Compatibility of Forages and Livestock with Plantation Crops

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Abstract

There is an inherent complementarity between plantation crops and the raising of ruminant livestock. The integration of ruminants into plantation crops is most successful when both improved management of the crop and an additional income are possible. Factors affecting the competitive effects of forages on plantation crops are species of forage used, application of fertilizer, and the recycling of nutrients by grazing.

Ruminants may damage plantation crops by grazing foliage and fruit and must be excluded from very young plantations. Bark damage may occur in older dicotyledonous plantations. Goats are especially damaging in this regard but sheep and cattle may also damage the trunks of trees. One major advantage of integration is improved control of weeds and reduced use of toxic herbicides.

RUMINANTS have always been associated with plantation crops, both as 'sweepers' for weed control and for animal production. A large variety of crop-livestock combinations has been reported (Table 1); this indicates the inherent complementarity of plantation crops and livestock that can be exploited to improve land use and increase income. The main plantation crops that have been integrated with livestock include coconut, various forestry and horticultural species, and, more recently, rubber and oil palm. All the major domestic ruminant species (cattle, sheep and goats) have been integrated.

Successful integration of plantation crops and ruminants usually requires that the grazing livestock can be used as an aid in the management of the plantation crop, and that the combined income of the two enterprises is greater than obtained from the plantation crop alone. Moreover, as the plantation crop is usually, but not always, the main economic activity, any substantial negative effects of the livestock on either the yield or the management of the plantation will render the combination incompatible.

This review will discuss the compatibility of various plantation crop-livestock combinations concentrating on coconut, rubber and oil palm, although other crops will be mentioned. Compatibility of both forages and ruminant species with plantation crops will be mentioned considering both competitive and synergistic effects.

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Effects of Forages on Plantation Crops

Forages will clearly compete with plantation crops for moisture and nutrients. In situations where rainfall is high and well distributed, and where soil fertility is high or fertilizer is liberally applied, there will be little competition. In practice, such situations rarely exist and competition will occur at various times during the development of the crop.

The effect of such competition from improved forages has to be considered against that from naturally occurring vegetation which is inevitably present. Plantation crops do not fully utilise all incoming radiation, or all of the available moisture and nutrients, and managers must direct both financial and labour resources to the chemical or mechanical control of weeds. One of the positive effects of integration is therefore the 'replacement' of non-productive weed species with productive forage.

Table 1. Examples of ruminant-plantation crop combinations.

Plantation crop	Animal type				
	Cattle	Dairy	Sheep	Goat	References
Coconuts	x	X	X	X	1, 6
Rubber			X		2
Oil palm	X		X		3, 7
Forestry	X				4
Durian			X		5
Mango		X			6

1. Reynolds 1988. 2. Jusoff 1989. 3. Chen et al. 1978. 4. Shelton et al. 1987. 5. Najib 1990. 6. Moog (pers. comm.). 7. Tajuddin (pers. comm.). 8. Sophanodora (pers. comm.).

Forages in plantations which achieve closed canopy

In rubber and oil palm, and many forest plantations, competition with understorey vegetation occurs only during the immature phase before canopy closure. At this point light transmission is low (often <20%) and competition is minimal. However, during the immature phase, the developing trees are susceptible to weed competition and twining leguminous cover crops are usually planted to control less desirable weeds, especially in rubber and oil palm.

Cover crops are used to both 'smother' undesirable weed growth and to contribute to early rubber growth through nitrogen accretion (Watson 1963). Broughton (1977) in a survey of the effect of various covers on soil fertility and growth of rubber concluded that growth rate, trunk girth, tree height, bark renewal and ultimately latex yield is enhanced by the presence of the leguminous covers. Broughton further suggested that the effect may be smaller on fertile soils and can be partially offset on infertile soils by the application of higher rates of fertilizer. An example of this is shown in Table 2 of Pushparajah and Mahmud (1977). Latex yields were substantially lower when grown with improved grasses or with natural vegetation than when grown with leguminous cover crops. However, there was some recovery of yield when high rates of nitrogen fertilizer were applied.

Table 2. Effect of nitrogen fertilizer on accumulative latex yield over 14 years.

N treatment	Cover crop (kg/ha)	Grasses only (kg/ha)	Natural vegetation (kg/ha)
Low N	19 620	16 820	18 390
High N	20 620	20 670	20 460

Source: Pushparajah and Mahmud 1977.

The introduction of high-yielding grasses into young rubber plantations may be expected to exert a stronger competitive effect than either leguminous cover or natural vegetation, primarily due to the increased demand for nitrogen. This is of concern as a limitation to the growth of young rubber will adversely effect the yield potential of mature rubber (Broughton 1977).

Waidyanatha et al. (1984) investigated the effects of the grasses *Panicum maximum, Brachiaria brizantha* and *B. miliiformis* grown in monoculture with moderate applications of nitrogen fertilizer or in association with *Centrosema pubescens* and *Pueraria phaseoloides,* on girth increments in young rubber. Increments were significantly lower in rubber growing with grass monocultures and with mixtures (which contained little legume) than with the leguminous cover crop control. The effect was apparent for the first three years but not thereafter. In this experiment, *B. miliiformis* was less competitive but there was no clear relationship between pasture yield and girth increments of the trees.

In another experiment, Dissanayake and Waidyanatha (1987) compared the effects of various regularly cut grasses which were moderately fertilised (100 kg N/ha), with a *Pueraria phaseoloides* cover crop on growth of young rubber over a 2.5 year period. The grasses varied in their effect and some were actually less competitive than the cover crop (Table 3). As in the previous experiment there was no significant correlation between forage yield and tree girth or tree height. In a second experiment by the same authors, a different result was obtained as tree girth was larger when grown with *Pueraria phaseoloides* (9.5 cm) than when grown with either *Panicum maximum (7.9* cm) or *Brachiaria ruziziensis* (8.3 cm). The effects of grasses on rubber yields are therefore not definitive.

In these experiments, grasses were cut and removed, resulting in substantial removal of plant nutrients. For instance, the average removal of dry matter over the period of the experiment was 18.3 t/ha. Assuming a concentration of 1.4% N, then 256 kg/ha of nitrogen was removed while only 100 kg/ha was added.

In grazed pastures, however, most of the ingested nitrogen is returned to the soil as excreted dung and urine. Unfortunately there is little data on the effect of grazing leguminous covers or natural vegetation on the growth of young trees. Kamaruzaman Jusoff (1989) reported higher soil and rubber leaf N and P levels in grazed than in ungrazed plots of young rubber. Tree girths were also larger in grazed than in ungrazed plots but variability was too high to make definitive conclusions. In another study, the N and K concentrations in durian leaves were increased after a period of grazing of understorey herbage by sheep (Mohd. Najib 1990).

Table 3. Girth of 2.5 year-old rubber trees grown in association with various forage species.

Species	Tree girth* (cm)
Panicum maximum (cv. Petrie)	9.6[a]
Setaria sphacelata (cv. Kazungula)	9.3[a]
Paspalum plicatulum	9.0[ab]
Brachiaria miliiformis	8.9[abc]
Brachiaria ruziziensis	8.5[bcd]
Pueraria phaseoloides (Control)	8.2[cd]
Panicum maximum (A)	7.8[de]
Panicum maximum (B)	7.2[e]
Brachiaria decumbens	7.1[e]
Pennisetum purpureum (NB21)	7.1[e]
Brachiaria brizantha	5.7[f]

*Girths followed by different superscripts are significantly different ($P < 0.05$).
Source: Dissanayake and Waidyanatha 1987.

Forages in open canopy plantations

The situation is different under plantations with open canopies such as coconuts. Here light transmission remains high for the life of the crop, as the majority of coconut plantations are of the tall, well spaced varieties. There are many reports on the effects of understorey forages on coconut yield and these have been reviewed by Reynolds (1988). These have variously shown positive, negative or nil effects on coconut yield. A summary of some of the important results is given below.

Application of fertilizer can reduce the competitive effects of understorey vegetation. Reynolds (1988) in his review showed that the negative effect of high-yielding grasses can be ameliorated and sometimes switched to a positive effect by appropriate fertilisation.

The presence or absence of grazing animals is important. Grazing of natural vegetation under coconuts in East Africa nearly doubled yield compared to ungrazed areas (Childs and Groom 1964). Such effects can be attributed partly to improved nut collection but also to the recycling of nutrients 'locked up' in the standing biomass, as previously discussed. Santhirasegaram (1966) showed that coconut yield was reduced by 28% in a lightly fertilised but ungrazed *Brachiaria brizantha* pasture compared to ungrazed natural vegetation. When the *B. brizantha* pasture was grazed, the reduction was only 13%.

Variation in grazing system or stocking rate usually has only a small effect on coconut yield (Reynolds 1988). An exception is the data of Rika et al. (1981) who found that the yield of coconuts was higher at higher stocking rates (Table 4). This may have been related to the greater utilisation of forage and therefore improved nutrient cycling. Fertilizer (20 kg P/ha) was applied at planting only, and none was applied directly to the coconuts. Palms therefore relied on fixation and accretion from the legume component of the pasture for nitrogen.

Forage species vary in their competitiveness with coconuts (Reynolds 1988). In one experiment. coconut yield was substantially lower in moderately fertilised *Brachiaria mutica* and *Panicum maximum* pastures than in unfertilised natural pastures (Table 5) (Reynolds 1981).

Table 4. Effect of stocking rate on coconut yield in Bali.

Pasture treatment	Stocking rate (cattle/ha)	Coconut yield* (nuts/ha/month)
Natural pasture	-	291
Sown pasture	2.7	26.3[a]
	3.6	287[a]
	4.8	439[b]
	6.3	454[b]

*Yields followed by different superscripts are significantly different ($P < 0.05$).
Source: Rika et al. 1981.

Competition for moisture may also reduce coconut yield as coconuts are sensitive to moisture stress (Smith 1966) which causes abortion of young inflorescences (Chile 1974 cited in Reynolds 1988). In areas with a pronounced dry season, drought-tolerant grasses may further reduce moisture supply to palms and decrease nut yield. As *Brachiaria miliiformis* tends to cease growing at the onset of moisture deficit, it is regarded as being less competitive than some other species (Lane 1981 cited in Reynolds 1988).

Physical structure of forage plants is also important in coconut plantations. Tall species such as some cultivars of *Panicum maximum* make location of coconuts difficult and increase the labour requirements during the coconut harvest. Shorter, decumbent or stoloniferous types are preferred in this regard.

Table 5. Effect of various grass species on coconut yield over a 1-year period.

Species	Coconut yield as % of that obtained on natural pasture*
Natural pasture	100[a]
Ischaemum aristatum	86[c]
Brachiaria brizantha	102[a]
Brachiaria miliiformis	92[b]
Bruchiaria mutica	70[e]
Panicum maximum	79[d]

* Yields followed by different superscripts are significantly different ($P < 0.05$).
Source: Reynolds 1981.

Direct Effects of Ruminants on Plantation Crops

The compatibility of various ruminant species for grazing under plantation crops varies. An understanding of this compatibility has evolved largely on a 'trial and error' basis. Incompatibility is based on unacceptable damage or interference in the management of the plantation crop.

In all plantation types, animals are kept away from young trees until fronds or leaves are out of reach of the grazers. Both cattle (Chen et al. 1978) and sheep (Pillai et al. 1985) have been reported to browse fronds and nibble the bunches of oil palm. However, the authors concluded that damage was minor with only a negligible effect on yield. Pillai et al. (1985) suggested that damage was greater when forage resources under the palms were depleted.

Goats are renowned for their browsing of both tree foliage and bark. Bark damage sometimes occurs with species other than goats. Sheep damage to the bark of young rubber has been observed at the Malaysian Rubber Research Institute experimental station at Sg. Buloh (Tajuddin I., pers. comm.) but was relatively minor in the study of Pillai et al. (1985). Rams in particular cause damage when sharpening their horns.

Cattle grazing under *Eucalyptus deglupta* and other forestry plantations in the Solomon Islands caused serious damage to trees (Shelton et al. 1987). Damage to the trunk took two forms; bark stripping caused by cattle feeding on the bark was the most serious, but damage to the outer sapwood layer caused by cattle rubbing against trees also occurred. Damage to bark resulted in a doubling of the incidence of entry of decay fungi into the lower trunks of trees. Damage to the exposed main surface roots was also suspected but not confirmed.

Direct damage to stems of mature oil palm or coconut is minimal although there are concerns over possible soil compaction (Chen et al. 1978) and increased erosion hazard that may occur at higher stocking rates. Rubber root damage has been observed at the Rubber Research Institute of Malaysia from the treading effects of grazing cattle (Tajuddin I., pers. comm.). Cattle and goat are incompatible in rubber as they disturb the tapping cups.

There are also some negative effects of plantation crops on the grazing animal. Sheep have been observed to suffer from an abnormally high proportion of cuts (up to 24% in one case) when grazing oil palm due to the sharp spines on the petioles of fallen fronds (Tajuddin I., pers. comm.). This effect can be minimised by careful movement of the flock through the plantation or 'heaping' of the fronds.

On the positive side, apart from the recycling of nutrients, grazing ruminants are important in weed control in all plantation crops. Early this century, the principal reason for the grazing cattle in estate coconut plantations in the South Pacific was brush control. Currently, in Malaysia, it is estimated that the grazing of sheep in young rubber plantations results in a saving of approximately 30% of the costs of chemical weed control (Tajuddin et al. 1990). These savings, together with the reduced chemical hazard of ruminant grazers compared to chemical control, are important factors in the promotion of sheep grazing under plantation crops in Malaysia.

Conclusions

The integration of ruminants into plantation crops is most likely to be successful where both improved management of the crop as well as an additional income is feasible. It is imperative that the introduction of forages and grazing animals into plantations does not substantially interfere with management or reduce the yield of the plantation crop.

There are a number of factors which appear to influence the level of competition. Legumes are less competitive than grasses; there is variation among the species of grasses in their competitiveness; application of fertilizers reduces competition: and grazing promotes the recycling of nutrients so that yield of the plantation crop may even be improved.

Ruminants will graze foliage and fruit in very young plantations and must be excluded at this stage. Bark damage may occur in older dicotyledonous plantations. Goats are well known to cause this problem but cattle may also damage the trunks of trees. Soil compaction and root damage have been noted by some authors.

There is scope for greater integration of ruminants into plantation crops because of the inherent complementarity of the two enterprises.

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