Integration of Animal Production in Coconut Plantations

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Abstract

Worldwide there are between 10 and 11 million hectares of coconuts. With the marked fluctuations and long term decline in copra and coconut oil prices the integration of livestock and coconuts is economically increasingly attractive. Traditionally used for weed control in plantations so that coconuts could be located, cattle (and sheep and goats) are increasingly seen as important parts of the system. Although there are constraints particularly related to the level of shade under closely spaced coconuts, a number of grass and legume species have been identified which have varying degrees of shade tolerance. Where light transmission is greater than 50%, sustainable grazing of pastures is possible.

The paper reviews some of the main production systems and details animal production levels in grazing and cut-and-carry systems.

Key areas for future work are:

- the screening of new forage species for shade tolerance and persistence;
- the focus on systems of coconut spacing which emphasize wide inter-row areas for increased forage production under high light conditions;
- the development of coconut multicropping systems where various management options are modelled to maximize returns for the grower, and
- the increased use of by-products and alternative feed resources by smallholder farmers.

KEY WORDS: coconut, plantation, forage, feed, livestock

Introduction

The substantial potential for animal production from a number of agroforestry systems has been reviewed by Gutteridge and Shelton (1994). The plantation crop system with perhaps the greatest potential for further development is the integration of livestock, especially cattle (but also sheep and goats) with coconuts (Shelton, 1991). Worldwide there are probably between 10 and 11 million hectares of coconuts, with more than 90% located in the Asia and Pacific region.

Integration of cattle production with coconut plantations is based on the premise that cattle are beneficial to the management of coconuts and that the combined income of the two enterprises is greater. In the past, coconut was the main agricultural activity and cattle management was directed towards reducing plantation weeding costs and increasing copra production (largely from a higher recovery of fallen nuts). In recent years the marked fluctuation in copra prices, both monthly and from year to year, and the structural decline in copra prices since 1950, has encouraged farmers to diversify.

Cattle production is one avenue for diversification. It is increasingly economically attractive both through consistent price increases and price stability. In the Philippines retail prices for beef nearly tripled between 1985 and 1992. Although increases in actual farmgate prices may have been lower, cattle production compares favourably with other intercropping options. Similarly the demand for meat is increasing in Indonesia and this has lead to considerable price increases.

Benefits and Constraints

Any attempt to grow two or more crops together, and particularly to grow one (forages) beneath the shading canopy of another(coconuts), necessitates some understanding of the environmental factors involved and the degree of competition likely. Important factors affecting the growth of forage species under coconuts are the available soil moisture and nutrients, the amount of light and the degree of competition between the forage species and the coconuts. The yield of plantation crops may be positively or negatively affected by the pasture system, depending on the nature of the interference which develops and the net effect on the crop environment. The influence of the plantation tree canopy on the quantity and quality of light reaching the ground surface, on temperature and humidity and soil moisture levels has been reviewed by Wilson and Ludlow (1991).

On the positive side, cattle are important for weed control and this has been the traditional use of cattle in coconut plantations. Light transmission in the commonly used tall coconut varieties decreases from >90% in recently planted coconuts to a minimum of around 40% at an age of 5-15 years, and then increases again with time until the coconuts are due for replanting at age 50-60 years. Light transmission obviously varies depending on variety (with dwarf or hybrid varieties intercepting more light than the tall varieties), tree spacing and management. Much of the area of existing coconut plantations is of tall varieties and often more than 30 years old, therefore light levels are high enough to support an understorey vegetation. Unless it is controlled this understorey vegetation competes with the trees for water and nutrients.

Grazing can reduce competition from the understorey vegetation by recycling nutrients "locked up" in the standing biomass. A near doubling of coconut yield was reported by several researchers when previously ungrazed coconut plantations were grazed. This was probably only partly related to increased nutrient cycling; the main effect of grazing being related to a higher recovery rate of nuts in short grazed vegetation. Negative effects of any understorey vegetation on coconut yield must be expected if rainfall or soil fertility is marginal for coconut growth, although the latter can be ameliorated by sufficient fertilization. Competition for moisture is likely to occur where annual rainfall is below 1750 mm, particularly if rainfall is not evenly distributed.

As far as animal production is concerned the provision of shade and thus lower heat loads on animals is likely to have a positive effect on animal productivity. The nutritive quality of forages grown in partially shaded environments such as old coconuts is comparable to those grown in full sun (Norton *et al.* 1991). Incompatability of cattle and coconuts is likely to be caused by unacceptable damage to young trees or interference in the management of coconuts. Damage to fronds of young coconuts could be caused by grazing animals and it is usual practice to keep cattle away from young coconuts until fronds are out of reach of the grazing animals. The time required for coconuts to grow beyond the reach of cattle varies, but periods of 3-8 years have been mentioned in the literature. Small ruminants such as sheep have been successfully grazed in 2-year old coconuts (Simonnet, 1990). Damage to stems of coconuts is minimal although there are concerns over possible soil compaction and increased erosion that may occur when the understorey vegetation is overgrazed.

Forage Species

Some grasses and legumes are more shade tolerant than others (see Table 1). When light transmission values fall below 40 or 50% then both production values and the range of species are severely reduced. In general herbage production (and therefore carrying capacity) is inversely proportional to tree density (and light transmission values). Wong (1991) defined shade tolerance (agronomically) as "the relative growth performance of plants in shade compared to that in full sunlight as influenced by regular defoliation. It embodies the attributes of both dry matter productivity and persistence". The term persistence includes both the survival of individual plants and seedling replacement.

Indigenous species

Native vegetation under coconut varies according to the location and intensity of grazing. Unless there is control of the stocking pressure there may be changes in pasture composition over time with undesirable weed species gradually dominating the sward. Using cattle as "sweepers" or "weeders" without additional selective weed control measures may control the weeds in the short term but allow tough unpalatable species to become dominant. The more promising of the native species include: carpet or mat grass (*Axonopus compressus*), buffalo couch grass (*Stenotaphrum secundatum*), Pemba grass (*Stenotaphrum dimidiatum*), T-grass (*Paspalum conjugatum*), as well as various legumes such as alyce clover (*Alysicarpus vaginalis*), *Desmodium ovalifolium*, *Desmodium triflorum*, hetero (*Desmodium heterophyllum*) and sensitive plant (*Mimosa pudica*).

Table 1 Shade tolerance of some tropical forages (after Wong 1991, and Shelton *et al*. 1987)

Shade tolerance	Grasses	Legumes
High	*Axonopus compressus*	*Desmodium heterophyllum*
	Brachiaria miliiformis	*Desmodium ovalifolium*
	Ischaemum aristatum	*Flemingia congesta*
	Ottochloa nodosa	*Mimosa pudica*
	Paspalum conjugatum	
	Stenotaphrum secundatum	
Medium	*Brachiaria brizantha*	*Arachis pintoi*
	Brachiaria decumbens	*Calopogonium mucunoides*
	Brachiaria humidicola	*Centrosema pubescens*
	Digitaria setivalva	*Desmodium triflorum*
	Panicum maximum	*Pueraria phaseoloides*
	Pennisetum purpureum	*Desmodium intortum*
	Setaria sphacelata	*Leucaena leucocephala*
	Urochloa mosambicensis	*Desmodium canum*
		Neonotonia wightii
		Vigna luteola
Low	*Brachiaria mutica*	*Stylosanthes hamata*
	Cynodon plectostachyus	*Stylosanthes guianensis*
	Digitaria decumbens	*Zornia diphylla*
	Digitaria pentzii	*Macroptilium atropurpureum*

Productivity may vary from low to moderate depending on the relative percentage of productive grass, legume species and weeds, particularly bush weeds. For example, in Western Samoa local pastures dominated by Mimosa pudica and hetero were considered to be particularly productive while in the Solomon Islands there was no significant difference in liveweight gains between improved pastures and naturalized pastures with a high legume content and consisting of *Axonopus compressus, Mimosa pudica, Centrosema pubescens* and *Calopogonium mucunoides.*

Exotic species

Where the aim is to do more than merely keep weeds under control, so that fallen nuts can be located, then various exotic grass and legume species are available. Grass species most suited to the reduced light conditions under coconut palms are sod forming stoloniferous grasses that form short to moderate height swards. They provide moderate carrying capacity, allow fallen nuts to be quickly located, are inexpensive and easy to establish from cuttings, compete well with aggressive weed species, maintain a reasonable balance with companion legumes under grazing and do not compete excessively with coconut production. Such grasses include Angleton grass or Alabang X (*Dichanthium aristatum*), Batiki (*I. aristatum*), Cori (*B. miliiformis*), Koronivia (*B. humidicola*), Palisade (*B. brizantha*) and Signal (*B. decumbens*). Although Para grass (*B. mutica*) is popular in the Philippines, elsewhere it has been shown to be not very shade tolerant and requires good management under the high light conditions (light transmission >75%) of old coconut plantations or where trees are widely spaced (9 x 9 or 10m). Buffalo couch (*S. secundatum*) and Pemba grass (*S. dimidiatum*) are well adapted to heavy shade conditions in Vanuatu and Zanzibar, respectively.

The legumes most suited to coconut plantations include centro *(C. pubescens*) and Siratro (*M. atropurpureum*), with puero (*P. phaseoloides*) and sometimes Calopo (*C. mucunoides*) used as pioneers (and as cover crops). However, in some humid tropical environments Siratro is subject to Rhizoctonia leaf blight. Legumes that combine particularly well with *B. brizantha* and *B. decumbens* include hetero *(D. heterophyllum*), *D. triflorum* and *A. vaginalis*. Sensitive plant (*M. pudica*) should be utilized where it is indigenous, but needs to be carefully controlled. In Zanzibar, *T. labialis* was found to combine well with Pemba grass. Leucaena (*L. leucocephala*), or (on acid soils) gliricidia (*G. sepium*), can be grown as a double-row hedge (rows 1m apart) between every two rows of coconuts.

Although there have been a number of studies on the shade tolerance of herbaceous legumes less information is available on tree legumes. Leucaena leucocephala has been shown to have limited shade tolerance. In a more recent study of the response of six fodder tree legumes to a range of light intensities (ranging from 100 to 20%) the relative order of shade tolerance was *Gliricidia sepium* > *Calliandra calothyrsus* > *Leucaena leucocephala* > *Sesbania grandiflora* > *Acacia villosa* > *Albizia chinensis*. With the psyllid insect causing serious damage to *Leucaena leucocephala* in Bali, Indonesia, psyllid-resistant tree legumes are required. A trial under coconuts (58% light transmission) to identify suitably adapted species concluded that *Calliandra calothyrsus*, *Codariocalyx gyroides, Desmodium rensonii* and *Gliricidia sepium* warranted further study as forage species for use in the coconut plantations in Bali. A similar study was carried out in North Sulawesi where *Gliricidia sepium* and *Erythrina* sp. are commonly used as fences and live stakes under coconuts. *Calliandra* sp. CPI 108458 produced by far the highest leaf yields and other potentially useful species included *Flemingia macrophylla, Calliandra calothyrsus* (local), *Gliricidia sepium* (local), *Desmodium rensonii* and *Codariocalyx gyroides*. In the drier environment of South Sulawesi, there was little difference between the leaf yield of *C. calothyrsus, L. leucocephala* and *G. sepium*. This was before the effect of the psyllid on *Leucaena*.

Production Systems

In Asia, smallholder farmers often have one or two cattle which are grazed on whatever feed resources are available in their area. This varies considerably, depending on the available resources and farming system. In many situations cattle are grazed on fallow cropping areas before and after rice or other food crops, and are shifted to plantation areas during the cropping period when there is little available land for cattle. Also smallholders have to maximize use of their limited land resources, and coconuts are usually intercropped with food and other perennial crops such as banana, cloves, pepper and vanilla, particularly in areas with high population density. Despite this intensive land use there are often small areas under coconuts available for grazing or the growing of forage crops. Cattle are generally tethered in such intensive farming systems and shortfalls in feed are overcome by cutting naturally occurring grasses from communal areas such as roadsides. In these circumstances tree legumes can play a significant role in increasing protein content of the feed material, and thereby animal production. The use of tree legumes grown along field boundaries is particularly widely used in Bali.

In the Pacific, a large proportion of cattle are grazed under coconuts. In Fiji, Papua New Guinea (PNG), Western Samoa and Vanuatu cattle have been used traditionally to control weeds and thus reduce upkeep costs, and to provide an additional income from extra copra and meat. In PNG a 70% reduction in upkeep costs has been mentioned and substantially reduced labour costs on plantations in the Solomon Islands have also been indicated.

Cut-and-carry systems extract a considerable amount of nutrients from the forage production area and this is moved to where the animals are fed; particular care is required to return nutrients to the forage area. Neglect to do so may result in loss of coconut yield and cause a sharp decline in forage yield.

Grazing systems are generally found in more extensive coconut production areas such as in North Sulawesi, Indonesia, parts of the Philippines and also in many South Pacific countries. Some tethering is used to control animals but the majority of cattle are herded or animals are allowed to graze freely. A key factor hampering the development of more commercially oriented cattle production systems under coconuts is the lack of marketing facilities in the more remote coconut plantation areas. The importance of market access for the successful development of a viable cattle industry in the South Pacific was clearly demonstrated by Shelton (1991).

Animal Production

Grazing Systems

The level of animal production reported in grazing trials varies greatly (Table 2). Average daily gains (ADG) vary from 0.12 kg/hd/day to 0.51

kg/hd/day and liveweight gains per hectare varied from 44 kg/ha/year to 744 kg/ha/year. Stocking rates (SR) also varied widely from 1 to 4 cattle/ha (varying sizes) and stocking rate was related negatively to ADG.

The variation in animal production was clearly related to the feed resource available. Liveweight gains were lower on natural vegetation than on improved pastures except in the Solomon Islands where the natural pasture consisted of a very high proportion of legumes. In other cases substantial improvement in LWG was obtained by planting improved pasture. The importance of legumes was clearly indicated in many experiments. Other factors affecting forage growth and therefore animal production were soil fertility and/or fertilizer strategy, and light transmission. In general terms, as indicated above, yield of forages is linearly related to the amount of light available, provided that other factors affecting growth are not limiting. Thus in a coconut plantation with 50% light transmission, the yield of a highly productive grass like *Panicum maximum* will be approximately 50% of the yield achieved in full sunlight. Animal production is likely to be affected similarly by light transmission.

Cut-and-Carry Systems

Small backyard dairy and beef units are common in Bali, Indonesia, Philippines and Thailand, with the grasses Panicum maximum and Pennisetum purpureum being supplemented with leucaena, gliricidia and various by-products. These are widely used in the tropics because of the small size of holdings and the limited grazing area, the fragmentation of land holdings, a lack of fencing in cropping areas and the low cost of labour. These grasses are particularly suitable for plantation crops when the trees are young and vulnerable to damage from grazing animals. Animal production in smallholder cut-and-carry systems is difficult to assess. Rika *et al.* (1981) compared the growth rates of 12 Bali cattle leased individually to local farmers and fed natural vegetation, banana stem and coconut leaf (a local feeding system) with the growth rates of cattle grazing improved pasture in Bali. Average daily gain of cattle in the local feeding system was similar to that at the highest stocking rate in the grazing trial but considerably lower than those obtained at lower stocking rates where animals were able to choose their own diets.

However, a comparison of a cut-and-carry feedlot system, a semi-feedlot system, and free grazing for beef cattle in Johore, Malaysia revealed higher daily gains for stall-fed animals (Sukri and Dahlan, 1986). Trials were carried out with smallholders in West Johore, where coffee was grown as an intercrop under coconuts. Feed rations consisted of coffee by-products (30%), palm kernal cake (37%), urea (2%) and mineral-vitamin premix (1%) and various native forage species (*Paspalum, Axonopus, Ottochloa, Ischaemum* and *Brachiaria*) for grazing. The animals under the feedlot system were confined and fed the feed ration ad lib.; the semi-feedlot treatment involved tethering and grazing on the native grasses for 5 hours daily before the animals received the same feed ration ad lib.; the free-grazing animals were tethered to graze the native grasses. Average daily gains of the animals in the feedlot, semi-feedlot and free-grazing systems were 0.48, 0.37 and 0.15 kg respectively (over period of 178 days). The feedlot and semi-feedlot groups were extended for a further 116 days (trial 2) with average daily gains of 0.60 and 0.38 kg/animal respectively An economic evaluation demonstrated that gross profit was higher for the feedlot animals than the semi-feedlot or grazing groups. It was concluded that feedlot and semi-feedlot systems had great potential for increasing beef production among smallholder farmers and should avoid the major problem of low feed availability (and quality) in dry spells.

Table 2 Cattle production from grazing experiments under coconut

Country	Pasture	Light transmiss -ion(%)	LWG (kg/ ha/yr)	Stocking rate (b/ha)	ADG (kg/ha/d)
Solomon	natural	60	235-345	1.5-3.5	0.27-0.40
Islands	improved	60	227-348	1.5-3.5	0.27-0.40
(2900 mm)	natural	60	219-332	1.5-3.5	0.26-0.40
	improved	62	206-309	1.5-3.5	0.23-0.35
Western	natural	50	148	1.8	0.22
Samoa	improved	50	225-305	1.8-2.2	0.33-0.47
(2900 mm)	natural	50	127	2.5	0.14
	improved	70-84	273-396	2.5	0.30-0.43
	natural	70-84	401-466	4.0	0.27-0.32
	improved	70-84	421-744	4.0	0.29-0.51
Indonesia (1700mm)	improved	79	288-505	2.7-6.3	0.22-0.29
Philipp-	improved	n.a.	169-315	1.0-2.0	0.43-0.47
ines	improved	n.a.	130-155	1.0-3.0	0.14-0.36
(>2000mm)	improved	n.a.	137-306	1.0-3.0	0.20-0.37
	natural	n.a.	51	1.0	0.14
	improved	n.a.	91-146	1.0-2.0	
Thailand	natural	n.a.	44	1.0	0.12
(1600mm)	improved	n.a.	94-142	1.0-2.5	0.16-0.26
Vanuatu	improved	n.a.	175	1.5	0.32
(>1500mm)	natural	n.a.	250-285	2.6-3.0	0.26
	improved	n.a.	550	3.0	0.50

Annual rainfall in brackets
n.a. - not available.
Source: Adapted from Shelton (1991)

In Timor, tethered bulls fatten at an excellent rate of over 1 kg/day on an *ad lib.* diet of *Leucaena* leaves plus a metre of banana stem for moisture each day. The arrival of psyllids has reduced *Leucaena* growth in this system and *Leucaena* has been replaced by other tree legumes such as *Sesbania grandiflora*, *Acacia villosa* and *Gliricidia sepium*. However, in all cut-and-carry systems animal performance depends on the skill and experience of the farmer in ensuring that forages and feeds are provided according to the animal requirements.

Future Developments

The present emphasis in coconut areas is on planting high-yielding hybrids (mainly in large commercial plantations) and/or on coconut based farming systems where complementary enterprises such as livestock are integrated with coconuts to increase productivity per unit area, increase employment opportunities and to provide a buffer against low and fluctuating copra prices. Increasingly, new management techniques have been adopted, improved grasses and legumes have been planted to increase the animal carrying capacity and in smallholder systems increased use is being made of by-products and forage production is being integrated with food crops.

What is likely to happen in the future and can we learn from the experience of livestock integration with other tree crops?

i) For the immediate future the large majority of coconut areas will remain planted at traditional spacings, so there is a continuing need to identify grass and legume species for reduced light situations (and especially < 50% light transmission).
ii) Where high yielding hybrids are planted at even closer spacings than those traditionally used it remains to be seen if intergrazing is feasible and catch cropping prior to canopy closure may be the main intercropping activity. With the positive results from grazing sheep under coconuts in Vanuatu the integration of sheep at low stocking rates may be feasible, with the same need for low light species as in (i).
iii) As long as high prices were obtained for rubber, palm oil and copra and coconut oil then any use of ruminants was as an aid to the management of the key enterprise, the plantation crop. With the fall

in prices for rubber, palm oil, copra and coconut oil in recent years there has been more interest in integrating tree crops and livestock and in developing systems where the combined income from the two enterprises is significantly greater than that obtained from the plantation crop alone.

iv) In many areas seasonality of forage production is a problem. There are large quantities of alternative feed sources which can be used as supplements including banana, cassava, cocoa pod husk, copra cake, oil palm products, rice by-products, sugar cane residues and by-products etc.

Conclusions

Coconut plantations offer an excellent opportunity for the integration of cattle and a tree crop, particularly in the less populated areas where the land under coconuts is not fully utilized and is weed covered.

Given the appropriate tree spacing there are few major constraints and provided that adapted forages are planted to ensure a high quality sustainable feed resource, cattle production under coconuts can be a profitable and sustainable form of land use.

Unfortunately in many areas tree spacing is such that reduced light availability restricts the range of forage species and their productivity. Also, there has been little work on developing farming systems which allow farmers to choose from various management options. While research work is ongoing to identify alternative feed sources there is need to develop and apply low input systems in many coconut areas where poor farmers are faced with feed shortages especially in the dry season.

Areas where future work needs to be focussed include:

i) The identification of forage species better adapted to the low light environment of coconut plantations (<50%) which are capable of persisting under heavy grazing pressure.

ii) The adoption of coconut planting (rectangular) configurations with wide between-row spacing which allow for maximum light penetration, encourage cultivation, improve forage yields and to which to a large extent forage species already available would be well adapted.

iii) More detailed and systematic studies of the pasture-livestock-crop-coconut system and to develop management options for the farmer.
iv) Better utilization of existing by-products and alternative feed resources for livestock in the smallholder coconut based farming systems.
v) Continued efforts to identify alternative tree legumes to supplement *Leucaena* where infestation of the *Leucaena* psyllid has devastated production and severely affected smallholder cattle feeding systems.

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NOTE: More detailed information on the pasture-cattle-coconut system can be found in the following, copies of which will be sent on request (provided full name and address are forwarded):

Reynolds, S.G.(1995) Pasture-Cattle-Coconut Systems. FAO RAPA Publication 1995/7, 668p.

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