Review of Forage Resources in Plantation Crops of Southeast Asia and the Pacific

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Abstract

Vast tracts of land in plantations in Southeast Asia and the Pacific sustain the growth of naturally occurring forages. The productivity of these forages under grazing is generally low, but most are persistent and well adapted to the local environmental and management conditions. No species is productive at light levels of less than 30% because of the limited production potential at low-light environments. In plantations with light transmissions of 30-50%, species such as *Axonopus compressus*, *Stenotaphrum secundatum*, *Ischaemum aristatum* and *Desmodium heterophyllum* are successful. At light levels higher than 50%, the more productive introduced species warrant consideration. A greater range of species is required which will persist and suppress weeds at moderate light intensities and low management levels.

A brief description of the principal species currently used for forage supply in plantation crops is given.

PLANTATION tree crops do not intercept all incoming light and consequently there is scope for the growth of natural vegetation or the cultivation of other useful introduced species.

From an animal production point of view, understorey natural vegetation can be divided into species which are eaten by ruminants and those which are unpalatable. In this context, the latter will be referred to as weeds while the 'eaten' species will be called forages. Undoubtedly, many plantation managers would use a different definition of the term weed.

The vast majority of available land in coconut, rubber and oil palm plantations is occupied by naturally occurring species. However, there are considerable areas of planted cover crops and very limited areas of planted forages.

This article describes the environment in which the three major plantation types (coconut, rubber and oil palm) occur, discusses the adaptation and value of the most frequently encountered naturally occurring and sown forage species, and reviews the potential for making best use of existing forage resources in plantation crops.

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Distribution and Habitat of Plantation Crops

The climatic and edaphic requirements of rubber and oil palm (Purseglove 1968, 1972) are somewhat similar, while coconut has different requirements (Table 1). Rubber and oil palm are grown mainly in the lowlands of the humid tropics, with high rainfall and no or only short dry seasons. While these crops can be grown on a wide range of soils they are usually found on acidic soils of low fertility.

Coconut, on the other hand, is grown chiefly along coastal belts in areas with an annual rainfall of 1300-2600 mm. Long dry periods are detrimental but can be tolerated where there is a good ground water supply. Long sunshine hours are required for high productivity. Coconut is grown on less acidic soils than rubber and oil palm, and is often found on alkaline and saline soils. The fertility of coconut soils varies from fertile volcanic soils to infertile coralline sands. The latter soils may be deficient in potassium (Macfarlane and Shelton 1986) and iron (Gutteridge 1978).

The root distribution of coconut and oil palm is similar with the majority of roots being concentrated within 2-3 m of the trunk (Purseglove 1972; Kushwah et al. 1973; Steel and Humphreys 1974), although some laterals occur. Roots of rubber are concentrated in the top soil layer with long laterals reaching into the interrows (Purseglove 1968).

The light environment under rubber and oil palm is similar with high initial light transmission at planting (>

Table 1. Distribution and habitat of plantation crops.

	Coconut	Rubber	Oil palm
Distribution	20ºN - 20ºS	15ºN - 10ºs	10ºN - 10ºS
Altitude (m)	< 300	Lowland	Lowland
Rainfall (mm/year)	1270-2550	> 1900	> 1800
Acceptable dry season	Short - medium	Short only	Short only
Required sunshine	Long	–	–
Humidity	High	Very high	–
Soil	Coastal belt (Wide range)	Wide range	Wide range
Soil pH range	5 - 8	4 - 8	4 - 6
Salinity	Tolerant	–	–
Required drainage	Excellent	Good	Adequate
Ground water supply	Required	–	–
Root distribution	Top 1.5 m. mainly within 2 m from trunk some laterals	Mainly top layer but long laterals 2 m from trunk	Top 15 cm. mainly within
Light transmission %*			
0 – 5 years	100-60	100-30	100-30
6 – 15 years	60-40	< 30	< 30
> I5 years	60-80	<30	< 30

* estimation
Source: Purseglove 1968, 1972

90%); this declines to very low levels (10-20%) within 6-7 years and remains low until the trees are replanted at an approximate age of 25 years. The majority of coconut stands in the world are of the tall variety, in which light transmission is high initially, declines to around 40% at age 5-15 years, and then increases up to 80% in old coconut stands aged 60 years and over (see Figure 1, Wilson and Ludlow, these Proceedings). Dwarf and hybrid varieties allow less light to penetrate their canopies and light levels are much lower.

Naturally Occurring Forage Resources

Many naturally occurring forage species are found in coconut, rubber and oil palm plantations in countries of Southeast Asia and the South Pacific. Some of the more important species are shown in Table 2. Both native and naturalised forages thought to have been present for many decades are included. Sown or planted species of more recent origin (some of which are now naturalised) are discussed in a later section.

Species which occur in all three plantation types, and in several countries, are *Axonopus compressus, Imperata cylindrica, Mimosa pudica* and *Paspalum conjugatum*. Their distribution includes both Southeast Asia and the South Pacific, which shows their ubiquitous nature and their ability to grow in a wide range of environmental conditions. Other species such as *Ottochloa nodosa. Mikania cordata* and *Asysrasia* spp. are mentioned frequently in rubber and oil palm in Southeast Asia. There is also a large number of species observed under coconuts in the South Pacific some of which occur in Indonesia. Many of these may be adapted to the more alkaline coconut soils. The most widespread naturally occurring legume in natural vegetation in the South Pacific is *Desmodium heterophyllum* (Reynolds 1988).

The adaptation and value of the major naturally occurring forages are summarised in Table 3 (Bogdan 1977; Holm et al. 1977; Plucknett 1979; Steel et al. 1980; Macfarlane and Shelton 1986; Reynolds 1988). Some of these species are now discussed.

Axonopus compressus is renowned for its ability to withstand heavy grazing pressure and it has been reported to invade sown pastures which were not fertilised (Roberts 1970), which were overgrazed (Watson and Whiteman 1981), or where light levels were low (Chen et al. 1978). It is particularly valuable in heavily shaded situations (maybe less than 30% light transmission) where sown grasses cannot survive regular grazing (Reynolds 1988). Productivity of this grass is low and it is outyielded by more productive grasses in less heavily shaded areas, provided the level of management is sufficiently high to ensure persistence of the sown grasses (e.g. Smith and Whiteman 1983). It is well accepted by stock and produces moderate liveweight gains (Reynolds 1981), particularly if combined with naturally occurring legumes such as *Mimosa* spp. Nutritive value measurements indicate a high digestibility compared to *Pennisetum clandestinum* and *Stenotaphrum secundarum* (Samarakoon et al. 1990a).

Table 2. Natural vegetation occurring frequently in plantations.

Species	Coconut	Rubber	Oil palm
Grasses			
Axonopus compressus	Indonesia (11) Solomon Islands (1,9) Thailand (2) Vanuatu (6)	Malaysia (3,5, 10)	
Brachiaria miliiformis	Indonesia (12)		
Brachiaria mutica		Malaysia (3)	
Chrysopogon orientalis	Thailand (2)		
Cyrtococcum oxyphyllum		Malaysia (5)	
Digitaria spp.	Indonesia (11,12)		
Eremochloa ciliaris	Thailand (2)		
Imperata cylindrica	Indonesia (11,12) Papua New Guinea (4) Thailand (2)	Malaysia (5, 10)	Malaysia (8)
Microstegium ciliatum	Thailand (2)		
Otochloa nodosa	Thailand (2)	Malaysia (3,10)	Malaysia (8)
Paspalum conjugatum	Indonesia (12) Thailand (2) Papua New Guinea (4) Vanuatu (6) Solomon Islands (9)	Malaysia (3,10))	Malaysia (8)
Pennisetum polystachyon	Solomon Islands (9)		
Stenotaphrum secundatum	Vanuatu (6)		
Themeda australis	Solomon Islands (9)		
Legumes			
Calopogonium mucunoides	Solomon Islands (1,9) Papua New Guinea (4)		
Centrosema pubescens	Solomon Islands (1)		
Desmodium canum	Vanuatu (6)		
Desmodium heterophyllum	Indonesia (11)		
Desmodium ovalifolium	Thailand (2)		
Desmodium triflorum	Indonesia (11)		
Mimosa pudica and *M. invisa*	Solomon Islands (1,9) Vanuatu (6) Western Samoa (13)	Indonesia (12)	Malaysia (10)
Broadleaf species			
Asystasia spp.		Malaysia (3.7)	Malaysia (8)
Mikania cordata		Malaysia (5.10)	Malaysia (8)

Sources :- (1) Watson and Whiteman, 1981; (2) Manidol, 1983; (3) Ani Arope et al., 1985; (4) Hill, 1969; (5) Lee et al., 1978; (6) Macfarlane and Shelton, 1986; (7) Wong et al., 1989; (8) Chen and Othman, 1983; (9) Steel et al., 1980; (10) Wan Mohammed, 1978; (I I) May, 1977; (12) Rika et al., 1981; (13) Reynolds, 1981; (14) Plucknett, 1979; (15) Holm et al., 1977; (16) Reynolds, 1988; and (17) Bogdan, 1977.

Paspalum conjugatum has a similar distribution to *A. compressus* but grows best on more acidic soils. While it can withstand moderate grazing it disappears under continuous high grazing pressure. In the South Pacific, it is less productive than *A. compressus* (Smith and Whiteman 1983). It is less readily accepted by stock than *A. compressus* and is generally regarded as a grass of low nutritive value.

Mimosa pudica is often regarded as a weed because of its spiny stems, but it is readily accepted by stock and high animal weight gains have been recorded (e.g. Partridge 1979; Reynolds 1981). It combines well with sward-forming grasses such as A. *compressus* and can withstand heavy grazing. Because of its spiny stems it is not usually recommended in sown pastures but it can form a useful component in naturally occurring swards (Reynolds 1988).

Desmodium heterophyllum is a perennial prostrate creeper which occurs throughout the South Pacific and Southeast Asia. Its success is related to its ability to withstand very heavy grazing pressure, and its shade tolerance (Reynolds 1988). While low-yielding,

it can improve animal production when a component of grass pastures and is therefore a valuable component in any pasture. Except for coralline sands, it is adapted to a wide range of soils (Steel et al. 1980). Although a good seeder, mechanical harvest of seed is difficult and no commercial seed is available. However, it can be propagated vegetatively.

Imperata cylindrica is regarded as one of the worst weeds in the region (Holm et al. 1977), as it is often not readily accepted by stock. However, Falvey (1981) in a review of *I. cylindrica* concluded that it is underrated as a forage resource. It can support low rates of animal weight gain, particularly when grazed young or associated with a legume. It cannot withstand heavy grazing pressure and is seldom found in heavily shaded situations. Growth of this species is best on fertile soils but it is also found on poorer soils. Replacement with other more productive and nutritious grasses, particularly in intensive grazing systems, is generally recommended.

Ottochloa nodosa, Mikania cordata and *Asystasia* spp. occur frequently in rubber and oil palm plantations of Southeast Asia. All of these are readily eaten by stock (Ani Arope et al. 1985) and can contribute to animal production. A high feeding value has been reported for *Asystasia* spp. (Wong et al., 1989) and *M. cordata* (Ginting et al. 1987). All three species occur at varying light levels but are susceptible to regular grazing at low light levels. It is difficult to generalise on animal preference. For example, Pillai et al. (1985) found that the proportion of *A. intrusa* increased under sheep grazing in immature rubber while *O. nodosa* decreased. On the other hand, Rosley Abdullah (1985) observed that sheep grazed *A. intrusa* before *O. nodosa* and *M. cordata* in a slightly older rubber plantation.

Other herbaceous legumes which occur in some coconut areas include *Desmodium triflorum, Desmodium canum* and *Alysicarpus vaginalis.* Of these, *D. triflorum* is probably the most widespread legume but, because of its very low growth form and productivity, contributes little to animal production.

Sown or Planted Forage Species

There has been a long history of the use of legume cover crops in rubber, oil palm and, to a lesser extent, in coconut plantations. The planting of 'improved' forages for animal production has so far not been practised in rubber and oil palm except on an experimental basis, while there are some examples of commercial 'improved' pastures under mature coconuts.

Cover crops

Cover crops are planted to suppress weeds, control soil erosion and to add nitrogen to the plantation crop. Commonly used species are *Calopogonium mucunoides, Calopogonium caeruleum. Pueraria phaseoloides* and *Centrosema puhescens* (Plucknett 1979; Chee 1981). These are usually sown shortly after the planting of the plantation trees and dominate the interrow area for several years. As the light level decreases, naturally occurring species invade.

A summary of the adaptation and value of these cover crops as forages is presented in Table 3.

Chee (198 1) described the succession of these covers when grown in combination and without grazing in young rubber. *Calopogonium mucunoides* dominates for the first year and then *Pueraria phaseoloides* in the second and third years. As light levels decrease further, *C. caeruleum* and *Centrosema pubescens* dominate and these latter two species will persist longer. When grazed by sheep, the proportion of *Calopogonium caeruleum* has been observed to increase while that of *P. phaseoloides* and *Centrosema puhescens* decreased (Pillai et al. 1985). This low acceptability of *Calopogonium caeruleum* has also been noted for cattle (Middleton and Mellor 1982). In a feeding trial with sheep and goats, Ginting et al. (1987) found that the digestibility of both *P. phaseoloides* and *C. caeruleum* was high, but the intake of *C. caeruleum* was low. A similar low intake by sheep of *C. mucunoides* has also been recorded (McSweeney and Wesley-Smith 1986).

Animal production from pastures containing *Centrosema puhescens* and *P. phaseoloides* has been excellent (Reynolds 1988). Both types require careful management to ensure persistence, a feature common to most twining, scrambling forage legumes. *Centrosema puhescens* can withstand moderate grazing pressure, while *P. phaseoloides* pastures can only be grazed lightly. *Calopogonium mucunoides* has persisted under moderate grazing pressure (cattle) under 60% light transmission coconuts in the Solomon Islands (Watson and Whiteman 198 1).

Introduced forage species

Although many of the common 'improved' pasture species have been tried experimentally under coconuts, particularly in the South Pacific, only a few species are in commercial use.

The major problem encountered with many introduced forage species is lack of long-term persistence. There are many examples of excellent initial growth of highly productive species, but soon naturally occurring species (particularly unpalatable weeds) invade and the planted species disappear. There are, however, some examples of introduced species which have persisted for many years and which may be regarded as naturalised in some areas. These include *Stenotaphrum secundatum* and *Ischaemum aristatum* in the South Pacific and possibly *Brachiaria decumhens* in parts of Southeast

it does particularly well on alkaline coralline soils (Macfarlane and Shelton 1986). It can withstand a higher stocking pressure than *B. decumbens* and, although less readily accepted by cattle, it has been reported to produce reasonable liveweight gains (Reynolds 1988). As with *B. decumbens*, a major difficulty is the maintenance of companion herbaceous legumes. On the other hand, its vigorous habit suppresses weed growth. This species is widely used in Fiji and can be propagated easily by cuttings.

Panicum maximum cultivars have been used for grazing under coconuts in some areas. Plucknett (1979) considered the cultivars Petrie (Green Panic) and Embu (Creeping Guinea) to be the two most promising cultivars. These grasses combine well with legumes and produce excellent liveweight gains (Macfarlane and Shelton 1986). However, careful management including moderate grazing pressure and regular fertilisation is also required. Overgrazing or lack of fertilizer leads to weed invasion and the loss of the sown grasses.

Other grasses which are used to some extent under coconuts are *Brachiaria miliiformis* and *B. mutica.* The popularity of the latter species is related to its ease of establishment from cuttings, and its high yield and quality. However, it is not shade-tolerant and suitable only in very old coconut plantations in wetter areas (Reynolds 1988). *Brachiaria miliiformis* is used extensively in Sri Lanka but has been prone to disease attack in the more humid tropics (Reynolds 1988). It has been reported to be more shade-tolerant than other *Brachiaria* spp.

The legumes *Centrosema pubescens, Desmodium heterophyllum, Puearaia phaseoloides* and *Calopogonium mucunoides* have been described already. Other herbaceous legumes used to some extent include *Macroptilium atropurpureum, Desmodium intortum* and *Neotonia wightii.* All of these require careful management and will not persist when overgrazed.

Leucaena leucocephala and, to a lesser extent, *Gliricidia sepium* are used as a feed supplement to grazed pastures under coconuts. The prospects of *L. leucocephala* have diminished with the arrival of the leucaena psyllid but tree legumes in general have excellent prospects for integration into plantation systems. Their main advantage is their persistence, even under heavy grazing, where it is often difficult to maintain herbaceous legumes.

Conclusions

There is quite a range of species naturalised under the various environmental regimes of plantation crops. However, no species can be recommended for light levels of less than 30% because of the limited production potential of very low-light environments. In plantations with light transmissions of 30–500%, species such as *Axonopus compressus, Stenotaphrum secundatum, Ischaemum aristatum* and *Desmodium heterophyllum* may be suitable. Only when light levels are higher than 50% do more productive species warrant consideration.

At low management levels (high stocking pressure, no fertilizer, etc.), persistence and suppression of weeds usually requires an aggressive grass such as *Stenotaphrum secundatum.* Unfortunately, the ability to suppress weed growth usually means incompatibility with most useful herbaceous legumes. The most successful herbaceous legumes for combining with aggressive grasses are *Desmodium heterophyllum* and *D. triflorum.* Tree legumes may also play an important role in improving the feeding value of such pastures. Under higher levels of management, excellent levels of animal production can be achieved with highly productive sown grass/legume swards, particularly at light levels of 70% and above.

Despite the plethora of naturally occurring species available for reduced light situations, a greater range of grasses and legumes is required which will persist and contribute to annual production in low management and input systems.

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