

Cost reduction (Summary)	k	P(S)	K
PHILIPPINES			
CAR	1.83	1.00	1.83
Ilocos	1.83	1.00	1.83
Cagayan Valley	1.83	1.00	1.83
Central Luzon	1.83	1.00	1.83
Southern Tagalog	1.83	1.00	1.83
Bicol	1.83	1.00	1.83
Western Visayas	1.83	1.00	1.83
Central Visayas	1.83	1.00	1.83
Eastern Visayas	1.83	1.00	1.83
Western Mindanao	1.83	1.00	1.83
Northern Mindanao	1.83	1.00	1.83
Southern Mindanao	1.83	1.00	1.83
Central Mindanao	1.83	1.00	1.83
ARMM	1.83	1.00	1.83
CARAGA	1.83	1.00	1.83

Cost reduction (Summary)	k	P(S)	K
AUSTRALIA	–	1.00	
PAPUA NEW GUINEA	–	1.00	
VIET NAM	–	1.00	
REST OF THE WORLD	–	1.00	

An Assessment of Epizootic Ulcerative Syndrome (EUS) Research in the Philippines (PN 7660, FIS/1991/030)

M.C. Mangabat, E. Esplana and E. Sanguyo[1]

Summary

ACIAR support for epizootic ulcerative syndrome (EUS) research in the Philippines materialised with two collaborative projects with the Bureau of Fisheries and Aquatic Resources (BFAR). The first, PN 7660, was a 6-month pilot study which determined the identical relationship of red spot disease in Australia and established that EUS is caused by a single fungus, *Aphanomyces*. The second was a 4-year project, FIS/1991/030, which identified and tested the applicability in the country of an existing aquatic algicide, Coptrol™, a chelated copper chemical developed in Australia that controls algae in freshwater fishponds. So far, there are no reports of adoption of Coptrol™ in the country for several reasons: it is expensive compared with other control agents such as salt (NaCl); most affected fishes are of wild species and not commercially produced. The potential use of Coptrol™ depends upon economies of scale in the cultivation of species susceptible to EUS.

The significance of the two EUS research projects is in terms of the technical information generated; enhancement of research skills and capacity of project staff through training and the provision of research equipment; and establishment of research links between collaborating countries. The important technical information generated from the projects is as follows: establishment of a reliable model of infection through the isolation, cultivation, sporulation of pathogenic *Aponomyces* sp. under field and laboratory conditions; development of a fungal capture technique for monitoring water bodies for infection; guidelines for raising pond pH and salinity applicable in countries with EUS problems; a mechanism for the formulation and elution of acid from soils; and changes to water quality parameters. This information from the two EUS research projects has been useful in BFAR's contingency planning for continuing EUS occurrences in the Philippines. Also, several technical papers were written from the results of the EUS projects: two of have been published in refereed scientific journals and the rest mostly in workshop and conference proceedings.

1 Introduction

This ex-post assessment of the epizootic ulcerative syndrome (EUS) research in the Philippines is a follow-up of an ex-ante evaluation of the same project in Australia, Indonesia and the Philippines undertaken by the Centre for International Economics in July 1998.

1.1 EUS Disease and Its Incidence in the Philippines

EUS disease, or red spot as it is known in Australia, is a specific condition characterised by the presence of lesions and ulcers of varied appearance and size, ranging from small haemorrhagic lesions during the early stage to large, deep necrotic ulcers after destroying the underlying musculature at the later stages (Bondad-Reantaso et al. 1992). The disease occurs in cultured and wild freshwater and estuarine fishes in the Asia–Pacific region, including mudfish, catfish, gouramis, carp, theraponids, goby and mullet (Pacalibre and Mayo, no date).

1 Ms Susan Mayo of the Bureau of Fisheries and Aquatic Research (BFAR), project leader of FIS/1991/030 in the Philippines, provided useful information.

The first confirmed occurrence of EUS in the Philippines was in late 1985–early 1986. The disease recurred in 1989 and 1990 and spread to the freshwater and estuarine fishes in several provinces in five regions in Luzon island. It affected 15,000 lakeshore families in Laguna Lake in Southern Tagalog region with a 30% fall in average daily income of fishermen and caused losses also in Naujan Lake in Mindoro province. In Pangasinan province, about 5,000 ha of the Mangabol swamp supporting 75,000 people who were dependent on capture fishery and pond culture suffered 50% losses during the outbreak in 1989 and 40% in 1990. In Buguey lagoon in Cagayan province, an outbreak in December 1990 affected 50% of the total catch which in turn resulted in price decreases of 40% to 60% (Pacalibre and Mayo, no date). EUS incidence usually occurs during November–February. The Bureau of Fisheries and Aquatic Resources (BFAR) reported an outbreak in Lake Lanao in Mindanao island in early 1999 (S. Mayo, pers. comm., 1999). Another EUS occurrence was reported in three villages in the municipality of Magallanes in Eastern Visayas region in starting November 1999 (BAS 2000). Low water temperature and acid sulfate soils were suspected to be associated with EUS outbreak.

Areas affected by past and present occurrences of the EUS disease in the Philippines are summarised in Table 1 and as shown in Figure 1.

Table 1. EUS incidence (endemic areas) in the Philippines, by regions and provinces

Region/province	Region/province
I Ilocos Region	*IV Southern Tagalog*
Ilocos Norte	Laguna
Pangasinan	Quezon
II Cagayan Region	Mindoro Oriental
Cagayan	*V Bicol Regio*n
Isabela	Catanduanes
III Central Luzon	*VIII Eastern Visayas*
Bulacan	Western Samar
Pampanga	*XII Central Mindanao*
Tarlac	Lanao del Norte
Nueva Ecija	
Zambales	

The EUS occurrences in the Philippines have prompted fish health scientists to look at the possible causes of the disease, its control and prevention measures in order to lessen if not eradicate the disease. One research agency that showed interest in EUS was AC I AR.

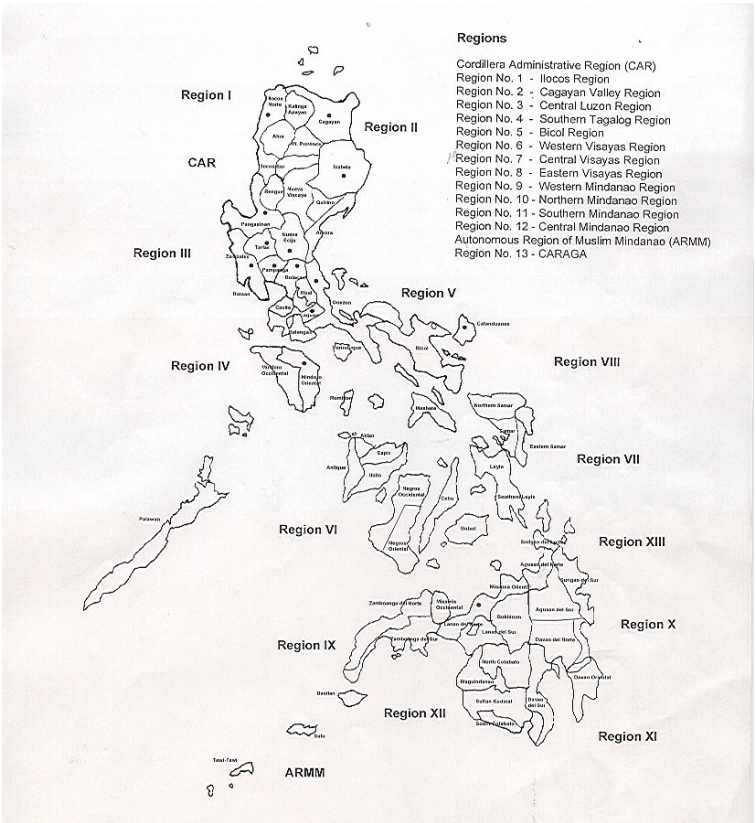

Figure 1. Map of the Philippines showing provinces (dotted) where epizootic ulcerative syndrome (EUS) occurs.

1.2 ACIAR Research on EUS

ACIAR invested in two EUS research projects in the Philippines in collaboration with the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA).

- **PN 7660.** A six-month (September 1991–February 1992) pilot study on EUS before FIS/1991/030. It was commissioned by ACIAR to the New South Wales Fisheries and in collaboration with DA–BFAR in the Philippines. The research focused on snakehead and catfish. It had a total project cost of 600,000 pesos.
- **FIS/1991/030**, 'Improving Fish Production in Freshwater Aquaculture and in Estuaries by Reducing Losses due to Epizootic Ulcerative Syndrome'. This project had a duration of 3 years (January 1993–December 1995) with an extension of one year (January–December 1996). Total research investment of ACIAR for the whole project was A$213,078.89. Fund balances were applied during the one year extension. There were four collaborating countries—Philippines, Australia, Indonesia, and India.

2.1 PN 7660

Objectives

These were:

- to determine the relationship of red spot disease in Australia with the EUS disease in the Philippines;
- to identify a technique in the isolation and culture of *Aphanomyces* sp. in EUS-infected fishes; and
- to lay down the groundwork for a future collaborative study on EUS between Australia and the Philippines.

2.1.1 Important information generated

Although there was no technology developed, the project provided important information for fish scientists.

- Findings from the project suggested that EUS in the Philippines and the red spot disease in Australia are identical and established that EUS is caused primarily by a single fungus, *Aphanomyces*.
- The project identified possible techniques in the isolation and culture of *Aphanomyces* sp. in EUS-infected fishes.

The above information helped establish the cause of the disease affecting freshwater fishes in the Asia–Pacific region. Several significant papers were written, such as Lilley et al. (1997) entitled 'Pan-Asian Spread of Single Fungal Clone Results in Large Scale Fish Kills'. This paper shows that various *Aphanomyces* isolates from the Asia–Pacific region including the Philippines, Australia and Japan are not of a single clonal type. It emphasises the importance of regulation in the international trade of aquatic organisms. There is increasing evidence that massive cross-border movement of fish for aquaculture and ornamental fish is the main cause of the EUS outbreak in the Asia–Pacific region. It is expected that these findings by Lilley et al. (1997) will come to the attention of government decision-makers. Several major programs involving the FAO and Office International de Epizootics (OIE) are being undertaken to develop effective regional health certification and quarantine guidelines. The findings of the Lilley et al. (1997) paper lend support to the importance and urgency of these initiatives by FAO and OIE (S. Mayo, pers. comm., 1998).

2.1.2 Other impacts

In addition to the above important information, the project enhanced the research skills of the project research assistant involved in PN 7660 from the BFAR. Also, several pieces of research equipment acquired through the project were left with BFAR including a Suzuki 800D, laminar flow hood, H_2O distilling apparatus with deioniser, inverted microscope, photocopier, computers and printers. This equipment, which is expected to last from 6 to 10 years, enhance the capacity of the Fish Health Section of BFAR.

2.2 FIS/1991/030

Objectives

- To develop practical, cost-effective, environmentally acceptable control and prevention measures for EUS in pond and rice–fish culture systems that would be applicable to smallholder land throughout Southeast and South Asia; and
- To identify the major causal factors for EUS in estuarine fish, with particular reference to the

possible role of run-off water from acid sulfate soil areas.

2.2.1 Information generated

There was no technology developed for the control of EUS under FIS/1991/030. It merely identified and tested the applicability of an existing technology, an aquatic algicide, with a brand name Coptrol™, which was developed in Australia (S. Mayo, pers. comm., 1998). Coptrol™ is a chelated copper chemical used to control EUS in freshwater fishponds. At present, there are no reports on the adoption of Coptrol™. First, it is expensive compared to other control agents such as salt (NaCl) which is commonly used in affected areas. Second, most of the fishes affected by EUS are of wild species and not commercially produced. These species are produced by marginal farmers or are found in lakes and other estuarine areas. The potential for the use of control lies in the economic size of the cultivation of the species susceptible to EUS.

There are several important pieces of technical information generated by the project as reported by the project leader of FIS/1991/030 (S. Mayo, pers. comm., 1997, 1999).

- Establishment of a reliable model of infection for reference of future studies. This is the isolation, cultivation and sporulation of pathogenic *Apanomyces* sp. under field and laboratory conditions. In 1991, the BFAR Fish Health Section in collaboration with Dr Richard B. Callinan of Australia, successfully isolated for the first time in Southeast Asia the fungus *Apanomyces invadans* from EUS-affected fish (Pacalibre and Mayo, no date). A model of infection is currently in use by scientists and researchers in Australia, Thailand, Scotland, the Philippines, Japan and USA.
- Based on the Philippine experience, Coptrol™ is a preventive agent for EUS. This chemical has been tried in 1997 by some marginal fishermen in Pakistan and the Indian Continent (as per information by Dr R.B. Callinan of the NSW Fisheries to the project leader of FIS/1991/030 in the Philippines).
- Development of a fungal capture technique for monitoring water bodies for infection. This is of importance for quantification in mycological research and as a basis for development of quarantine monitoring in the Philippines, Australia and Indonesia. This technique was developed by Dr Graeme Fraser and Dr Richard Callinan of the NSW Fisheries.
- Development of guidelines for raising pond pH and salinity which can be used by countries with EUS problems.
- Development of a causal relationship between acid sulfate soil and environment and pond management, a mechanism for the formulation and elution of acid from soils and changes to water quality parameters. This is currently utilised in Australia.
- The Fish Health Section of BFAR has reported several occurrences of EUS based on their monitoring in the various regions of the country in 1999. In the recent reports of regional occurrences it is suspected that tilapia, a freshwater fish, although not susceptible to EUS, is a carrier of the fungus causing the disease. The results of FIS/1991/030 have been useful in the current contingency planning of the BFAR. Accordingly, the movement of fingerlings of freshwater species susceptible to EUS, such as snakehead and catfish, will be strictly monitored by BFAR field staff.

2.2.2 Results of a field survey on EUS

A survey on EUS of a cross-section of freshwater fishermen was conducted in the endemic provinces of Bulacan, Nueva Ecija and Pampanga in Central Luzon region in 1998. A total of 21 fishermen involved in freshwater aquaculture and others who fished in creeks were interviewed to determine the extent of EUS in the said EUS endemic areas and the current farm practices to control the disease.

The sample farmers had been fishing for an average of 10 years. Farm size utilised in freshwater production ranged from 0.06 to 0.10 ha with catfish, snakehead/mudfish and carps as the dominant fish species being raised. Most of the fish farms were fully owned by the fishermen (71.43%), and the rest were either leasing their ponds or partly owned, holders of certificate of land transfer (CLT), or were fishing in creeks.

Based on the responses of sample fishermen, EUS-affected fish species were characterised by scars and wounds, decomposing body parts, sometimes chaffed skin with ulcer in the tail, and stunted growth. They reported that EUS has infected the fish farms since early 1986, reducing fish catch to

40% on average. These were also fewer buyers for affected fish.

Measures to control the disease were adopted. Most of the respondents used salt (NaCl), some used chemicals such as protocide, potassium and metaline blue. Others control the disease through natural means, that is, by changing regularly the water of the fishpond. One of the respondents reduced water in the pond, which accordingly, makes it easier for the heat of the sun to penetrate the water thereby increasing its temperature. High temperature water is less prone to EUS. Some of the respondents removed all the fish species in the pond and let the pond dry for two months (Table 2). Only one of the respondents reported that he had heard about Coptrol™ as a means of controlling EUS.

2.2.3 Barriers to the adoption of technology (Coptrol™)

Based on the survey, some of the barriers to adoption are as follows:

- salt (NaCl), which is much cheaper than Coptrol™, can cure EUS;
- there are alternative methods adopted by fishpond owners farmers such as the use of chemicals, by simply changing or reducing the water in the pond; and
- lack of a substantial campaign or extension work on the use and importance of Coptrol™ as a control agent.

Table 2. Epizootic ulcerative syndrome control by selected freshwater farmers, regions, Philippines

Measures of EUS control	No. reporting
TOTAL	21
1. Use of chemicals	4
a. Protocide	2
b. Potassium fertiliser	1
c. Metaline blue	1
2. Natural means	6
a. Regularly changing water in the pond	5
b. Reducing water in the pond	1
3. Other control	11
a. Salt	8
b. Dry the pond	2
c. Feed infected fish to animals	1

2.2.4 Other impacts

- Enhancement of research capacity

During the implementation of FIS/1991/030 four of the project staff from the Bureau of Fisheries and Aquatic Resources (BFAR), Philippines were sent to Australia to enhance their research skills. Conversely, there were two staff from the NSW Fisheries, Regional Veterinary Laboratory, Australia who came to the Philippines to enhance their research skills. Also, through FIS/1991/030 a member of the project team was able to pursue PhD studies at the University of Tasmania in Australia.

ACIAR provided the project staff the opportunity to attend international workshops and symposia which further enhanced their skills.

The project encouraged young scientists to excel in quality research with the help of collaborating foreign scientists.

- Collaborative research

The project led to the close collaborative links between collaborating agencies as good partners. There is also a spin-off benefit that includes establishment of skills and knowledge between collaborating partners which may be used in the future.

- Scientific knowledge

a. Paper published in refereed journal

Callinan, R.B.; J.O. Paclibre; M.B. Reantaso; J.C. Chin & R.P. Gogolewski. 1995. *Aphanomyces* species associated with epizootic ulcerative syndrome (EUS) in the Philippines and red spot disease (RSD) in Australia: preliminary comparative studies. Disease in Aquatic Organisms 21: 233–238.

b. Paper submitted to refereed journal

Catap, E.S.; R.B. Callinan; G.C. Fraser; S.C. Lumanlan-Mayo & J.O. Paclibare. Water quality changes associated with outbreaks of epizootic ulcerative syndrome (EUS) in rice–fish culture in the Philippines. Disease in Aquatic Organisms. In Press.

c. Papers published in conference proceedings

Callinan, R.B.; S.C. Lumanlan-Mayo; A. Rukyani and C.V. Mohan. Outcomes of collaborative research project on EUS in Australia, Indonesia, the Philippines and India: 1992–1995. Presented at the Third Symposium on Diseases in Asian Aquaculture, 29 January to 02 February 1996, Bangkok, Thailand. Diseases in Aquaculture III. In Press.

Lumanlan-Mayo, S.C.; E.S. Catap; J.O. Paclibre; R.B. Callinan & G. Fraser. Epizootic ulcerative syndrome (EUS) in rice–fish culture systems: Overview of field experiments 1993–1995. Presented at the Third Symposium on Diseases in Asian Aquaculture, 29 January to 02 February 1996, Bangkok, Thailand. In Press. Disease in Asian Aquaculture III. In Press.

Callinan; R.B., J.O. Paclibre; M.B. Reantaso; S.C. Lumamlan-Mayo; G.C. Fraser & J. Sammut. 1995. EUS outbreak in estuarine fish in Australia and the Philippines: associations with acid sulphate soils, rainfall and *Aphanomyces*. In Disease in Asian Aquaculture II. M. Shariff, J.R. Arthur & R.P. Subasinghe (eds.) p. 291–298. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

d. Papers published in workshop proceedings

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Assessment of Grain Storage Related Research in Philippine Agriculture (ACIAR PHT/1983/010, PHT/1983/014, PHT/1988/006)

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Summary

Concurrently with pesticides research conducted by the National Postharvest Research and Extension (NAPHIRE), now the Bureau of Postharvest Research and Extension (BPRE), were three storage-related research, all undertaken under the auspices of ACIAR. The first of these projects, PHT/1983/010, entitled 'Moisture Movement in Grain', addressed the problem of moisture migration associated with storage in hot humid climates in the tropics which aggravates the condition for insect development.

While PHT/1983/010 was under way, another concern needed to be addressed and that was the effect of oxygen and carbon dioxide tension in the storage atmosphere on the quality of stored grains. These issues were investigated under PHT/1983/014, 'Effect of Controlled Atmospheres on Quality of Stored Grains'. The basic data derived from PHT/1983/014 were integrated into the mathematical models of storage heat and moisture environments constructed by scientists in PHT/1983/010.

Another grain-storage-related research project was conducted following the research on the quality of stored grain. This was PHT/1988/006 entitled 'Fungi and Mycotoxins in Asian Food and Feed Stuff', which dealt with the distribution, prevalence and importance of postharvest spoilage fungi in cereals and other food and feed stuffs.

New information derived from the above three projects was used to enhance the postharvest technologies that were being developed concurrently, such as the long-term storage of grain under plastic covers in PHT/1983/007 and the integrated use of pesticides in PHT/1983/009.

1 PHT/1983/010—Moisture Movement in Grain (February 1983–December 1987)

Research activities of the project included the following:

- extensive experiments on heat and moisture transfer by natural convection in porous hygroscopic media;
- analysis through experiments on the effects of heat transfer alone and the combined effects of heat and mass transfer;
- determination of the effects of fumigants on the degree of natural convection; and
- devising and testing improved methods of storing commodities in bags and bulk.

The results of the project were tested on a laboratory scale and later in full-scale field trials under PHT/1983/007. The project provided information on the precise definition of storage conditions, particularly moisture migration which becomes an essential consideration in the development of the design of a long-term storage system for grain and other food and feed stuffs that minimises losses due to moisture problems under PHT/1983/007 (Champ, undated).

2 PHT/1983/014—Effect of Controlled Atmosphere on Quality of Stored Grains (January 1985–September 1989)

This project was closely linked with PHT/1983/007 which was concerned with the long-term storage of grain using the controlled atmosphere storage technique (CAST). The CAST was an improved storage technology for long-term grain storage in warehouses or godowns, primarily designed to minimise losses due to insect infestation. It is a controlled atmosphere storage technique wherein stacks of grains are sealed in gastight plastic enclosures such that the oxygen is reduced, while the carbon dioxide concentration is increased. Another strategy is to alter the atmosphere by introducing toxic gases (fumigants) such as phosphine (PH_3) into the enclosure. Since it is a technique for insect control in long-term storage, there were doubts, however, whether the use of this technique would affect the quality of grains during storage. Thus, PHT/1983/014 primarily aimed to determine the effects of sealed storage technique or CAST using CO_2 and PH_3 as fumigants on quality of stored maize, paddy and milled rice.

Field trials for PHT/1983/007 were undertaken in the warehouses of the National Food Authority in Cabanatuan City and Cebu City in order to determine the response in quality of stored grains or maize in terms of the following parameters: moisture content, damaged kernels, fat acidity value, milling recovery rate, head rice recovery, and chalkiness of the grain.

The results of PHT/1983/014 showed that using carbon dioxide and phosphine, the CAST is an alternative technology for long-term indoor storage of maize and milled rice with a safe level of moisture and better grain quality protection against the normal control measures. Specifically on paddy, there was no significant effect on milling recovery, head rice yield, chalkiness and fat acidity value. In milled rice, an altered atmosphere has no effect on its moisture, colour and chalkiness and cooking and eating qualities. In maize, the altered atmosphere has no significant effect on its moisture, colour, and fat acidity value. However, the use of phosphine was not recommended for milled rice because it increases chalky kernels, resulting in breakage during milling. The latter finding, however, required further investigation.

3 PHT/1988/006—Fungi and Mycotoxins in Asian Food and Feed Stuffs (1990–1992)

The project was originally proposed to be an ACIAR collaboration with the three countries of China, Thailand and Indonesia. However, owing to the political climate in China at that time following the Tiananmen Square incident in 1989, ACIAR replaced China with the Philippines as the other project site. In the Philippines, PHT/1988/006 was linked to other ACIAR-supported research such as PHT/1983/007 which dealt with the CAST as a technique for long-term indoor storage of grain and PHT/1988/045 which was concerned with outdoor storage of grain. These projects utilised the laboratory procedures developed in PHT/1988/006 for testing microbial infections of grains.

PHT/1988/006 aimed to study the distribution, prevalence, and importance of postharvest spoilage fungi in cereals and other durable commodities used in both foods and animal feeds in the Philippines. The specific objectives were the determination of the following:

- the fungal species growing in maize, peanuts, rice, mungbeans, soybeans, and black pepper;
- the significance of prevalent species of fungi as mycotoxin producers; and
- the aflatoxin status of maize and peanut.

Samples of major cereals and nut crops from major producing and consuming areas were procured from retail outlets and were subjected to laboratory test procedures developed in the earlier phase of the project. Results of these laboratory tests are as follows:

- Peanuts had the highest percentage seeds infected with fungi while mungbeans had the lowest percentage seeds infected with fungi.
- The fungi common in all grain commodities were *Aspergillus flavus*, *A. niger*, *Chaetomium* sp. and *Eurotium chevalieri.*
- Among the processed commodities, fried peanuts had the highest percentage infection while fried maize had the lowest.
- Among the commodities included in the survey, only maize and peanuts are susceptible to high levels of aflatoxin contamination.
- Aflatoxin concentrations exceeding 20 µg/kg were evident in samples of peanut and maize at

harvest and were also found in processed products which are ready for consumption.

From the results of the project, the following fungal species were found to be prevalent in maize, soybeans and rice: *Aspergillus flavus, Fusarium moniliforme, Fusarium equiseti*, and *Aspergillus candidus.* Moreover, the *Fusarium equiseti* isolate was positive for zearalenone mycotoxin and the *Aspergillus candidus* isolate was also found positive for citrinin mycotoxin production.

The data on aflatoxin generated by the project were used to support the claim that maize is heavily contaminated with aflatoxin. This led to the inclusion of aflatoxin surveillance in maize in the Medium Term Development Program of the Department of Agriculture. Moreover, the data from this project were used to support the possible presence of *Fusarium* toxins in maize and a proposal to do a further study of mycotoxins in maize was prepared (P. Sayaboc, National Postharvest Institute for Research and Extension (NAPHIRE), pers. comm., 1998).

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Storage under Plastic Covers (ACIAR PHT/1983/007, PHT/1988/045)

M.A. Ilagan and M.C. Mangabat

Summary

Two ACIAR-funded projects on grain storage were undertaken by the National Postharvest Institute for Research and Extension (NAPHIRE), now the Bureau of Postharvest Research and Extension (BPRE), with a common objective of minimising postharvest losses in grains.

The project entitled 'Long Term Grain Storage of Grain under Plastic Covers' (PHT/1983/007) addressed the problem of long-term indoor storage of grains in large commercial and government warehouses. An indoor storage system for bag-stacked grain known as the sealed enclosure fumigation storage technique (SEFST) was developed, a modification of the controlled atmosphere storage technique or CAST developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. Because of its lower cost, phosphine was substituted for carbon dioxide as fumigant. One unit of SEFST can store 325 tonnes of milled rice for a period of at least 3 months. The technology is disseminated through field demonstrations, training courses, seminar-workshops, and technological forums. The National Food Authority (NFA) adopted the technology for its stock of milled rice. This agency acquired several units from local manufacturers and distributed them to its regional warehouses. The technology is not economically feasible for individual farmers nor for small cooperatives or small traders due to volume requirement. This factor and the high capital requirement pose a problem to wide adoption of the technology. Because of this, PHT/1988/045, a sequel project, ensued.

PHT/1988/045 on 'Outdoor Storage of Grain in Plastic Enclosures in the Humid Tropics' was concerned with short-term outdoor storage of grains for farmer groups and small-scale traders. Through the project, a 'pouch type' plastic sealed enclosure for storing grains known as a local plastic enclosure, or LPE, was developed. The material used is imported polyvinyl chloride (PVC) and the enclosure is fabricated locally. It has a storage capacity of 6 tonnes of rice or maize, and a life span of 3–5 years. LPE is disseminated through similar modes as with the SEFST. More than 300 units were reported to have been distributed by PBRE through the Department of Agriculture's grain development programs. Utilisation has not yet been maximised for several reasons, such as: most of these units have been distributed only recently; other recipients have not followed properly the right procedures for storing grains; additional labour required in managing LPE; some farmers sell their grains immediately after threshing for economic reasons.

1 Introduction

Rice and maize (corn) remain the two most important grains in the Philippines. Rice is the staple food of the country while white flint maize is a staple crop in some regions and yellow maize is a major feed ingredient. Rice contributes on average 25%, the largest share, to the gross value added (GVA) in agriculture. The share of maize is 10%, the third largest.

Among the primary postharvest processes, storage is of vital importance to individual rice and maize farmers, farmer cooperatives, and traders for various reasons. Large farmer cooperatives and traders require dependable and sustainable storage facilities to accommodate large volumes, particularly during peak harvest periods. On the other hand, individual farmers store their grains for various reasons: home consumption, for seed, for animal feed, and in

anticipation of higher prices. Maranan and Dator (1993) have also noted that some maize traders store their grains while waiting for mechanical dryers and shellers to become available.

Storage facilities can be classified as indoor and outdoor. In the Philippines, individual farmers and cooperatives use several indoor storage facilities such as warehouses (concrete, semi-concrete open-sided, or wood), village halls, and even public infrastructure such as gymnasia. A more common indoor storage practice is the bag-stacked technique where 50 kilogram lots of grains, packed either in jute or polypropylene bags, are stacked inside warehouses and left uncovered for varying periods. Such practices expose these stored grains to factors such as insect and rodent infestation, microbial infection, and adverse weather conditions that often result in grain deterioration and losses due to spoilage (Paz and Cabacungan 1992). On the other hand, the most prevalent practice for outdoor storage is the ordinary (open) method using tarpaulin sheets as covers. However, this practice is susceptible to pilferage, moisture migration and mould contamination in the grain, and rodent and pest damage. Inadequate or low capacity facilities, pest infestations and mould contamination lead to greater postharvest losses.

The high investment cost associated with setting up storage infrastructures discourages storage by farmers, farmer cooperatives, and small-scale traders who handle comparatively small volumes of grains. This limits their chances of improving their income through better and higher priced grains after storage, and reduced losses from pest and rodent damage and mould contamination (Maranan and Dator 1993).

The storage problem for grains has been addressed by the government, private sector and international research funding agencies through continuous research and development (R&D) and subsequent dissemination of appropriate technologies developed. This is aimed at minimising postharvest losses. For its part, the Australian Centre for International Agricultural Research (ACIAR) through its Grain Storage Research Program, funded two research projects on long-term storage of grain under plastic covers in four Asian countries —Philippines, Thailand, Malaysia and Vietnam. ACIAR PHT/1983/007 and PHT/1988/045 were collaborative projects which involved the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, and in the Philippines, the National Postharvest Institute for Research and Extension (NAPHIRE) of the Department of Agriculture (DA) (now the Bureau of Postharvest Research and Extension, BPRE).

This paper is an assessment of PHT/1983/007 and PHT/1988/045 focusing on the technologies developed from these two research projects and their adoption. The paper commences with a brief background of the projects followed by a discussion the principal outcomes of the project and the status of the adoption of the technologies developed.

2 ACIAR Project PHT/1983/007, Long Term Storage of Grain under Plastic Covers

2.1 Project Overview

The development of a project proposal on long-term grain storage of grains under plastic covers was initiated in 1983 by the Philippine Council for Agriculture and Resources Research and Development (PCARRD) in collaboration with ACIAR. This proposal was developed fully and implemented by NAPHIRE as PHT/1983/007. Counterpart projects also existed in Thailand, Malaysia and Indonesia.

PHT/1983/007 basically sought to determine the technical applicability, economic feasibility and social acceptability of the controlled atmosphere storage technique (CAST), a method developed by the Division of Entomology of CSIRO, by using either carbon dioxide (CO_2) or phosphine (PH_3) gases as fumigants.

PHT/1983/007 is linked to a series of studies undertaken under ACIAR's Storage Grain Research Program which include (a) PHT/1983/010—Moisture Movement in Grain; (b) PHT/1983/009—Integrated Pesticide Use in Grain Storage in the Humid Tropics; and (c) PHT/1983/014—Effect of Controlled Atmospheres on Quality of Stored Grains. These projects contributed to the wider information base for treatment standards and good fumigation practice throughout the ASEAN region (Ryland et al. 1991).

2.2 Project Results

Through a series of field trials conducted at the warehouses of the National Food Authority (NFA) in Cabanatuan City and Cebu City, the CAST method has been tested and evaluated to be an effective technology for storing grains. The combined use of

bag-stack storage within well-sealed plastic enclosures and initial disinfestation with adequate dosages of either CO_2 or PH_3 can be a reliable, functional and economical pest and quality control procedure for long-term storage of milled rice and maize. However, the study showed that the use of CO_2, while providing a safe and efficient method of fumigation for milled rice and maize, tends to be too expensive for routine use in the Philippines. Thus, phosphine (PH_3), a much cheaper fumigant, was used as a substitute for carbon dioxide. Reduced levels of infestation were also recorded in several stacks except in cases of heavy infestation. In the Philippines, the new grain storage technique is now commonly called the sealed enclosure fumigation storage technique (SEFST), a local modification of the Australian CAST method.

In the conventional bag-stack method, storage of large volumes of grains is usually accompanied by sanitation and hygiene measures such as: (1) residual spraying[1]—which is usually done before stocks of grain are piled for storage to ensure safety of stocks; (2) protective spraying—which is done every 21 days during the whole storage period; (3) fumigation[2]—usually done every 3 months (twice within a 6-month storage) or as soon as internal infestation is detected in bags of stored grains; and (4) fogging[3]—which is administered only when necessary. With SEFST, a polyvinyl chloride or PVC-sheet storage consisting of a cover and floor sheet can store from 6 to 6.5 thousand bags or 325 tonnes of grains for a maximum of 12 months. This technique employs residual spraying and fumigation at least within 6 months of storage or when the need arises. The stacks are disinfested with PH_3 at the rate of 2 to 4 tablets per tonne for paddy or 1 tablet per tonne for milled rice and maize (NFA 1999b).

2.3 Costs and Returns of SEFST

Attempts were made to establish the economic feasibility of the SEFST technology. The socioeconomic component of PHT/1983/007 made use of the cost and return analysis approach whereby cost estimates and benefits of existing storage technology and the recommended technology were compared. The analysis revealed that the gain in storage using sealed enclosure is higher using phosphine PH_3 than carbon dioxide for storing milled rice, while the gain in storing the maize is also higher by using PH_3 than CO_2.

A recent economic analysis conducted by NFA on a 12-month storage period for milled rice using the conventional (bag-stack) and the sealed enclosure, showed that the cost of storage per bag is higher in the conventional (P2.76) than in the SEFST (P1.24). As depicted in Table 1, the reduction in unit cost is attributed partly to the decrease in fixed and variable costs, with a subsequent increase in milled recovery after storage (less weight loss during storage). The assumptions used in the analysis are provided in Appendix A for milled rice and for maize in Appendix B. A detailed cost analysis for milled rice is given in Appendix C.

2.4 Technology Dissemination and Adoption

BPRE played a major role in the introduction of the indoor storage technology of SEFST to potential users—NFA, private traders and grain processors, and farmer groups. A number of field demonstrations, training courses, seminar-workshops, and the TeknoTalakayan[4] were held to reach the intended clients and to put these research findings into practice. Aside from this, media exposure through television coverage like in the *Ating Alamin* Program and several communication materials—both instructional and promotional, also served as a medium for the extension of the SEFST to potential adopters. BPRE also provides technical assistance to the accredited manufacturers through the provision of blueprints and in the testing and

1. Residual and protective spraying are types of surface treatment administered as pest controls. The whole warehouse is sprayed with insecticide to prevent pest infestation or minimise the insect population if already present. The limitation of spraying is that only insects that come in contact with insecticide are killed (NFA 1999a).
2. Fumigation is simply the release of gas at sufficient concentration maintained long enough to be considered lethal to a given pest organism. This is usually practiced when internal infestation is already present among the stocks. Unlike insecticide, fumigants like methyl bromide and phosphine can penetrate grain kernels and reach pests even in the most remote hiding place, and are capable of killing insects of all stages (eggs, larvae, pupae and adults) (NFA 1999a).
3. Fogging is a type of space spray intended to kill flying and crawling insects. Fogging is necessary to supplement protective spraying. Smoke is generated inside the warehouse by vaporising the insecticides in oil solution or water emulsion. To maximise the effect, fogging should be conducted at dawn or dusk when insects are usually active (NFA 1999a).
4. *TeknoTalakayan* is an innovative type of technological forum involving technology generators and prospective users of the postharvest technology discussing the *ins* and *outs* of the said technology (BPRE 1998).

evaluation of the technology prototypes. A technical guide or 'how-to' manual on the use of SEFST was prepared and distributed by BPRE to potential users (BPRE 1998). An operational guide for sealed storage is provided in Appendix D.

Table 1. Comparative cost analysis of conventional storage and sealed storage technique for storing milled rice over a period of 12 months (NFA-owned warehouse) (as of July 1999)

Cost of pest control	Storage technique	
	Conventional storage	Sealed enclosure using PH_3
I. Direct costs		
Variable	P138,515.30	P24,460.32
Fixed	78,000.18	63,018.13
Sub-total	216,515.48	87,478.45
II. Indirect cost		
Cost of weight loss during storage	166,551.00	9,100.00
Cost of losses during blowing		
Cost of blowing/cleaning stored grain		
Sub-total	166,551.00	9,100.00
III. Total storage cost	P 383,066.48	P96,578.45
IV. Gain with sealed storage		P286,488.03
V. Estimated storage cost per bag	2.76[a]	1.24[b]
VI. Estimated gain per bag with sealed storage (with PH_3)		1.52

Source: Technology Resource Development Directorate (TRDD), National Food Authority (1999c).

Notes:
[a] No. of bags per file for conventional storage = 11,550
[b] No. of bags per file for sealed storage = 6,500

As mentioned in the ACIAR PHT/1983/007 terminal report in 1992, a number of private traders and processors and the NFA have shown strong interest in the application of the SEFST. According to the report, Nestlé Philippines, the largest local food processor, entered in a six-month collaborative project with NAPHIRE in 1988–1989 aimed at the application of the sealed stack technology using phosphine for storing soybeans. NFA pilot-tested the technique on milled rice in 1990–1991 and jointly with NAPHIRE organised a hands-on training course for its Pest Control Officers in December 1992. By conducting a series of studies on the storage life of paddy and milled rice and maize, the project researchers found that milled rice showed early signs of deterioration compared to paddy and maize after three months of being conventionally stored.

SEFST is currently used for storing milled rice by the NFA which is primarily tasked to store and maintain food security stocks to buffer trade and offset fluctuations in supply and prices of grains[5]. In 1998, NFA began adopting the SEFST with modification of its size to suit its needs. At present, some 162 units of the sealed-plastic storage have been bought by NFA from local manufacturers and redistributed to NFA regional warehouses (Table 2). Only 80 units have been fully utilised. These are reported to have stored a total of 615,555 bags of milled rice. Each unit cost P42,700 pesos (cover sheet, P26,400; floor sheet, P16,300) and has a storing capacity of 6,000 tonnes. On actual NFA operation, each SEFST material can store 6,000 to 6,500 bags of milled rice (E. Mendoza, National Food Authority, Quezon City, Philippines, pers. comm., 1999).

Also, the NFA has plans to utilise the same technology for storing maize. They are presently in the process of selecting local manufacturers that would supply the plastic storage in accordance with NFA specifications for future storage operations.

2.5 Barriers to Adoption

In the Philippines, since most of the farm operators in the country are of the small enterprise type, adoption of the technology is economically not feasible. Furthermore, the adoption of such technology is curtailed for the following reasons:

(i) High capital requirement

A unit of the sealed enclosure fumigation storage costs as much as P42,700 (cover sheet, P26,400; floor sheet, P16,300). The demand for storage facilities could arise particularly during peak harvest where low prices of grain discourage farmers from selling their harvest. Most of the farmers who opted to store showed preference for permanent storage infrastructures such as concrete warehouses despite the high cost associated with building permanent storage. Outdoor storage is more of a short-term storage practice by farmers and usually requires minimal cost of establishment and maintenance

5. The palay procurement enhancement program of the NFA aims to influence the farm market price through direct buying from farmers so as to raise their selling price at the support price level. The rice distribution program (rice injection), on the other hand, prevents retail price from going beyond the ceiling curve, thereby providing protection of consumers (NFA 1995).

(M. Andrada, National Food Authority, Quezon City, Philippines, pers. comm., 1999).

Table 2. Local distribution of the sealed enclosure fumigation storage technique (SEFST) in NFA for indoor storage of grains (as of June 1999)

Region	SEFST (CAST) material			Volume of grains stored (No. of bags of milled rice)
	Allocated	Utilised	Balance	
NCR	37	14	23	129,158
Region I	10	7	3	44,271
Region II	2		2	–
Region III	16	15	1	108,810
Region IV	–	–	–	–
Region V	10	9	1	66.676
Region VI	12	6	6	76,512
Region VII	10	6	4	33,775
Region VIII	10	5	5	40,482
Region IX	10	3	7	21,777
Region X	13	8	5	43,852
Region XI	10	3	7	19,964
Region XII	15	4	11	24,278
ARMM	10	1	9	6,000
Total	163	81	82	615,555

Source: Technology Resource Development Directorate, National Food Authority, 1999d.

(ii) Limited volume of harvest

One unit of the SEFST can store 6.5 thousand bags or 325 tonnes of milled rice for a period of at least three months. In practice, individual farmers usually store 2 to 3 tonnes of paddy in expectation of better prices for a month or so while others store their harvest for more or less than a week while waiting for a buyer or the availability of the truck to deliver their goods to grain trading centres in nearby towns, or mainly for food consumption. Demand for temporary storage is more pronounced among seed growers who usually wait for the next planting season or the opportunity to demand higher prices for their grains (M. Andrada, National Food Authority, Quezon City, Philippines, pers. comm., 1999).

(iii) Limited role of the end users in the development of the technology

NFA, being the target end user, has had limited participation in the development of the technology. Accordingly, this poses a disadvantage for them since there is the probability that the technology developed by another group of scientists will not be the appropriate one for NFA. It also encourages redundancy of work since there are possibilities that certain modifications in the design should be made in order to incorporate the technology in their actual operation (E. Mendoza, National Food Authority, Quezon City, Philippines, pers. comm., 1999).

2.6 Other Benefits from the Research

In addition to the benefits from the use of the SEFST technology, institution building, human capacity improvement, and strong linkages among government and private agencies and the scientific communities were established.

3 ACIAR Project PHT/1988/045, Outdoor Storage of Grain in Plastic Enclosures in the Humid Tropics

3.1 Project Overview

After the success of the development of the bag-stacked grain indoor storage method or SEFST under PHT/1983/007, ACIAR and NAPHIRE collaborated on a complementary grain storage project, PHT/1988/045, which catered to the needs of small farmer cooperatives. While PHT/1983/007 addressed the problem of long-term indoor storage of grains in large commercial and government warehouses, PHT/1988/045 focused on short-term outdoor storage for farmer groups and small-scale traders. This is in recognition of the situation in the Philippines wherein most farm operators are of the small enterprise type such that the establishment of capital-intensive storage facility is economically not feasible.

PHT/1988/045 in general was aimed at developing a commercially viable method of storing stacks of grains (paddy, milled rice, maize) outdoors under plastic sheeting. Phase I of the project was to assess a prototype sealed enclosure for fumigation, insect proofing and freedom from the moisture migration that results from the extreme physical conditions in outdoor storage. Phase II was to optimise the selected system in field trials, and Phase III was to test the technology in long-term field trials. The principles of large-scale (bunker) outdoor storage of dry grains developed at CSIRO were applied in developing the small-scale storage under PHT/1988/045. Also, the experience gained in PHT/1983/007 in the use of plastic enclosures was utilised in PHT/1988/045.

A similar project funded by the United States Agency for International Development (USAID) on small-scale storage of dry grains was also undertaken simultaneously by the same researcher of PHT/1988/045 at NAPHIRE. Due to volume requirements, the technology is designed for use by cooperatives and small traders who practice storage rather than small individual farmers.

3.2 Research Methods

Several techniques for sealing stacks of grains outdoor were investigated in the field. From a selection of varying types and grades of plastic sheets exposed to the rigours of outdoor storage, the best technique and the most practical method of minimising moisture migration through rice insulation was developed. A series of storage experiments was conducted to determine the effectiveness of the new technology in terms of the following measures: moisture migration, pest infestation, rice-milling yield, yellowing of paddy and mould contamination. Assessment and optimisation of the prototype sealed enclosures for fumigation, insect proofing and freedom from moisture migration were accomplished at the end of the project. However, the project team failed to establish the sustainability of the technology under long-term commercial operation.

A socioeconomic assessment on the potential adoption of the technology was also undertaken. Much information were elicited from the survey including the existing storage practices, reasons for storing and not storing grains, current storage problems, and a comparative cost–benefit analysis between the prevailing/traditional method and the outdoor storage developed from the project (ACIAR 1994).

3.3 Project Results

Project staff at NAPHIRE have developed a 'pouch type' plastic sheeting sealed enclosure for storing grains known as the local plastic enclosure or LPE. The final design incorporates a fabricated white nylon-fibre reinforced pouch-type polyvinyl enclosure of 0.6 mm thickness. The enclosure is folded at the top and clamped with two lengths of timber bolted together. Moisture condensation and moisture migration are minimised by insulating the stacks with bags of rice hulls. The LPE is said to minimise insect infestation and preserve grain quality for three months of storage.

LPE which is made of imported polyvinyl chloride (PVC) sheet (4.25 m L × 3.45 m W × 5.30 m H, 0.40 mm thickness) costs as much as P10,000 per unit with a storage capacity of 120 bags or 6 tonnes of paddy rice and maize, and has an estimated lifespan of 3 to 5 years, when properly utilised and handled. The evaluated prototype sealed enclosures can store 5.4 tonnes (109 bags) and 5.5 tonnes (110 bags) of paddy and maize, respectively. Maintenance of the enclosure while in utilisation is required to ensure the protection of stored grains from moisture condensation and insect and rodent damage (Maranan and Dator 1993; NAPHIRE 1995).

The other outputs of the project are four scientific papers from the results of the study, three of which were presented at various international conferences.

3.4 Comparative Cost Analysis of LPE and the Conventional Method

Based on the socioeconomic analysis of Maranan and Dator (1993), the local plastic enclosure is economically efficient given its costs and potential returns upon adoption. Results showed that LPE has a comparative advantage over the conventional open (tarpaulin) method in storing maize, but only a very minimal advantage for paddy (Table 3). The gain from LPE storage is higher for maize (P32.95/ bag) than for paddy (P12.01/bag). However, this advantage is primarily founded on the assumption that the price of the stored grain will increase, counteracting a decrease in weight due to the 'gastightness' of the outdoor storage compared with the conventional method.

3.5 Dissemination and Adoption of the Technology

The local plastic enclosure or LPE is one of two outdoor storages developed by NAPHIRE, now BPRE, for storing grains outdoors for a period of three months or more.[6] The LPE was introduced by BPRE as early as 1997 through field demonstrations to prospective recipients who were then evaluated and selected based on a set of criteria. Promotion and extension of the

6. The other is Volcani Cube, which was developed through a collaborative project between the Agricultural Research Organization (ARO) of Israel and NAPHIRE. The Volcani Cube was tested with higher gastightness or 'hermetic sealing' compared to the local plastic enclosure which enables it to preserve the quality of the grain and minimise insect damage (NAPHIRE 1995).

technology were accomplished through a series of accreditations, *Tekno Tokelauan*, agri-fairs and exhibits, training courses, hands-on demonstrations, and via the mass media. Communication materials were also produced and distributed to further increase the awareness of the target clientele, policy-makers, and research institutions on the potential benefits of the technology (NAPHIRE 1995; BPRE 1998). Since 1997, funds were released to local government units to enable them to procure postharvest facilities and farm equipment in preparation for the La Niña phenomenon. However, due to the delayed supply of LPE materials, only Volcani Cube units were allocated for distribution among the regions of the country directly affected by La Niña.

In continuance with the postharvest facilities and technology support component of the Grains Production Enhancement Program (GPEP), now with the banner name of *Agrikulturang Makamasa* (literally, Agriculture for the Masses), LPEs were distributed to farmer cooperatives. Based on a list from BPRE (Table 4), some 336 units were distributed to farmer cooperatives in the different regions (BPRE 1999).

A survey on actual adoption of the local plastic enclosure was conducted from November to December of 1999. The survey covered several LPE recipients from the provinces of Bulacan, Nueva Ecija, South Cotabato, Saranggani and Bukidnon. Out of the total visited area, only 15 respondents were successfully interviewed. Results revealed that 9 of the 15 respondents were actually using the LPE, but two of them have not followed the right procedure of storing grains using the technology. Some have used the storage as an extension of their solar dryer while some prefer to use them as temporary shelter/cover for dry grains stacked outside their warehouses. Most of the recipients have utilised the units for only a short period, from 2 days to 2 weeks, for various reasons. Most of the farmer cooperatives interviewed expressed preference to sell their harvest right after threshing due to the following reasons: absence of mechanical dryers; immediate cash requirement for payment of loans; and they need the income to support their family. Some of the information elicited from the survey include actual storage requirements, existing storage facilities, percentage usage of storage facilities, cost analysis of storage practices and impressions on the new technology. Their storage requirement varies with a number of factors—volume of harvest, prices of grains, existing facilities, and existence of grain traders/buyers. It was observed, however, that while some cooperatives expressed their need for extra storage, the information they provided during the survey indicated that their existing storage facilities, e.g. warehouse, have not been fully utilised. There is a need to assess further the utility of the technology, and whether it is appropriate for small farmer enterprises.

The LPE is commercially available through local manufacturers who import the PVC material and fabricate it locally following the recommended specification of BPRE. BPRE is also distributing a manual on the use of the outdoor storage where the

Table 3. Comparative financial analysis of storing maize and paddy using the local plastic enclosure and the conventional (open tarpaulin) method

Cost item	Local plastic enclosure		Conventional method	
	Maize	Paddy	Maize	Paddy
Initial investment cost	P5,840.00	P5,840.00	P4,200.00	P4,200.00
Fixed cost per batch	1,206.53	1,206.53	1,099.00	1,099.00
Variable cost per batch	675.68	671.97	804.16	579.73
Total storage cost per batch	1,882.21	1,878.73	4,200.00	1,678.73
Total storage cost per bag	17.11	17.23	21.71	16.16
Total initial value of maize/paddy per batch	28,600.00	29,991.50	1,903.16	31,644.00
Total final value of maize/paddy per batch	47,993.75	42,719.10	23,800.40	42,302.30
Net profit after storage per batch	16,233.54	9,499.87	10,051.02	7,555.59
Net profit after storage per bag	147.58	87.11	114.63	75.10

Source: Maranan and Dator (1993).

specification and the methods of storing are discussed.

Table 4. Distribution of the local plastic enclosure outdoor storage, Bureau of Postharvest Research and Extension implemented (as of August 1999)

Region/Province	No. of local plastic enclosure
TOTAL	**334**
Cordillera Autonomous Region (CAR)	2
Abra	2
Region I	**26**
Pangasinan	8
La Union	2
Ilocos Norte	10
Ilocos Sur	6
Region II	**46**
Cagayan	4
Quirino	4
Isabela	38
Region III	**74**
Bataan	4
Bulacan	18
Nueva Ecija	28
Zambales	2
Pampanga	8
Tarlac	14
Region IV	**48**
Aurora	2
Batangas	2
Cavite	4
Laguna	8
Mindoro Oriental	4
Mindoro Occidental	2
Romblon	2
Quezon	12
Palawan	12
Region V	**24**
Camarines Norte	2
Camarines Sur	16
Albay	2
Sorsogon	2
Masbate	2
Region VI	**6**
Iloilo	4
Negros Occidental	2
Region VII	**4**
Bohol	2
Negros Oriental	2
Region VIII	**6**
Leyte	6
Region IX	–
Region X	**38**
Bukidnon	38
Region XI	**32**
South Cotabato	16
Saranggani	12
Davao Sur	4
Region XII	**12**
Cotabato	6
Sultan Kudarat	4
Lanao del Norte	2
Autonomous Region in Muslim Mindanao (ARMM)	**8**
Lanao del Sur	6
Maguindanao	2
Caraga	**8**
Agusan del Sur	4
Agusan del Norte	2
Surigao del Norte	2

Source: Bureau of Postharvest Research and Extension, 1999.

3.5 Barriers to Adoption

Some of the limiting factors in the adoption of the LPE were cited in the preliminary survey of actual utilisation of the said technology. They include:

1. Unavailability of the PVC material locally

   The polyvinyl chloride (PVC) material used in the fabrication of the outdoor storage is imported. Local producers act mainly as middlemen, they negotiate the price and are responsible for importing the material.

2. Increased labour requirement

   It requires at least two to three persons to manage the LPE system in order to store grain properly, making it inconvenient for individual farmers to adopt the technology. Some farmers have to hire additional labour which entails additional cost.

3. Limited capacity

   For individual farmers who cultivate an average of 2–3 hectares of farm land with an average harvest of 90 bags per hectare, a single unit would suffice to meet the demand for temporary storage. However, it would not be economically efficient for those who cultivate less than or more than 2–3 hectares.

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APPENDICES

Appendix A

Analysis of costs of conventional and sealed storage techniques for storing 6000 bags of milled rice for 8.5 months, in Philippine pesos.

Cost of pest control	Storage technique		
	Conventional	Sealed enclosure	
		with CO_2	with PH_3
I. Direct costs			
Variable	13,560.46	20,224.61	4,789.91
Fixed	28,121.00	29,782.45	26,552.95
Sub-total	41,681.46	50,007.06	31,342.86
II. Indirect costs			
Losses due to insects	13,477.50	1,080.00	4,500.00
Losses due to remilling	44,730.45	0.00	0.00
Cost of remilling	116,895.60	0.00	0.00
Cost of handling	7,395.43	0.00	0.00
Sub-total	182,498.98	1,080.00	4,500.00
III. Total storage cost	224,180.44	51,087.06	35,842.86
IV. Gains with sealed storage		173,093.38	188,337.58
V. Estimated storage cost per bag			
Conventional	37.36		
Sealed storage with CO_2	8.51		
Sealed storage with PH_3	5.97		
VI. Estimated gains per bag with sealed storage			
Sealed storage with CO_2	28.85		
Sealed storage with PH_3	31.39		

Source: ACIAR PHT/1983/007: Philippine Terminal Report.

Appendix B

Analysis of costs of conventional and sealed storage techniques for storing 5000 bags of maize over a period of 5 months, in Philippine pesos.

Cost of pest control	Storage technique		
	Conventional	Sealed enclosure	
		with CO_2	with PH_3
I. Direct costs			
Variable	12,280.46	17,503.54	4,639.91
Fixed	28,121.00	29,782.45	26,552.45
Sub-total	40,401.46	47,285.99	31,192.36
II. Indirect costs			
Losses due to insects	68,028.75	11,632.50	15,513.75
Losses due to blowing	52,848.56	0	0
Cost of blowing	46,976.50	0	0
Sub-total	167,853.81	11,632.5	15,513.75
III. Total storage cost	208,255.27	58,918.49	46,706.11
IV. Gains with sealed storage		149,336.78	161,549.16
V. Estimated storage cost per bag			
Conventional	51.65		
Sealed storage with CO_2	11.78		
Sealed storage with PH_3	9.34		
VI. Estimated gains per bag with sealed storage			
Sealed storage with CO_2	29.87		
Sealed storage with PH_3	32.31		

Source: ACIAR PHT/1983/007: Philippine Terminal Report.

Appendix C

Cost details used in the cost analysis of sealed enclosure fumigation storage technique (SEFST) and the conventional method in storing milled rice over a period of 12 months (as of July 1999).

Cost details	SEFST	Conventional method
1. Investment cost (P)	6,900,000	6,900,000.00
2. Economic life (years)	25	25
3. Salvage value (%)	10	10
4. Depreciation (straight line method)		
5. Warehouse repair and maintenance (%)	1	1
6. Insurance (%)	0.825	0.825
7. Warehouse capacity (bags)	50,000	50,000
8. Warehouse dimension (20 m × 60 m × 7 m)		
9. Pile size	11m × 7.5m × 5m	22m × 7m × 5m
10. No. of piles	10	5
11. No. of bags per pile	6,500	11,550
Weight per bag (kg)	50	50
Weight of bags per pile (t)	325.00	577.50
12. Duration of storage (months)	12	12
13. Frequency of fumigation	–	4
14. Frequency of protective spraying	–	17
15. Frequency of residual spraying	1	1
16. Frequency of fogging	–	43
17. No. of days of fumigation	–	2
18. No. of days of spraying/fogging	–	–
19. Pest control team salary/wages/day		
Pest control officer (P)	622.18	622.18
Labourer	200.00	200.00
20. No. of casting days	2	–
21. Fumigating sheet/SEFST unit		
Price per unit (P)	60,000	9,400
No. of units needed	1	1
Life span (years)	1	5
22. Ladder		
Price per unit (P)	5,000	5,000
Life span (years)	5	5
23. Full face mask		
Price per unit (P)	5,000	5,000
Life span (years)	5	5
No. of units needed	1	1
24. Gas mask filter		
Price per unit (P)	2,130	2,130
No. of units needed	2	2
25. Sprayer (back-pack type gasoline-powered engine)		
Price per unit (P)	–	40,000
Lifespan (years)	–	40,000
26. Fogging machine (gasoline powered)		
Price (P)	–	90,000
Life span (years)	–	10
27. Fumigant (aluminium phosphide tablets)		
Rate of application (tablets/MT)	1	2
Price per tablet (P)	5.34	5.34
Price per 25 grams (P)	177.00	–

Appendix C (cont'd)

Cost details	SEFST	Conventional method
28. Grain protectants (pesticides)		
Actellic 25 EC (for fogging)		
Price per litre (P)	–	1,040
Rate of application (mL soln/500cu.m)	–	100
Mixing ratio (mL product/450 mL diluent)	–	100
Coopex 25 WP (for spraying)		
Price per 25 grams (P)	–	177
No. of Coopex needed/pile (protective)	–	5
No. of Coopex needed/pile (residual)	23	23
Amount of chemicals needed/fogging (L)	–	0.33
Rate of application (L soln/100 sq.m)	–	5
Mixing ratio (gram product/5L water)	–	25
29. Hand gloves (plastic disposable)		
Price per pair (P)	25	25
No. of pairs needed	12	12
30. Phosphine detector tubes, cost per box (P)	3,500	
31. Plastic hose	5	
Cost per metre (P)	20	–
No. of metres needed		–
32. Mastic gun		
Cost per unit	200.00	–
No. of units needed	2	–
33. Silicon sealant		
Cost per tube	300.00	–
No. of tubes needed	1	–
34. Paint brush		
Price (P)	30	–
No. of pieces needed	4	–
35. PVC solvent glue		
Price (P)	300.00	–
No. of litres needed	4	–
36. Manometer		
Cost per unit (P)	30	–
No. of units needed	1	–
37. Pest control equipment could serve 10 piles at a time		
No. of turnover per year	1	1
Optimum no. of piles served per year	1	10
38. Fuel consumption		
No. of litres needed: Residual spraying	1	1.0
Protective spraying	–	0.3
Fogging	–	1.0
Price per litre (P)	12.78	12.78
39. Diluents (fogging)		
No. of litres needed	–	0.27
Price per litre (P)	–	8.87
40. Pile set-up		
No. of move(s) from truck to pile	1	1
Cost per move (P)	1.00	1.00
41. Loss due to blowing, 95% purity (%)		
42. Cost of blowing per kg (P)	0	0
43. Wt. loss (365 days) — TRDD study (%)	0.2	2.06
44. Selling price per kg (P)	14	14

Appendix D Operational Guide for Sealed Storage

1. Ensure that a hygiene program including rodent control is operating in the warehouse; if not, start one.
2. Inspect the warehouse floor for cracks. If there are cracks, patch them either with concrete or roof cement. Clean the stacking site. Sweep and properly dispose of spilled grains and dusts.
3. Ensure that the grain is dry enough for long-term storage. The maximum safe moisture content for sealed stack storage is the same as that established for safe storage in unsealed bag-stacks.

   Maximum Moisture Content (MC) for Storage

Rough rice	14%
Milled rice	12%
Maize	13%

4. Be sure enough pallets are available for the stack base. Examine the underside of all pallets and remove all sharp projections that may damage the floor sheets and cover. Pallets should be clean and dry.
5. Ensure that adequate carbon dioxide or phosphine will be available on site when the fumigation is carried out.
6. Spread out floor sheet and covers, and examine these for holes. Patch holes or damage before using these.
7. Carefully arrange the pallets on the floor sheet in such a way that a distance of at least 0.5 metres is maintained between the peripheries of the pallets and the floor sheet.
8. Build the stack on the pallet. Stacks should always be built to the full size of the plastic cover.
9. Raise the folded cover sheet to the top of the stack. First, partially unfold the cover sheet on the floor, then hoist it up with a rope fastened on one end. If a mechanical hoist or fork lift is available, this can be of help.
10. Working from the top of the stack, fit the cover sheet over the stack. The cover sheet should be fully unfolded with its corners positioned over those of the stack. The personnel handling the sheet should lie flat on the edge of the stack and slowly drop the end of the cover starting from the corner then to the sides. At least 4 people should gradually lower the cover sheet.
11. Inspect the cover sheet. Patch all holes, weakly sealed spots and other manufacturing faults observed.
12. Using scissors, trim any excess material from the skirt of the cover sheet so that it will hang straight on the sides of the stack, and match but not exceed the width of the floor sheet. This can be easily done by folding the material and running the scissors along the fold to be cut.
13. Depending on how the cover sheet is made, it will be necessary to fit corner pieces. These are square patches that have to be attached to the skirt on either side of a corner so that the skirt completely surrounds the stack.
14. Identify the side of the stack through which CO_2 and phosphine gases will be introduced under the pallet. Fix the gas and temperature sampling and gas introduction ports (for CO_2 fumigation).
15. Sweep any spilled commodity on the floor sheet then wipe it with a damp cloth. This will ensure a good seal.
16. Glue the cover sheet to the floor sheet to bond of about 2.5 cm. Fast drying PVC glue can be used for this purpose.
17. Pressure-test the enclosure. Attach gas sampling line manometer. Connect a vacuum cleaner to the gas introduction port so that air is sucked and a negative pressure of 500 pascals is created. Once this pressure is reached, stop vacuum cleaner. Observe and measure the time taken for the negative pressure of 500 pascals (5 cm of water gauge) to drop to 250 pascals (2.5 cm of water gauge). The target is 15 minutes or more, with 10 and 5 minutes being the absolute minimum acceptable for CO_2 and PH_3 fumigation, respectively. If the desired gastightness is not achieved, search for leaks, seal these and continue the test procedure until the enclosure is gastight.
18. The stack is now ready for gassing. *When using CO_2*: Insert copper gas pipe into the gas introduction port. Ensure that purge vent is open and disconnect sampling line from manometer. Add CO_2 gas until concentration of carbon dioxide at the top of the stack reaches at least 75%. Record number of cylinders used. Seal purge vent. Remove gas introduction tube and seal gassing port. *When using PH_3*: Using

scissors, cut the marked entry points for PH_3 tablets. Insert PH_3 tablets in a box then seal.

19. Measure and record gas concentration. For CO_2 fumigation, measure concentration at 5, 10, 15 days after treatment. For PH_3 fumigation at 1, 4, 7 days after treatment.
20. Display fumigation warning sign before leaving the warehouse.
21. The stack can be retained for long-term storage if: after 15 days the CO_2 concentration is at or above 35% or after 7 days the PH_3 concentration is at or above 100 ppm.
22. Ensure that the enclosure is well sealed throughout the storage period. Maintain a rodent control program and a high standard of hygiene inside the warehouse.

Equipment	*Supplies and Materials*
Plastic enclosure	1. 2 mm plastic hose
Vacuum cleaner	2. Gas detector tubes
Discharging rack	3. Silicone sealant
Gas detector pump	4. Paint brush
Ladder	5. PVC solvent glue
Plastic gun	6. CO_2 gas or PH_3 tablets

Source: NAPHIRE (1991). Primer No. 9.

An Assessment of Research on Pesticide Use in Grain Storage in the Philippines (PHT/1983/009, PHT/1983/011, PHT/1986/009, PHT/1990/009)

N.T. Yanson, J. Lantican and M.C. Mangabat

Summary[1]

Four related ACIAR research projects addressed specific issues on pesticides in grain storage. PHT/1983/009 confirmed the resistance of major beetle pests to malathion and pirimiphos-methyl. The results of PHT/1983/009 served as inputs to PHT/1983/011 which studied the kinetics of pesticide decay. It provided information on the application rates of pesticides by type of commodity, storage period, temperature, relative humidity, and moisture content. The results of PHT/1983/011 were used as bases in the experiments undertaken under PHT/1986/009 which extended its scope on pest control involving treatment of grains stored in bulk in warehouses, bag stacks, and building fabrics. The last project in the series, PHT/1990/009, developed pesticide admixtures at reduced application rates and hence, lower residue levels. Field trials on the minimum effective doses of grain protectants were verified for mungbean and maize but not for paddy.

The Bureau of Postharvest Research and Extension (BPRE) disseminates the technology by conducting training on the use of grain protectant admixture mostly participated in by farm cooperative members and non-members. Cooperative farms in one of the major mungbean producing provinces in Region I are utilising the technology but BPRE does the mixing of protectants. Dissemination has also started in the other mungbean-growing provinces of Region I. The technology was also demonstrated to maize growers in Isabela province in Region II, a major maize-producing area. It was also tested and validated by the National Food Authority (NFA), the central marketing agency for grains, but utilisation is constrained by the absence of bulk storage (godowns or elevators) in which the technology is best suited. Accordingly, future adoption by NFA would depend on the type of storage system and availability of equipment such as built-in sprayers.

BPRE also coordinated with the Fertiliser and Pesticide Authority (FPA) and chemical companies. One of the major constraints in the wide utilisation of the technology is that chemical companies are sole distributors of certain types of chemicals and registered with the FPA as single chemicals. The production and marketing of admixtures would materialise if the required chemicals are sourced from one company and registered with FPA as admixture.

1 The authors would like to thank Dr Perlina Sayaboc, project leader, and Miriam Acda, project entomologist, of the Bureau of Postharvest Research and Extension.

1 Introduction

From 1983 to 1984, ACIAR executed a series of research projects on the use of pesticides in storing grains in the tropical areas of Australia and in countries of Southeast Asia, such as the Philippines, Malaysia, China and Thailand (Table 1). It was part of ACIAR's wider program of grain storage research. In the Philippines, the research projects were undertaken by the National Postharvest Institute of Research and Extension (NAPHIRE) (now the Bureau of Postharvest Research and Extension, BPRE).

This paper complements an earlier assessment by P.D. Chudleigh (1991) which was done after the completion of PHT/1986/009. The present assessment highlights the results and impact of the last project in the series, PHT/1990/009.

2 Linkages of the Pesticides Research Projects

Before the four research projects in the Philippines, there were findings that farmers and industries were also using chemicals as grain protectants against pests. It was observed, however, that over time some pests have developed resistance to specific chemicals, particularly malathion and pirimiphos-methyl. This observation prompted the development and screening of new chemicals to be applied through the series of four projects which began with an exploratory project, PHT/1983/009. Results of a national survey which assessed the resistance of major coleopterous pests confirmed widespread resistance to malathion, especially with the presence of mixed populations of different pests on stored grains. Pirimiphos-methyl was also found to be insufficiently potent, thus preventing its use in practice. These findings shed some light on the failure of previous pest control strategies using these chemicals. The project therefore sought to screen new chemicals which are biologically effective and economical to use.

Since the studies under PHT/1983/009 focused mainly on the application of chemicals, very little information was provided on the behaviour of pesticides when exposed to high ambient humidities and moisture contents that prevail in the humid tropics. Hence, a sequel project, PHT/1983/011, was undertaken in 1984 which looked into the kinetics of decay of pesticides used, in order to determine the rates of application for a specific commodity. Laboratory analyses were conducted to determine the effects of temperature and moisture content on the stability of various insecticides during storage, the effects of processing on that stability, and using synthesised model compounds, the relation between stabilities during storage and processing, and other physical parameters. Samples from PHT/1983/009 were analysed and the results served as input to PHT/1983/011. Field trials were undertaken to compare the data obtained from commercial warehouses with those from laboratory models. Due to the difficulty of developing a synthesised model, however, project activity was confined to pesticide residue monitoring.

The data generated by PHT/1983/011 were used in the experiments undertaken under PHT/1986/009 which extended its scope on pest control involving

Table 1. ACIAR research on the use of pesticides in grain storage

Project no.	Project title	Duration	Collaborating countries	Total project cost	Commodity focus
PHT/1983/009	Integrated Use of Pesticides in Grain Storage in the Humid Tropical Countries	1 Feb 1983–31 Dec 1983	Australia, Malaysia, Philippines	A$27,429	Rice – 50% Maize – 50%
PHT/1983/011	Kinetics of Decay of Candidate Pesticides for Integrated Pest Control Programs	1 May 1984–30 June 1987	Australia, Malaysia, Philippines	A$351,900	Rice – 50% Maize – 50%
PHT/1986/009	Integrated Use of Pesticides in Grain Storage in the Humid Tropic	1 July 1987–30 June 1990	Australia, China, Malaysia, Philippines, Thailand	A$794,000	Rice – 60% Maize – 30% Legumes – 10%
PHT/1990/009	Increasing Efficiency of Integrated Pest Control in Grain Storage and Minimising Pesticide Residues by the Use of Mixtures of Grain Protectants	1 July 1991–30 June 1994	Australia, Malaysia, Philippines	A$127,500	Maize – 70% Mungbean – 30%

treatment of bulk stored grains in commercial storages, bag stacks, and building fabrics. Through the research collaborators from Queensland, Australia, basic research was focused on the evaluation of the performance of grain protectants and fabric treatments including insect-growth regulators at high grain moisture and/or relative humidity levels which are prevalent in tropical countries. These insect-growth regulators are a new class of pesticides which are seen to leave less toxic residues. Moreover, the efficacy of synergised combination of insecticides was evaluated and the commodities considered extended to legumes.

While significant progress was made through the previous three projects in developing effective treatments of pests in grain storage including the use of synergised combinations of insecticides (mixtures) to increase their efficacy, the toxicological impact of pesticide residues on health and the environment become a major public concern, particularly when used in the growing crop and in the storage and handling of harvested crop. The foreseen increasing reliance on pesticide use, especially in developing countries, paved the way for PHT/1990/009. It was aimed primarily to evaluate the use of insecticide mixtures which have potential in reducing insecticide residue levels. It was deemed that mixtures have greater potency than the utilisation of individual components thereby allowing reduced application rates and in turn reduced residue levels (Champ 1994).

3 Outcomes of the Projects

PHT/1983/009 identified two grain protectants that are biologically and economically effective—deltamethrin and chlorpyrifos-methyl (NAPHIRE, undated a). Laboratory screening showed that deltamethrin was most effective against *Rhyzopertha dominica* but not on *Sitophilus zeamais*. Chlorpyrifos-methyl was potent against *S. zeamais* but when combined with pyrethroids such as deltamethrin, the compound was most potent on *Tribolium castaneum*. Deltamethrin combined with an organophosphorous compound such as chlorpyrifos-methyl increases its efficiency against all stored product pests and is economical to use.

The efficacy or potency of the identified new protectants was tested in PHT/1990/009 in coordination with the National Food Authority (NFA). Trials were conducted in NFA warehouses. The benefit–cost ratio (BCR) for each treatment was also obtained. For paddy, treatment trials employed the bag stack treatment combined with fumigation. It was found that the most effective and economical compound used for paddy was chlorpyrifos-methyl + permethrin + piperonyl butoxide with a BCR of 7.02 (NAPHIRE, undated a). For maize, the recommended compound was fenitrothion + fenvalerate + piperonyl butoxide with a BCR of 14.07. The recommended technique was grain admixture. The trials also showed reduction in storage losses by as much as 60% using such treatment.

Incorporating relevant data and findings from PHT/1983/009, the results of PHT/1983/011 gave information on the effective dosage or rates of application of pesticides based on the type of commodity, storage period, temperature, relative humidity, moisture content, including the processing method of dehusking or shelling, as well as various cooking times and methods.

Pesticide residues were studied under PHT/1990/009 through extensive laboratory work involving culture tests of insects and bioassays on treated surfaces and grains. These investigated the efficacy of synergists (potent admixtures of chemicals such as piperonyl butoxide or PB which serve as protectants) even at reduced levels which could also reduce insecticide residue levels. The field trials included the verification of minimum effective doses of pesticides applied to maize and mungbean to obtain 100% protection. Field trials on paddy were not undertaken because supposedly these would be undertaken by the Philippine Rice Research Institute (PHILRICE) but it was not pushed through (D.P. Sayaboc and M. Acda, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000).

The pest surveys, bioassays and field trials followed the procedures developed and used in PHT/1986/009 with some modifications (NAPHIRE, undated b) The field trials also included the evaluation of fabric grain protectant treatments in bulk storage using admixtures developed in PHT/1986/009 and integrated with good storage practices including good hygiene, fumigation and other control measures. To make research relevant in the Philippines, laboratory work and field trials focused on major pest species of maize and mungbean which included *Sitophilus zeamais*, (Sz or maize weevil), *Tribolium castaneum* (Tc or rust-red flour beetle), *Rhyzopertha dominica* (Rd or grain borer), and *Callosobruchus maculatus* (Cm). The insecticides used were mixtures of organo-

phosphates such as pirimiphos methyl (PM) and fenitrothion (F); and pyrethroids such as permethrin (P), deltamethrin (D) or fenvalerate (FV). The mixtures of protectants that were evaluated and tested were PM + P, F + FV, and PM + D. The pyrethroids used were synergised with piperonyl butoxide (PB) at a rate of 10 mg/kg. The evaluation of grain protectant treatments showed that there is strong synergism among these protectants such that it was effective on *S. zeamais* rather than *R. dominica*. The recommended mixtures for the latter pest species were F + FV and PM + D (Table 2). Based on field trials conducted, the efficacy of these mixtures of protectants was 100% mortality of *R. dominica*, *S. zeamais*, and *T. castaneum* for at least 3 months. For mungbean, the treatments gave complete control of *Callosobruchus macalatus* adults at least for three months. It was found that reducing the application rates of these mixtures below the rates at which 100% protection was attained for three months storage to reduce residues, is not feasible because it will reduce its potency level (NAPHIRE, undated c).

The maximum residue limits (MRLs), the dosage rates and residue before and after research are summarised in Table 3. The reduction in application rates that would still maintain the potency of the protectants range from 10% (deltamethrin) to 67% pirimiphos methyl). With reduced levels of the chemicals, residues after storage were also reduced, ranging from 5% (permethrin) to 76% (pirimiphos methyl).

4 Developments

One and a half year after the completion of PHT/ 1990/009 in June 1994, a team from the Grain Crop Operations Ltd, Australia and the National Economic Development Authority (NEDA) in the Philippines was commissioned to conduct a review and assessment of the project. The recommendations of the team focused on how the results of the project can be disseminated. To date, some of these recommendations as listed below have already been addressed by BPRE (D.P. Sayaboc and M. Acda, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000).

a. *Extensive training of the grain producers and cooperatives with the aim of achieving maximum benefits of the research.* As part of BPRE's extension program, training on the use of the grain protectant admixture are conducted three times a month. Most of the training

Table 2. Reduction in F_2 progeny of test insects on maize treated with combinations of protectants at different storage periods

Treatments*	T0			T1.5			T3.0			T4.5		
	Rd**	Sz	Tc	Rd	Sz	Tc	Rd	Sz	Tc	Rd	Sz	Tc
PM + D + PB	100	100	100	100	100	100	100	100	100	100	100	100
PM + P + PB	100	100	100	100	100	100	100	100	100	99	100	98
F + FV + PB	100	100	100	100	100	100	100	100	98	100	100	99

T = duration of storage in months, e.g. 0, 1.5, 3.0 and 4.5 months.
* PM = pirimiphos methyl, D = deltamethrin, P = permethrin, F = fenitrothion, FV = fenvalerate, PB = piperonyl butoxide.
**Rd = *Rhyzopertha dominica*, Sz = *Sitophilus zeamais* and Tc = *Tribolium castaneum*.
Adapted from Sayaboc et al. (1998).

Table 3. Maximum residue limits (MRLs), dosage rates and residue after storage of different grain protectants

Grain protectants	MRL (mg/kg)	Dosage rates (mg/kg)			
		Previous rates	Residue after storage	Reduced rates	Residue after storage
Deltamethrin	2.0	1.0; 0.4	0.14; 0.06	0.10	0.015
Fenitrothion	10.0	12.0; 10	0.32; 0.11	6.00	0.19
Fenvalerate	5.0	1.0	0.11	0.50	0.005
Permethrin	2.0	1.0	0.075	0.50	0.004
Pirimiphos methyl	10.0	6.0; 8.0	0.5; 1.59	4.00	0.38; 0.33

Adapted from Sayaboc et al. (1998).

participants are members of farm cooperatives and non-members.

b. *Transfer of the research output to end users*. BPRE coordinated with the NFA, the Fertiliser and Pesticide Authority (FPA), private chemical companies, and cooperatives concerning the application of the technology to end users. A meeting with the chemical companies was held in September 1999. Since the chemical companies carry only certain types of chemicals and do not mix them, especially when these chemicals are not produced by them, BPRE is considering packaging the admixture itself to make it ready by for use, especially by farmers of mungbean and maize. Also, chemical companies are not sure of the demand for ready-mixed chemicals which may not warrant their preparation and marketing of the product.

   By function, BPRE's focus is basic to midstream research while midstream to upstream research shall be done by the regional field units of the Department of Agriculture, the NFA and the local government units (LGUs)[1].

c. *A regular program of pesticides resistance screening.* So far, BPRE conducts screening of pesticides but not resistance screening because of limited resources. The latter activity may be conducted by BPRE should sufficient funds become available.

5 Adoption of the Technology

As part of BPRE's commitment to the dissemination of the admixture technology, the agency took the lead in introducing and conducting field demonstrations from the preparation and application of the admixture to mungbean growers in the municipality of Urdaneta, Pangasinan province in Region I. These mungbean growers are organised as cooperatives. They became aware of the technology during previous training conducted by BPRE. Farmer members of the cooperatives, however, have not yet fully gained the skill of preparing the mixture. They still continue to seek the assistance of the pesticide project staff in the preparation of the admixture each time that they apply the technology. The project leader perceives that this situation is not sustainable because the availability of BPRE staff may not be assured each time that they are needed, due to other commitments. Farmers, however, are hopeful that the admixture would become available in the market (D.P. Sayaboc, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000).

Moreover, the BPRE management has provided some funds for extending the pilot-testing on the actual application of the technology to mungbean growers in other provinces of the Ilocos region. This region is also noted for mungbean production.

With regard to the application of the admixture technology for bulk storage of maize, the project staff have started field demonstrations on the use of the admixture technology to maize farmers in Isabela province of Region II which was the pilot area for PHT/1990/009. The project staff will be extending the field demonstrations to maize traders and grain cooperatives in that province which is one of the major maize producers in the Philippines.

Another breakthrough of PHT/1990/009 is an on-going research study by the BPRE in the major maize growing areas in Mindanao with regards to bulk handling of maize. This study incorporated the results of ACIAR's pesticides research, particularly the results of PHT/1990/009. This research was expected to be finished by the end of 2000 (D.P. Sayaboc and M. Acda, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000).

6 Major Concerns on the Application of the Technology

The wide application of the technology developed by the project is constrained by several factors (D.P. Sayaboc, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000).

a. Being the central marketing for grains in the country, the NFA is a major end user of integrated pest management (IPM) technology. NFA is fully aware of the new IPM—pesticide admixture—developed by BPRE, since this was already tested and validated by the former agency's research operation staff. However, the agency's utilisation is constrained by the absence of bulk storage or handling (godowns or elevators) in which the new IPM technology is best suited. NFA is currently using the results of their own IPM research which are

1. Since the devolution 1997, field agricultural officers are now administratively under the supervision of the local government units.

specifically designed to suit their needs. Future adoption by the NFA of the new IPM developed by BPRE is deemed necessary and would depend on the type of the storage system and the availability of equipment such as built-in sprayers. It was also expressed that since NFA was among the target users, the agency should have been included in the implementation of the project so that the technology developed would also be suited to its needs (C. Mangaong, National Food Authority, Quezon City, Philippines, pers. comm., 1998, 2000).

b. The new pesticide admixture developed by the project is not readily available for use since it requires mixing by the end users. The chemicals are registered with the FPA as single chemicals. As stated earlier, chemical companies are constrained to mass-produce the mixture because of the sole distributorship of certain types of chemicals. Patronising a chemical produced by a competitor company may not be feasible. Ideally, the production and marketing of the admixture is possible if the chemicals are sourced from only one company and must be registered with the FPA as an admixture.

c. There is a vacuum from the basic research to the extension or adoption phase because the role of an agency undertaking the basic research is not well defined in terms of the extent of its involvement in technology dissemination or extension. In general, the mechanism for coordination with other agencies involved in technology dissemination is a difficult task to undertake which results in a very slow dissemination of any new technology.

7 Future Directions

In the Department of Agriculture (DA), the regional field units (RFUs) of the DA and the local government units (LGUs) generally play a major role in the extension activities for any given technology. The BPRE has initiated coordination with these agencies with regard to the dissemination of the admixture technology. Moreover, being the proponent of the basic research, BPRE initially took the responsibility of disseminating the technology to potential users in so far as the agency resources would allow. On the other hand, the private chemical companies are assessing the market for chemical admixture (D.P. Sayaboc, Bureau of Postharvest Research and Extension, Muñoz, Nueva Ecija, Philippines, pers. comm., 2000). It was opined by the leader of the pesticide project that another direction that may be taken is to conduct a sequel project to the ACIAR pesticide projects which would focus on the identification of substitutes of the chemical protectants identified under the previous projects, taking into consideration the distributorship of the types of chemicals to be used in order to address the ready availability of the chemicals and hence adoption of the technology.

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Assessment of ACIAR-funded Research on Grain Drying in the Philippines (PHT/1983/008, PHT/ 1986/008, PHT/1990/008)

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Summary

Improperly dried, high moisture content (MC) grain is prone to dry matter and quality loss during storage. The major problem of grain drying occurs during the wet season when drying is delayed due to adverse weather and inadequate drying and storage facilities. This problem was the focus of collaborative grain drying research between ACIAR and the Bureau of Postharvest Research and Extension (BPRE) — PHT/1983/008, PHT/1986/008 and PHT/1990/008 — where a two-stage drying system was developed. The first stage is to rapidly dry grain of more than 24% MC, which is characteristic of the wet season harvest, through a **flash dryer** to 18% MC at which it can be stored up to 21 days without quality deterioration. The second and final stage is gentle drying to 14% MC using an **in-store dryer**. The flash dryer has a capacity of 10–12 bags or 0.6 tonnes of grains per batch with one hour drying time. The in-store dryer with a recommended design of 6 compartments, has a maximum capacity of 11 tonnes per compartment and can dry 66 tonnes within 6 days.

The Department of Agriculture (DA) pursued the dissemination of the dryer technology through the Mechanical Dyer Assistance Project of the Post-Harvest Facility Program (PHFP), under the Grains Production Enhancement Program (GPEP) and similar successive programs. The target beneficiaries are farmer cooperatives. Under an impact assessment project also funded by ACIAR, a cross-sectional survey of farmer cooperatives was conducted in 1997 and 1998, for evaluating technology adoption and provide a comparative cost analysis between the mechanical dryer technology and sun drying. Based on the survey results, three quarters of those sampled utilised the flash dryers while the rest were not able to use them. At the time of the survey, about one-third of the dryer units were non-operational for various reasons. The time of the survey coincided with a prolonged dry season and cooperatives resorted to sun drying. Some dryers were defective at the time of delivery and others were damaged during drying operations and were pulled out. Other users found the dryers to be labour-intensive and have high operating costs. In some instances, the limited volume of paddy procured did not maximise dryer utilisation. In other cases, paddy was unevely dried and sometimes had a kerosene taint when material was used as fuel. More than half of the cooperatives were satisfied with the capacity of the flash dryers, while the rest found the dryer capacity insufficient to accommodate paddy handled by their cooperatives. Most respondents noted the usefulness of the flash dryers during the wet season while some found them not too useful because these became idle after the wet season drying operations. Several respondents reported that flash dryers have minimised postharvest losses; few claimed higher milling recovery rates, others found similar rates with flash dryer and sun drying. Some of the technology adoption constraints are: lack of a nationwide information drive and a monitoring scheme on dryer utilisation; not all beneficiaries received training in operating the flash dryer and some of those trained left their respective cooperatives; and manufacturers were not compelled to provide after-sales service. Sun drying was found to be less costly, but the return on investment was higher for the flash dryer.

1 Introduction

In the humid tropics, postharvest losses and wastage of grains can be traced to the combined effects of weather, climate, inadequate drying and storage facilities, and insect infestation. In the Philippines, about 58% of paddy (unhusked rice) and 65% of maize (corn) are harvested during the wet season, July–December (Table 1).

Table 1. Percentage distribution of paddy and maize production in the Philippines.

Period	Paddy		Maize	
	Jan.–June	July–Dec.	Jan.– June	July–Dec.
1991	41.86	58.14	28.24	71.76
1992	38.41	61.59	24.89	75.11
1993	41.23	58.77	27.96	72.04
1994	41.55	58.45	34.71	65.29
1995	40.96	59.04	38.33	61.67
1996	43.88	56.12	42.83	57.17
1997	43.01	56.99	42.53	57.47
1998	41.60	58.40	27.18	72.82
1999	44.73	55.27	37.79	62.21
2000	43.93	56.07	43.77	56.23

Source: Bureau of Agricultural Statistics (BAS), various years.

Usually, wet season harvests of grains are not properly dried which results in high moisture content (MC), from 26– 28% for paddy and up to 36% for maize (Tumambing 1984). When stored at high temperature and humidity, grains with high MC have reduced dry matter content and suffer from weight loss, quality deterioration and grain damage. Production losses result in increased marketing costs.

Sun drying is a traditional practice in the Philippines. Under normal conditions, sun-dried paddy and mechanically dried paddy may not have significant differences in terms of colour and milling quality. However, sun drying may result in the accumulation of foreign matter in the paddy. The major problem in grain drying occurs during the wet season, when drying is delayed due to adverse weather conditions coupled with antiquated handling practices and insufficient capacity of drying technologies (Tumambing 1987). This results in quality deterioration which is estimated to reduce the value of grains from by 5% to 58% (Mendoza and Quitco 1984).

As part of government efforts in addressing postharvest losses in the Philippines, the Bureau of Postharvest Research and Extension (BPRE), formerly the National Postharvest Institute for Research and Extension (NAPHIRE), in collaboration with the Australian Centre for International Research (ACIAR), undertook three research projects on grain drying (Table 2) over a period of 10 years starting in the first half of the 1980s. Other countries collaborating were Vietnam, Thailand and Malaysia. The first of these projects, PHT/1983/008, provided the basic information to PHT/1986/008 which focused on the design of a flash dryer for first-drying of paddy, its extension to drying of maize and peanuts, and short-term quality maintenance. The flash dryer allows pre-drying of wet season paddy to 18% MC which can be stored

Table 2. ACIAR–BPRE research on grain drying in the Philippines

Project no./Research type/Commodity coverage	Project title/Description/Technology developed
PHT/1983/008 Wastage reduction Paddy	**Drying in Bulk Storage** This extended Australian technology on grain drying through ambient aeration and bulk storage. Computer models were developed of mill-drying level systems using flat bed dryers, studies on rice hull gasifier, and a supplemental heating energy.
PHT/1986/008 Wastage reduction, quality change Paddy, maize	**Drying of High Moisture Grains in the Humid Tropical Climates** This project is a follow-on from PHT/1983/008 and carried out the computer program developed in the preceding project. The basic thermophysical properties of peanut and maize were determined. A mobile flash dryer was developed, for first-stage drying at the farm level.
PHT/1990/008 Wastage reduction, quality change, cost reduction Paddy, maize	**Applications of In-store Drying in the Grain Industry in Southeast Asia** The in-store drying technology, the 2nd stage drying instead of sun drying, was developed using the information from PHT/1986/008.

Source: Various project documents from BPRE.

for 3 weeks without deterioration. The third project, PHT/1990/008, designed and conducted field trials using a two-stage drying system, first-stage flash drying followed by second-stage in-store drying.

1.1 Description of a Two-stage Drying System

The use of a two-stage drying system has been recommended as one of the measures to reduce wet grain handling by several researchers and drying experts such as De Padua (1985), Adamczack et al. (1986), Driscoll (1987), and Tumambing (1985, 1987, 1989). The concept of a two-stage drying system is to rapidly dry grains with high MC of more than 24% that is characteristic of wet season harvest through a flash dryer that is high capacity, high temperature and high air-flow drying, to an intermediate MC of 18%. Grains at 18% MC can be stored under humid tropical conditions for up to 21 days without loss of quality. The second and final drying to a safe, long-term storage MC of 14% can be done by a near ambient temperature and low air-flow dryer. This can be achieved using a batch dryer, a multi-pass continuous-flow dryer or by gentle in-store drying (Tumambing et al. undated).

1.2 Objectives

This paper provides an assessment of the three interrelated research activities on grain drying funded by the ACIAR, focusing on the dissemination and adoption of the mechanical grain dryer technology developed under these three projects.

2 Technology Dissemination

2.1 Post-Harvest Facility Program

The dissemination of the mechanical dryer technology developed under the three projects—flash dryer and in-store dryer—was implemented by the Department of Agriculture (DA) through the Post-Harvest Facility Program (PHFP) under the Grains Production Enhancement Program (GPEP). Part of the PHFP is the Mechanical Dryer Assistance Project to farmer organisations such as cooperatives aimed at reducing their postharvest losses and improving their trading capabilities (DA, undated). Three types of dryers—flatbed, columnar flash, rotary flash—may be availed from the project. Some of the conditions to obtain the dryers are: (a) the farmer organisation must have at least 2,500 bags of wet paddy, and (b) the farmer organisation must be willing to enter into a 5-year lease agreement with the Regional Field Unit (RFU) of the DA for the use of the mechanical dryer. For the duration of the lease period, the farmer organisation pays a minimal fee of P1.00 annually. Thereafter, the organisation has the option to buy the mechanical dryer at a mutually agreed price. The DA–RFU conducts a public bidding in procuring the dryers, and testing and evaluation is conducted by the Agricultural Machinery Technology and Evaluation Committee (AMTEC). The accredited dryer manufacturers will provide hands-on training on the operation and maintenance and free repair services within 6 months of signing of the Certificate of Acceptance.

2.2 Technology Dissemination

One of the major efforts in the dissemination of the grain drying technology developed under the three ACIAR-funded projects was made through the National Food Authority (NFA), the central marketing agency for grains in the country. In 1993, the NFA Council authorised this agency to allocate the P600 million proceeds from the 1993 Thailand rice importation for the implementation of the PHFP through the Agency Program Implementors (APIs) which included the DA–RFUs, the former NAPHIRE, QUEDANCOR, and the local government units. A total of 777 units of mechanical dryers were distributed nationwide to farmer organisations, representing 94% of the targeted 830 mechanical dryers under the GPEP for the period 1993–1995. Most of the mechanical dryers distributed were flash dryers which were either the mobile type (MFD) or the stationary type. Three units of the in-store dryer were initially distributed to three farmer cooperatives in the Central Luzon, Southern Tagalog and Northern Mindanao regions. The distribution of the flash and in-store dryers continued with the succeeding grains production programs of the DA such as the *Agrikulturang Makamasa* Program. Based on a 1999 status report of the first tranche procurement and distribution of postharvest facilities and equipment under the La Niña phenomenon of the DA, a total of 155 mobile flash dryers (MFDs) were distributed from a total of 201 units procured for 6 regions of the country (Appendix A). Also, in 1998 the DA targetted a total of 25 units of in-store dryer to be procured and distributed in the various regions of the country (Appendix B). Funds for four units were, however, re-aligned to other mechanical dryers and to other postharvest facilities. Some delays in the procurement were also incurred partly due to bureaucratic processes. A status report from the Field Operations Service (FOS) of the DA indicated

that as of early June 1999 the in-store dryers were not yet procured and distributed.

The flash dryer has a capacity of 10–12 bags or 0.6 tonnes (t) per load and can dry this within an hour. The in-store dryer, on the other hand, has a capacity of 11 t per compartment. The recommended design of the in-store dryer is for six compartments which can dry 66 t of grains in 6 days.

3 Assessment

3.1 Survey of Farmer Cooperatives

Surveys of farmer cooperatives who were recipients of the dryer technology were conducted. These surveys had the following objectives: (1) assess the acceptability and utilisation of the mechanical dryers; (2) identify the constraints to adoption of the grain dryer technology; and (3) provide a comparative cost analysis between using a flash dryer and sun drying. The initial survey was conducted in 1997 with July 1996–June 1997 as the reference period. A total sample of 124 farmer cooperatives was selected from a list provided by the Field Operations Service of the DA. The second survey in 1998 had for its reference period July 1997–June 1998, with a sample of 65 farmer cooperatives. The reference periods of the two surveys coincided with the El Niño phenomenon. The second survey also included 28 cooperatives in the first survey for purposes of updating the information provided in the earlier survey. Effectively, the two surveys covered 161 farmer cooperatives in 30 provinces. Two of these cooperatives were recipients of the flash dryer and in-store dryer, representing the two-stage drying process of the technology developed under the ACIAR projects. Nueva Ecija province, a major rice producer, had the most number of cooperatives interviewed. Survey respondents were mostly farmer leaders and cooperative chairmen or members of the board of directors.

3.2 Survey Results

Multipurpose cooperatives dominated (91%) the total sample cooperatives; the rest were either solely for credit or for trading purposes (Table 3). Cooperatives engaged in grain trading procured paddy from their members and also from non-members, mill the paddy and sell rice directly to distributors and retailers. Other cooperatives do not mill but sell paddy to traders. Cooperative members comprised farmers and non-farmers. Of the total members of sample cooperatives, 80% were farmers and 20% non-farmers. The average harvest area of farmers was 1.88 hectares per cropping season and the paddy harvest ranged from 36 to 106 bags (50 kg) per hectare (1.8–5.3 t/ha). The lower paddy output is attributed to dry season harvest and non-irrigated farms and higher output to wet season harvest and irrigated farms.

Table 3. Type of farmer cooperatives surveyed

Type of cooperative	Number of cooperatives reporting	Percentage of total
Multipurpose	146	91
Credit	11	7
Others	4	2
Total	161	100

The mechanical dryers were acquired by the sample cooperatives between the period 1991 to 1997, the bulk (80 units) being distributed to them in 1995 (Table 4). This is in line with NFA's mechanical dryer distribution program discussed earlier. For the reference period, the volume of paddy dried ranged from 26 to 175 bags per operating period.

Table 4. Distribution of mechanical flash dryers to sample cooperatives, 1991–1997

Year	Number of mechanical flash dryers	Cumulative
1991	1	1
1992	4	5
1993	7	12
1994	25	37
1995	80	117
1996	32	149
1997	12	161

Before the acquisition of mechanical dryers, sample cooperatives adopted the traditional sun-drying method. A few cooperatives were also using mechanical dryers, for example, the Japanese-made Satake brand (Table 5).

About three-quarters of the cooperatives sampled (Table 6) utilised the flash dryers[1] and at the time of the surveys about one third were non-operational. There were various reasons cited by the

[1] These cooperatives utilised the flash dryers mainly during the wet season to curtail postharvest losses incurred in storing wet paddy, and sometimes in the dry season when paddy was procured in large volumes.

respondents: the time of the survey coincided with the El Niño phenomenon and cooperatives resorted to sun drying; dryers were defective when these were delivered and some were damaged during drying operation which were pulled out by the APIs; laborious to operate; high operation costs; limited capacity of the dryers per drying batch; limited volume of paddy harvest of cooperative members did not maximise utilisation of the dryers; unevenly dried and discoloured paddy; the paddy dried had a kerosene taint when that was used as fuel; and increased broken rice when paddy is milled.

Table 5. Dryer facilities used before the acquisition of flash dryers.

Dryer facility	No. of cooperatives reporting	Percentage of total
Sun drying	152	94
Other mechanical dryers (e.g. Satake)	9	6
Total	161	100

In several of the cooperatives, paddy was first dried using the flash dryers and then sun dried on adjacent concrete pavements.

Table 6. Utilisation of mechanical flash dryers

Item	YES No. of cooperatives (% reporting)	NO No. of cooperatives (% reporting)
Utilisation	138 (86)	23 (14)
Operational dryers	104 (65)	57 (35)

More than half of the survey respondents were satisfied with the capacity of the flash dryer, while the rest considered the dryer capacity insufficient to accommodate the volume of paddy handled by their cooperatives. Majority of the respondents also noted the usefulness of the flash dryers during the wet season. They averred that even with continuous rains they were able to dry paddy. Some found the dryers not too useful because these became idle after the wet season drying operations, and they do not have a storage space for the dryer.

In comparing the use of mechanical flash dryers and sun drying, several of the respondents reported that the flash dryers have minimised their postharvest losses. A few claimed higher milling recovery rates when using flash dyers, others noted the same milling recovery rate between the two drying systems. In terms of grain quality, most of the respondents revealed that when properly used, the flash dryer resulted in better grain quality.

About two thirds of the respondents expected an increase in paddy procurement for their cooperatives in the future. About half of the respondents claimed that they foresee an increase in the use of the flash dyers because of the onset of La Niña.

3.3 Constraints to Adoption of the Dryer Technology

Based on the surveys conducted, constraints to the adoption of the flash dryer technology may be noted.

1. The information drive regarding the program was not conducted fully nationwide.
2. Not all beneficiaries have received training on the technical operation of the dryer from the APIs/manufacturers, while some of those who were trained have already left the cooperatives.
3. Some of the mechanical dryers were not tested before delivery/acceptance of the cooperative beneficiaries, especially at the height of the dryer distribution program.
4. Lack of a monitoring scheme on the utilisation of the mechanical dryers delivered.
5. Supplier/manufacturers were not required or compelled by the APIs to provide after-sales service to cooperative beneficiaries.
6. In some areas, some of the cooperative recipients of the dryer were already dissolved, some are for closure by the banks such as the Land Bank of the Philippines due to large outstanding debts when the dryers were delivered.
7. Undercapacity utilisation of the dryers (flash dryer and in-store dryer) due to limited of volume of paddy procurement by some of the cooperatives.
8. Preference for sun drying especially during good weather. To some, sun drying procedures are simpler to follow.

4 Comparative Costs and Returns Analysis

The costs and returns analysis includes data from 26 farmer cooperatives. The other sample cooperatives were not considered because some did not use the flash dryer during the reference period, several have no paddy procurement, while some procured grain already at 14% MC.

Table 7 shows a comparative costs and returns analysis between sun drying solely and the use of a flash dryer during wet season. For the latter, paddy undergoes first-stage drying using the flash dryer and sun drying as the second stage. The respondents corresponding to the 26 cooperatives acknowledged the usefulness of the flash dryer during in the wet season. Due to the prolonged dry season during the reference period almost two-thirds of total grain harvests/procurement was sun dried and one-third passed through the flash dryers (Table 7). Wastage incurred in sun drying is reduced by about 70% when using flash dryer.

Table 7. Comparative costs of sun drying and use of flash dryer, wet season

Item	Method of drying	
	Sun drying[a]	Flash dryer[b]
Utilisation in procured grains (%)	65.00	35.00
Postharvest losses (%)	8.00	2.40
Average drying cost (P) per bag	19.00	21.80
Average total costs (P) per bag	351.88	354.51
Average gross revenue (P) per bag	500.00	500.00
Average net profit (P) per bag	148.12	145.49
Average return on investment (%)	24.84	27.09

[a] Utilised sun drying in the first stage (18% MC) and sun drying in the second stage (14% MC)
[b] Utilised a flash dryer in the first stage (18% MC) and sun drying in the second stage (14% MC)

Based on the survey results, compared with flash dryers as the first stage and sun drying as the second stage, drying grains into 14% MC using purely sun drying results in lower costs. On average, the unit cost difference is less than 1% or P2.80 per bag for the drying operations and less than 1% or P2.63 per bag for total costs (production and postharvest costs including drying and postharvest losses). The higher cost of using flash dryers can be attributed to higher operating costs (fuel, electricity and labour requirements). With the NFA buying price of P5 per kilo of paddy at 14% MC, net profit is higher for sun drying by 1.8% or P2.63 per bag. However, using returns on investment (ROI) as a tool for measuring profitability, ROI for flash dryers at the first stage and sun drying at the second stage is higher than sun drying alone, respectively, at 27.09% and 24.84%. This can be explained by the higher frequency of turnover using flash dryers. The flash dryers are designed to accommodate 10–12 50-kg bags per drying batch at an average of 1 hour drying time.

5 Impact of the Project

The significant contribution of the three related projects on grain drying is the development of an alternative drying system to the traditional practice of sun drying that would minimise postharvest losses and improve grain quality. It must be emphasised that the two-stage drying technology — first, a quick drying process using a flash dryer followed by a slower process using an in-store dryer — is suited to wet season harvests, although the in-store dryer can also be used as a single stage dryer during the dry season. It is meant also to accommodate large volumes of paddy harvests and can serve as a temporary storage for grains. The drying technology can also be extended to another major crop, maize.

While efforts towards the adoption and dissemination of the grain dryer technology have been widely supported by the government under several production programs of the Department of Agriculture, the task remains on how to monitor these dissemination efforts and address the constraints to adopting the technology.

Another impact of the project is the enhancement of research capability and technical expertise of the staff involved in the projects, and close collaborative links between research agencies.

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Appendix A

Status of La Niña grain dryer procurement and distribution, 1st tranche, summary by Region, 31 December 1999

Region	Type of grain dryer	No. of units procured	No. of units distributed
I Ilocos	1. In-store dryer	1	–
	2. Mobile flash dryer	150	103
	3. Flatbed dryer	9	2
	4. Recirculating grain dryer	3	–
II Cagayan Valley	1. Electric-driven grain dryer	15	15
III Central Luzon	1. Electric-driven grain dryer	21	14
	2.Mobile flash dryer	35	35
IV Southern Tagalog	1. Electric-driven grain dryer	47	47
	2. Mobile flash dryer	24	24
	3. In-store dryer	47	47
V Bicol	1. Recirculating grain dryer	30	15
VI Western Visayas	1. Electric-driven grain dryer	26	8
VIII Eastern Visayas	1. Electric-driven grain dryer	12	–
IX Western Mindanao	1. Mobile flash dryer	32	32
X Northern Mindanao	1. Electric-driven grain dryer	15	15
XII Central Mindanao	1. Electric-driven grain dryer	18	14
XIII CARAGA	1. Electric-driven grain dryer	25	25
	2. Mobile flash dryer	2	2
Autonomous Region for Western Mindanao	1. Electric-driven grain dryer	4	4
	2. Mobile flash dryer	14	10

Source: Physical Status of La Niña Post-Harvest Facilities and Farm Equipment Procured and Distributed, 1st Tranche, Summary by Region as of December 31, 1999. Field Operations Service, Department of Agriculture.

Appendix B

In-store dryer procurement for the Post-Harvest Facility Assistance Program, Agrikulturang Makamasa Program, 1998—as of 2 June 1999

Region	Target (no. of units)
Total	25
Cordillera Autonomous Region	1[a]
Ilocos Region	1
Cagayan Valley	3
Central Luzon	3
Southern Tagalog	2
Bicol Region	2
Western Visayas	2
Central Visayas	1[b]
Eastern Visayas	2[c]
Western Mindanao	1[c]
Northern Mindanao	1
Southern Mindanao	2
Central Mindanao	1
ARMM	1
CARAGA	2

[a] Funds re-aligned to multi-purpose threshers/shellers and hand tractors
[b] For re-bidding.
[c] Funds were re-aligned to mechanical dryers
Source: Field Operations Unit, Department of Agriculture

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