Agroforestry Systems 4: 55-66.

Integration of animals in rubber plantations

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Key words: smallholder rubber, animal integration, biological weed control, sheep under rubber, poultry under rubber, bee keeping under rubber, silvopastoral system

Abstract. This paper describes a rather unique agroforestry approach of integrating animals (sheep, poultry and bees) in smallholder rubber plantations. The approach is based on the existence of surplus family labour, utilization of interspaces between the rows of rubber, availability of cheap and nutritious animal feed and presence of favourable microclimate for animal growth under rubber. Results of trials carried out by the Rubber Research Institute of Malaysia since the 1970's are presented.

Rotational system of broiler production under rubber was found to be technically, socially and economically feasible, providing a net return on family labour of M$370–M$825 per consignment of rearing 500 birds. Sheep rearing under rubber also appeared to be very attractive and practical; apart from producing meat for sale it also served as a 'biological weed control' measure. Cost of controlling the weeds commonly found under rubber plantations could be reduced by about 21% over the usual method by using sheep grazing for weed control. The Internal Rate of Return (IRR) from sheep rearing can be as high as 44%. Details of operation and management aspects of sheep integration under rubber are given.

Bees kept under rubber feed on nectar produced by inflorescence and tips of young rubber shoots and also on flowers of intercrops and weeds. The *Apis cerana* species was found to be suitable producing about 3 kg of honey per colony per harvest.

1. Introduction

Rubber (*Hevea brasiliensis*) is the most important commercial crop of Malaysia and Malaysia is the biggest producer of natural rubber in the world. The country has 1.96 million ha under rubber and it provides 1.6 million tons of rubber accounting for 39% of the total world production. The size of the rubber production units range from very small holdings of an average of 1.4 ha to large estates of hundreds of hectares. The Government of Malaysia has designated rubber production units of less than 40.4 ha as 'smallholdings' and the rest as 'estates'. These smallholdings account for 1.5 million ha (76%

Contribution No. 14 of the series on Agroforestry System Descriptions under ICRAF's AF Systems Inventory Project, funded partially by the United States Agency for International Development (USAID) (see Agroforestry Systems 1(3), 269–272, 1983 for Project details). Series editor: P.K.R. Nair, ICRAF

of the total area of the country under rubber) and 0.9 million tons of rubber per annum (56% of the total national production) and involve an estimated 0.5 million families. (Rubber Statistics Handbook, 1982 and Leong, 1984).

Although the rubber production strategy in the smallholdings and the estates aims at maximum output of rubber, various types of intercropping and other plant associations are common in smallholdings, but not in estates. The rationale for intercropping is that in a monocrop of rubber, which is usually planted at 7.3 x 2.4 m spacing (570 trees/ha), about 75% of the total land area is not effectively occupied by the roots of the main crop when the rubber trees are under three years old (Tan et al., 1980) and in smallholdings, the farmers take advantage of this possibility using the surplus family labour that they usually have. It is also recommended by governmental authorities to plant intercrops such as banana, maize, groundnut and vegetables in the smallholdings during the immature growth phase of rubber (see Figure 1), whereas leguminous cover crops are recommended if intercropping is not practised. The leguminous covers are invariably a regular aspect of plantation management in estates. However, most intercrops cannot be grown when the rubber canopy closes in about three years after planting, and the leguminous covers (except the shade-tolerant species such as *Calopogonium caeruleum*) fade away progressively as the rubber trees grow. Consequently, the inter-row spaces in rubber plantations are infested by weeds. Since these weeds compete with rubber trees, they have to be controlled, which is usually done by the use of herbicides. It is estimated that the Malaysian rubber industry spends about M$ (ringgit) 100 million (1 US$ = 2.5 ringgit in May 1985) annually for weed control.

Recently some efforts have been undertaken to integrate animal production in rubber plantations, whereby the interspaces in the plantations are utilized to rear animals such as poultry and for bee keeping, while the weeds are used as feed for sheep. The approach seems a sound one in maximizing land use and diversifying agricultural production in rubber areas. The paper discusses the salient aspects of this new agroforestry approach.

2. The concept of animal integration in rubber plantations

The main objectives of integration of animals with rubber are:

- to increase the production of meat protein economically without having to open large new areas of land for animal production;
- to reduce weeding costs through controlled grazing of palatable species and/or threading and trampling of non-palatable species under rubber;
- to reduce surface erosion through controlled grazing – complete eradication of weeds is not recommended so that a continuous supply of feed to the animals can be maintained;
- to use the organic manure such as dung to fertilize the rubber trees and

Figure 1. Banana and pineapple intercropped with eight month-old budgrafted rubber.

intercrops, and thus reduce the cost of inorganic fertilizer on the one hand and improve soil fertility on the other;
- to provide additional income to rubber growers particularly smallholders through increased productivity from a unit of land.

Basically the concept is the same as that of integrated farming in rubber, discussed by Wan Mohamed (1978), with appropriate modifications. It is based on and motivated by the following factors.

2.1 Resource utilization

Surplus labour: In individual rubber smallholdings with average size of 1.2–1.6 ha, surplus labour is available especially during the unproductive immature phase of rubber growth (Selvadurai, 1970).

Planting of intercrops (Wan Mohamed and Chee, 1976) or rearing of poultry (Wan Mohamed and Abraham, 1976; Wan Mohamed and Chee, 1976), bees (Mohd Ali et al., 1984) and/or sheep/goats (Wan Mohamed, 1978; Lee et al., 1978 and Wan Mohamed, 1982) are some of the possible ways of utilizing excess family labour profitably. For the estates sector, although the possibility of excess labour usually does not occur, a part of the existing labour assigned to do normal weeding can be mobilised to manage sheep which perform the weeding work by grazing on the weeds.

Land: No additional land is required to carry out integration of animals under rubber. The interspaces between rows of rubber can be utilised to grow the supplementary feeds such as cultivated grass and legumes required by sheep, as well as to build shelter for the animals (poultry, bees and sheep) and also for grazing. However, before letting the animals (sheep) in, the rubber trees must be not less than 1½ year old and the plants at least 2 m tall, because the animals tend to feed on the lower whorls of the rubber plants.

2.2 Availability of cheap and nutritious animal feed

The ground vegetation that succeeds after the cultivation of intercrops or after the leguminous cover fade away grows naturally and thus constitutes a free source of feed for sheep. Wan Mohamed (1977) reported that the total dry matter yield of such undergrowth species found under rubber was between 500 and 600 $kg\,ha^{-1}$, and most of the species were palatable to sheep or goats. Table 1 lists the palatable and non-palatable undergrowth species found under rubber. Table 2 which gives the chemical composition of grasses, broadleaved plants and ferns in smallholdings and estates, indicates that these undergrowth species are quite nutritious. Moreover, it has also been observed that sheep feed on rubber seeds, young self-sown seedlings and also fresh leaves of fallen rubber branches. In the case of bee-keeping, the bees feed on nectar produced by inflorescence and tips of young shoots of rubber trees. Other sources of nectar for the bees are flowers of intercrops planted in the interrows, weeds and other plants around the rubber areas.

2.3 Favourable microclimate under rubber

The temperature inside a stand of rubber is 1 to 5 °C lower than in the open (Ani et al., 1985) which can be one of the factors contributing to better growth and productivity of sheep reared under rubber (Lowe, 1968). Under immature rubber where the canopy does not provide total shade for the sheep, the sheep have been observed to rest for a few minutes under the shade of the young trees, probably to cool off their bodies. Partial shade provided by the rubber canopies offers a conducive environment for poultry rearing and bee keeping too.

Table 1. Species composition of undergrowth in rubber plantations*

Palatable (to sheep)	Non-palatable (to sheep)
Asystasia nemorisa	*Ageratum conyzoides*
Axonopus compressus	*Boreria spp.*
Imperata cylindrica (very young)	*Bridellia tomentosa*
Ischemum muticum	*Cyperus spp.*
Mikinia cordata	*Eupatorium odoratum*
Ottochloa nodosa	*Hyptis brevipes*
Paspalum conjugatum	*Imperata cylindrica* (mature)
Paspalum orbiculare	*Lantana camara*
Rhynchltrum repens	*Melastoma malabatrichum*
Ferns (some *spp.* only)	*Mimosa pudica* (mature)
Rubber seedlings	*Mimosa invisa*
Planted legume covers	
Calopogonium mucunoides	
Centrosema pubescens	
Desmodium spp.	
Flemingia congesta	

*After Wan Mohamed (1977)

Table 2. Chemical composition of ground vegetation in smallholdings and estates*

Location	Plants	Chemical composition (%)		
		Crude protein	Crude fat	Crude fibre
Smallholdings	Grasses	9.4	1.5	33.3
	Broadleaves	13.2	1.9	32.9
	Ferns	11.4	1.8	31.9
	Mixed	11.4	2.1	28.0
Estates	Grasses	11.4	1.9	33.1
	Broadleaves	14.1	1.8	33.1
	Ferns	13.9	1.9	27.2

*After Wan Mohamed (1977)

3. Trials at the Rubber Research Institute of Malaysia (RRIM)

The RRIM initiated trials on animal integration with rubber in the 1970s. The emphasis has mainly been on those animals which do not adversely affect or interfere with normal growth, productivity and management of rubber. The animals found suitable so far are poultry, sheep and bees, and summary accounts of the results obtained so far are given in the following sections. Goats were found to cause damage on the bark of young rubber (Tan et al., 1980) while buffaloes did not thrive well on most rubber growing areas that are situated mostly on gently sloping and undulating terrains. Buffaloes also cause bark damage to rubber trees when they rub their horns on them. Cattle were not tested as they were known to drink and spill latex from the latex

Figure 2. Rearing of broiler chicken in the interrows of five year-old rubber trees.

cups on the trees, in addition to causing root damage and soil compaction due to trampling.

4. Poultry production in smallholdings

Two systems of broiler poultry production have been tested. In the first system, the chickens were given shelter at night and were allowed to go free in a fenced area in the smallholdings during the day, feeding on insects, worms, weed seeds, tender underground vegetation, etc. Concentrate feed which consists of grain and agricultural by-products were also given. In the second system, an intensive management of broiler production was adopted where the birds were kept housed at all times and fed with feed concentrates (Figure 2). It was found that the second system was more acceptable to smallholders. In 1983, the rotational broiler production system was introduced where groups of 5 to 10 smallholders in one area rear 500 birds per batch each continuously in a rotational system. The advantages of this system are that it allows agreements to be made between the smallholders and the suppliers of day-old chicks, feeds and other materials on the quality, supply and price of supplies on the one hand, and between smallholders and wholesale buyers of chicken produced, on the other. These arrangements allow for better planning and give more confidence on the part of the smallholders. Further, technical guidance and assistance by government agencies can be carried out more efficiently on a group basis.

The average production cost of producing broilers was M$3.27 per bird in 1976 (Wan Mohamed and Chee, 1976). It has gone up to M$4.83 in 1982 (Wan Mohamed, 1982) and to about M$5.30 in 1984, due to the increase in the cost of day-old chicks and feeds. Wan Mohamed (1982) estimated that in a smallholding of rubber rearing poultry, 85% of family labour was utilised to provide feed, water and general cleaning of the shed, feed and water utensils. The daily labour input was 3 to 4 man-hours to raise 500 to 1,000 birds per consignment.

Results of studies carried out on individual smallholdings and recent observations on rotational system of broiler production showed that broiler production is technically, socially and economically feasible (Wan Mohamed and Chee, 1976; Lee et al., 1978). The net return on family labour had earlier been calculated at M$370–835 per consignment for raising 500 birds (Wan Mohamed, 1982) but recently the figure has dropped to a much lower range mainly due to very poor selling price obtained. In fact, some smallholders experienced losses in some of the batches in the rotation. However, on the average, the smallholders received positive net family returns. The most important factors that influence income from broiler production as put forward by Wan Mohamed and Abraham (1976) and Lee et al. (1978) are:

- supply of high quality day-old chicks when needed;
- supply of unadulterated high quality feed;
- availability of market and suitable market price; and
- cost of day old chicks and feed.

Smallholders' efforts and their willingness to follow the recommended system are also major factors that determine the level of income and profit earned (Wan Mohamed, 1982).

5. Sheep rearing under rubber

The RRIM has been conducting investigations on sheep rearing under rubber since 1975 (see Figure 3). The technical, social and economic aspects have been discussed in detail by Wan Mohamed (1977; 1978; 1982), Tan and Abraham (1981), Wan Mansor and Tan (1980) and Wan Mohamed and Ahmad Hamidy (1983). The salient aspects are as follows:

5.1 Operational aspects

Sheep can be reared in both immature and mature rubber areas. In immature rubber, the rubber plants must be above 2 m in height and at least $1\frac{1}{2}$ year old as mentioned earlier, and the field must have palatable undergrowth species (Table 1). The number of sheep per unit area of holding or estate is determined mainly by the amount of growth rate of palatable undergrowth available. The present recommendation is 6 to 8 animals per hectare for

Figure 3. Sheep grazing under 12 year-old rubber trees.

immature areas and 3 to 5 animals per hectare for mature areas. Understocking leads to inefficient utilization of undergrowth vegetation, but high stocking rate may lead to depletion of palatable species and even erosion. Therefore, understocking at the start of the project is recommended to ensure that enough feed is available as the number of animals increases progressively.

Sheep rearing is not recommended in smallholdings of less than 2.5 ha that have no grazing ground adjacently, because, in such cases the direct and indirect returns will be too low. However, there is no upper limit of area for sheep rearing (in estates). Security of animals is one of the major problems in rearing sheep under rubber. Casualties due to attack by wild dogs as well as thefts have been experienced in the past. Regular shooting of wild dogs is necessary, and animal sheds should not be too isolated. Security problem has been a major reason for not initiating large scale free ranch system of sheep rearing under rubber. In this context, the use of solar-powered electric fencing with alarm system seems advantageous and it needs to be looked into.

5.2 Sheep rearing for weed control in plantations

One of the main objectives in rearing sheep under rubber is to use the sheep as an agent for 'biological weed control'. Since sheep can consume up to 70% of weed species (Wan Mohamed, 1977), the cost of weeding with herbicides and labour can be reduced. Wan Mansor and Tan (1980) reported that 75% of the available weeds in their trial area were edible by sheep so that the cost of weed control was reduced by M\$7.26 ha^{-1} amounting to a 21.7% saving per year during the study period of 4 years (1976–1979) In another study by Lim et al. (1983), savings in cost of weeding was M\$15.00 ha^{-1} $year^{-1}$. These differences in savings in weeding costs were due to different stocking rates and weed conditions.

Efficiency of weeding by sheep grazing can be further improved by the use of solar-powered electric fencing. This system of controlled grazing also reduces the requirement for labour for handling large flock-sizes (300 to 400 sheep) from three to only one worker. Since the fencing system used was of the portable type, grazing pattern according to weeding requirement in the plantations could be conveniently programmed (Tajuddin, I. and Chong D.T., unpublished).

5.3 Management aspects

Appropriate management of the grazing area is an important aspect. It is essential to constantly monitor the effect of grazing by sheep. Overgrazing leads to depletion of palatable weed species and can cause soil erosion. Non-palatable weeds will compete with the palatable species which might later lead to feed insufficiency (Wan Mohamed, 1982). Therefore those weeds that are not 'taken' by sheep should be removed manually by slashing or digging or chemically by herbicide application.

Sheep manure can be used as a source of manure for rubber. An adult sheep excretes about 186 g of droppings (dry matter basis) daily, so that at a stocking rate of 6 animals per hectare, an average of about 400 kg ha^{-1} of sheep manure can be obtained per annum. The droppings contain 2.40% N, 0.49% P, 2.89% K, 1.84% Ca and 0.54% Mg (Wan Mohamed, 1977). Thus the average annual nutrient addition could be about 10 kg N, 2 kg P, 11.5 kg K, 7 kg Ca and 2 kg Mg per hectare. While the sheep graze in the field, they deposit the droppings on the soil. The excreted droppings that accumulate in the shed have to be removed at about 2 to 3 times a month and can be applied to the rubber trees in the field. It has been observed on a field with sandy alluvial soil that the growth of rubber trees improved after constant grazing at 6 to 8 weeks intervals over a period of two years.

5.4 Performance evaluation

Studies carried out by the RRIM since 1975 have shown that both local and Dorset Horn (DH) crossbred sheep adapted well in smallholdings and in estates. However, in terms of growth and productivity, the DH crossbreds (especially 50% DH) performed better. In terms of grazing performance, it was observed that the DH crossbreds consumed more palatable weeds (on per animal basis) than local sheep because of the heavier body weight of the former. Tan and Abraham (1981) reported that sheep performed better at the

Table 3. Performance of sheep under rubber

Item	RRIM experiment station[a]	Smallholdings[b]
Average number of offspring (lamb/ram/year)	1.5	1.3
Productivity (%)	142	127
Lambing interval (days)	207	259
Age at first lambing[c] (days)	355	482
Single lambing (%)	94	100
Twin lambing (%)	6	0
Triple lambing (%)	0	0
Average lamb birth weight (kg)		
Male	1.63	0.99
Female	1.57	1.02
Mean	1.60	1.01
Average daily weight gain (g) to nine months of age		
Male	49.5	32
Female	43.0	30
Mean	46.5	31
Weight of adult ram (kg)	26.0	–
Dressing (%)	46.0	–
Lamb mortality (%)	18.0	–
Mortality rate from		
Single lambing (%)	15.0	23.1
Twin lambing (%)	50.0	0
Triple lambing (%)	0	0

[a]Wan Mohamed (1978)
[b]Lee et al. (1978)
[c]Wan Mohamed (1982)

RRIM Experiment Station than at farmers' smallholdings. The comparative data are given in Table 3. Obviously, the differences in environmental and management conditions explain these differential results.

It has generally been observed that growth of rubber is better in areas grazed compared to non-grazed areas. In a one-year study reported by Tan and Abraham (1981) it was observed that girth increment on trees in fields where the undergrowth was grazed by sheep by either rotational or free-range grazing system was generally better by 25 and 33% than that in the field where the undergrowth was not grazed. They attributed the differences to the reduction in weed competition as well as return of organic manure in the grazed fields. Recently it has been postulated that better growth of rubber trees is expected with sheep grazing adopting the controlled grazing system and using solar-powered electric fencing than with the free-range grazing system, because the former gave better weed control.

5.5 Economics

Income from sheep rearing can directly be derived from the sale of sheep either as breeding stocks or for slaughter. Indirect returns are in the form of savings in costs of weeding and fertiliser. From an economic analysis of the practice, Wan Mansor and Tan (1980) reported that rearing an original stock of 21 animals for a duration of 25 months resulted in a profit of M$2,970.15 amounting to a 107.5% increase of the total investment of M$1,724.30. The Net Present Value (NPR) and Internal Rate Return (IRR) were found to be M$1,975.24 and 44.06% respectively. Lim et al. (1983) reported that from an original stock of 6 animals, an average income of M$60.90 per month was obtained after rearing the sheep for 4 years.

5.6 Research needs

In view of the good potential for future development of sheep rearing under rubber in Malaysia, it is essential to carry out more research on various aspects in order to perfect the system. Tan and Abraham (1981) and Wan Mohamed and Ahmad Hamidy (1983) suggested several aspects to be studied. Some of their suggestions, along with a few additional ones are given here.

- Ecological succession of undergrowth vegetation of palatable and non-palatable weed species as a result of grazing.
- Methods of encouraging growth and persistence of palatable species of natural undergrowth.
- Introduction of new species of legumes and grasses that can grow under shade and withstand grazing.
- Systematic grazing schemes that will lead to more efficient weed control.
- Breeding for better crossbreds adaptable to local environment and feeds.
- Large-scale sheep rearing and management system with lower cost of initial inputs and management.
- Supplementary feeding of agricultural by-products, e.g., oil palm sludge, palm kernel cake, rice bran, etc.
- Ways of utilising sheep by-products such as wool and skin that could provide additional income.
- Replacing the expensive forms of mineral licks (salt + macro- and micro-elements) with cheaper materials.
- Conversion of sheep dung into nutrient enriched animal manure or compost.

6. Bee keeping under rubber

Work on bee keeping under rubber by the RRIM started in the early 1980's; mainly in rubber smallholdings. The *Apis cerana* species of bee has been found to be suitable under smallholders' conditions. The main harvesting season for honey kept under rubber is in February/March, i.e. during the flowering season of rubber trees. Currently, there are only a few smallholders participating in a pilot project with the RRIM. Preliminary observations indicate that an average of 3 kg of honey could be collected from one colony during the February/March flowering season (Mohd Ali et al., 1984).

Smallholders are encouraged to rear bees because the establishment cost of bee keeping is low and the technique can quite easily be acquired by them. In return the farmers can get additional income from the sale of honey.

7. Acknowledgements

The author wishes to thank the Director of RRIM, Dato' (Dr) Haji Ani bin Arope for his keen interest and support. The comments and assistance by Dr Samsuddin bin Tugiman and Tuan Haji Mohd Sharif bin Kudin are greatly appreciated. Valuable contributions by the staff of the Project Development and Implementation Division are hereby acknowledged. Co-operation given by the Managers and staffs of the RRIM Experiment Stations at Sungai Buloh and Kota Tinggi are also appreciated.

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