INTERCROPPING OF YOUNG RUBBER

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Introduction

About 50% of the rubber area in Thailand is now planted with old rubber clones which yield lower than 300 kg/ha/year. Currently, the Rubber Replanting Program of Thailand, set up in 1972 under the World Bank support, is encouraging the replanting of about 50,000 ha of old low-yielding clones with new clones of rubber annually. These new clones will yield over 1,800 kg/ha/year at peak production. In the future, the replanting program will be continued at an accelerated rate as more and more area of old rubber plantations planted with old or new clones enter the replanting stage.

A major constraint of small farmers to replant their rubber is the source of income for their subsistence during 6-7 years from felling the old stand until the new rubber enter production. However, during the 1-3 years after felling the old rubber trees, substantial area between rows of immature rubber trees is suitable for intercropping with food and cash crops. This will provide for alternative sources of income for small land-holders. Taking the present replanting rate into account and multiplying by number of years which intercropping could be undertaken, Thailand will have about 150,000 ha of replanted rubber area for intercropping during the immature stage, A large part of the total field area usually lies unutilized by the new trees.

Research on Intercropping of Young Rubber in Thailand

Intercropping of rubber in Thailand has been widely practiced by small farmers (Garot, 1970). Most of them intercrop their rubber, young and old plantations, with pineapple, banana and other fruit trees. During the establishment of the Accelerated Rubber Replanting Program in the 1970s, a systematic survey was made by investigators at the Rubber Research Center, Songkhla showing that popular intercrops were upland rice, banana, pineapple, tobacco, groundnut, sweet corn, vegetables, etc. (RRC, 1973). After 1973, a number of research projects was carried out by investigators at the Rubber Research Center and universities to identify crops suitable for intercropping of young rubber trees and component technologies for intercropping.

1. Identification of Crops Suitable for Intercropping.

As early as 1974, J.K. Templeton, a FAO expert at the Rubber Research Center, Hat Yai, recommended that many field crops and vegetables such as upland rice, pineapple, soybean, sweet corn, groundnut, water melons, mungbean, banana, sunflower and dwarf castor were suitable for intercropping between rows of young rubber trees (Templeton, 1974a). These crops were moderate yielders, many were known by farmers, adapted well to medium inputs in terms of materials and labours and favourable by local market. Subsequent research not only confirmed his recommendation but new crops were also identified. The following crops are the most favourable as they can provide for substantial income or are used for family consumption.

a. Upland rice. Upland rice is the most favourable intercrop of rubber or other fruit trees including oil palm in the South of Thailand. The cultivation of rice is well understood by most farmers and the product is used for family consumption with very little surplus sold to the local market. Early experiments showed that upland rice could be combined into systems of cropping with other crops such as sweet corn, groundnut and dwarf castor.

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(Templeton, 1974a; Wongsukon et al., 1978). Most of the small-holders intercrop their rubber only one or two years as they are afraid that intercrops may adversely affect the growth of rubber. An experiment conducted later at Songkhla confirmed that upland rice could be planted between rows of rubber for 4 years and it was not found to retard the growth and development of rubber if adequate fertilizer was applied (Table 1) (Laosuwan et al., 1988a). These yield levels were quite high and consistent from year to year regardless of shading effect due to rubber.

In 1987, extensive yield trials of upland rice varieties were conducted as a coordinated program between Rubber Research Center and Rice Department to identify upland rice varieties suitable for intercropping. Two local varieties, namely Dok Phayom and Kho Muang Luang were recommended to grow between rows of young rubber trees (Rice Department and Rubber Department, 1978).

Table 1. Yield of upland rice planted between rows of young rubber for four years.[1]

Rubber age[2]	Without fertilizer[3]	With low rates of fertilizer	With high rates of fertilizer
(months)	(kg/ha)	(kg/ha)	(kg/ha)
4 (Year 1)	1,488	1,893	2,038
16 (Year 2)	1,342	1,435	1,792
28 (Year 3)	1,268	1,952	2,435
42 (Year 4)	562	2,257	2,292

[1] Adapted from Laosuwan et al. (1988a)
[2] Rubber age at harvest of intercrops.
[3] All tests within years were significantly different.

b. Legumes. Besides legume covers, other food legumes were recommended to grow as intercrops of young rubber trees (Templeton, 1974a). These food legumes are groundnut, soybean and mungbean.

Groundnut is suitable for sandy loam or loamy soils and yields well in the South. Most small land-holders grow groundnut in the second year after upland rice for family consumption (RRC, 1973). It is very labour intensive particularly at harvesting and thus recommended to be grown in small plots. Experiments conducted at Songkhla in which the crop was planted repeatedly in the same plot for four years showed that the response to fertilizer application was not quite substantial. (Laosuwan et al., 1988a) (Table 2).

Soybean is the most important food legume and oilseed crop in Thailand but is usually not grown in the South due to unfavourable conditions and the lack of upland area. However, previous research showed that the production of this crop in the region is possible as it yielded well and had no major diseases (Loasuwan,1985). However, the performance of soybean as an intercrop of rubber, based on the crop

Table 2. Yield of mungbean, soybean and groundnut intercropping between rows of young rubber.[1]

Crop	Rubber age		Control[3]	Lime + Fertilizer[4]
	Year	Month[2]		
			(kg/ha)	
Mungbean	1	12	444	668
	2	24	310	510
	3	36	255	443
Soybean	1	3	1,250	-
	2	15	975	1,163
	3	27	765	1,216
Groundnut	1	3	1,193	-
	2	15	944	1,449
	3	27	1,090	1,284
	4	39	1,064	1,335

[1] Adapted from Laosuwan et al. (1988a)
[2] Rubber age at harvest of intercrop.
[3] No applications of fertilizers and other nutrients.
[4] Lime rate 625 kg/ha; fertilizers NPK formular 15-15-15 applied at 200 kg/ha.

from a three years experiment at Songkhla during 1981-1984, gave no impressive results as the yield was quite low (Table 2) (Laosuwan et al., 1988a).

Mungbean is grown very widely in the South as a sequential crop of rice in paddy fields and as intercrop with young rubber trees. Laosuwan et al. (1988a) demonstrated that mungbean could be planted for three years or more if fertilizers were applied to the crop especially in the second year or later (Table 2). This yield level was abnormally low due to poor soil conditions which were not suitable for mungbean. Subsequent experiments in other locations showed that mungbean grown as an intercrop of young rubber could yield higher than 1.5 tons per hectare (Laosuwan et al., 1987b). In 1988, a mungbean variety, PSU-1, was developed by the mungbean breeding program at Prince of Songkla University especially for intercropping with young rubber (Laosuwan, 1988).

c. Forage Crops. Animal production is a major component of agricultural system widely practiced in the South of Thailand. However, more and more area of communal grassland taken into the crop production system or other purposes which directly affect animal production. A series of investigations by researchers at RRC, Hat Yai showed that forage production is possible and many grass species grow well between rows of 1-3 year old rubber but the yield rapidly decreases in the fourth year (Table 3) (Jewtrakul et al., 1985, Jewtrakul, 1989). Only the cut and carry system is recommended for these intercrops to avoid contact injury by cattle to the young rubber trees.

d. Other crops. Many other crops have been evaluated for their suitability as intercrops with rubber. These include sweet corn, glutinous corn (Wongsukon and Templeton, 1974), Japanese mint (Templeton, 1974b), pumpkin (Charoensuesakul and Tantanawat, 1983), pineapple, banana, field corn (Laosuwan et al., 1988a), pigeon pea (Laosuwan et al., 1989), cardamon, fruit crops such as long-gong and gumpada, baby corn, (RRC, 1991a, RRI, 1991b), rattan (Anon. 1991), tomato (Anon. 1992) various kinds of vegetables, cassava, tobacco, papaya, water melons, etc. (RRC, 1991b).

2. Period Suitable for Intercropping

Procedures for planting or replanting rubber involve the felling of the old rubber stand and preparation of the area for planting which will be done from July through September. The immature rubber trees grow slowly in the first 1-3 years but the assets of soil and the sunshine falling on its surface remain available for productive plant growth. Young rubber can be intercropped for three years when planting with budded stumps in the field or over a period of four years when planting with seed-at-stake for bud-grafting in the following year. (Templeton, 1974a).

Ages of rubber trees that can be intercropped may depend on many factors such as the row

Table 3. Dry weight yield of certain grass species grown between rows of 1-4 years rubber.[1]

Species	Year 1	Year 2	Year 3	Year 4
	----------(kg/ha)----------			
Morichus *(Brachiaria mutica)*	1,256	4,913	131	0
Ruzi grass *(Brachiaria ruziziensis)*	706	8,381	3,713	1,012
Signal grass *(Brachiaria brizantha)*	2,200	19,819	6,544	2,338
Guinea grass *(Panicum maximum)*	1,706	11,494	4,956	1,238
Napier *(Pennisetum purpureum)*	4,575	13,331	2,656	513
Guatamala *(Tripsacum laxum)*	1,900	9,263	4,031	1,313

[1] *Adapted from Jewtrakul et al., (1985).*

orientation, spacings of rubber, soil fertility, topography, kind of intercrops, shading effect and root growth of rubber. Amount of light transmission through the rubber canopy at different ages is one of most important limiting factors affecting intercropping. In an experiment in which the rubber rows were arranged in East-West direction and the spacing of rubber was 7 by 3 m, it was shown that the percentage of light transmission was 89% and 56% for 30 and 40 weeks old rubber, respectively (Laosuwan et al., 1985). The shading effect of the young rubber trees was later investigated systematically by Laosuwan et al. (1987a). In this study the light transmission into the interrow was measured three times daily regardless of row orientation. The linear increase of shading effect was demonstrated at the increase of rubber age. About 50% sunlight was available for intercropping at 40 months after the planting of rubber and it decreased to 25% at 60 months or 5 years after planting (Fig. 1). Therefore, beyond these times the potential of profitable intercropping is limited by the effects of increased shading. However, many perennial intercrops such as fruit trees, rattan, biennial crops such as bananas and pineapples may be intercropped between rows of mature rubber if the row width and orientation is modified (Laosuwan and Sripana, 1985; RRI, 1991a)

3. Effect of Intercrops on Growth and Yield of Rubber

Intercropping of young rubber with different crops such as upland rice, sweet corn, groundnut, mungbean, etc. is widely practiced among small rubber farmers during the immature stage of their plantation. However, the possible adverse effects of intercropping on rubber have not yet been throughly investigated. Ideal intercrops, apart from their advantage in replacing weeds, should improve the growth of rubber or at least have no retarding effect on the main crop.

Wongsukon et al. (1978) tested different combinations of intercropping treatments in 1-3 year old rubber. Each of these treatments consisted of legumes, cereals, vegetables and other field crops such as sunflower and castor bean, planted in rotation over three years between rows of two clones of rubber, GT 1 and RRIM 600. They found significant differences in the girth increment of rubber due to these treatments in rubber clone RRIM 600 but not GT 1. Certain intercropped treatments showed a small advantage over legume cover in RRIM 600 and a small disadvantage in GT 1. Growth with natural covers has not been as good as with intercropping (Table 4).

Laosuwan et al. (1988b) tested eight intercropping treatments including natural cover, mungbean-soybean, mungbean-peanut, corn, upland rice, banana and pineapples between rows of young rubber trees. These treatments were grown successively at the same site for 3-4 years. Means for girth increments of young rubber at different stages of rubber and latex yield at 57 months old are given in Table 5. Differences in girth increments were found during certain periods of rubber growth. Legume cover and pineapples were more conducive to the growth of rubber than any other crops. However, other crops, including legumes, cereals and

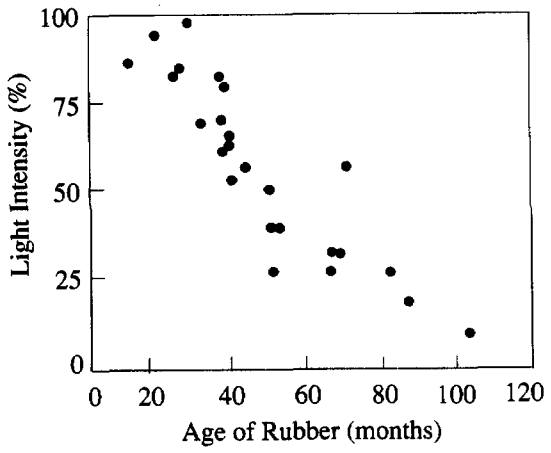

Fig. 1. Light penetration to interrow of rubber.

Table 4. Girth increments of Rubber Clone GT 1 and RRIM 600 (in 18 months).[1]

Treatments	Rubber Clone [2]			
	GT 1		RRIM 600	
	cm	%	cm	%
Legume cover	12.5	100	11.7b	100
Sweet corn-Upland rice	12.2	98	12.4a	106
Mungbean-Papaya	12.0	96	12.3a	105
Castor-Upland rice	11.6	93	11.1b	95
Groundnut-Upland rice	11.3	90	11.3b	96
Natural cover	11.1	89	9.9c	85

[1] Adapted from Wongsukon (1978).

[2] Means in columns followed by different letters are significantly different.

banana gave similar growth rates of rubber and none of these crops, as compared with control (natural cover), adversely affected the growth of rubber. These studies gave an evidence that intercropping of rubber with these crops can be recommended provided that adequate fertilizer is applied both to rubber and to intercrops. Cassava is believed to be a soil exhausive crop and usually not recommended as a rubber intercrop. It was demonstrated that this crop grown either solely or in combination with legumes still affects the growth of rubber (Buranatham, 1986).

4. Topography and Soils

The area suitable for intercropping will be limited first of all by topography. Cultivation of arable crops would be restricted to slopes of less than 12° in order to avoid soil erosion. In the South of Thailand the soils generally have been considered marginal for food crop production. They are highly weathered, contain large amounts of variable charge colloids, have a soil pH below 5.0, and have a low CEC, low base saturation, low P availability and high Al saturation (Land Development Department, 1984, cited by Suthipradit, 1993).

All experiments provided with the same recommendation that intercropping practices should be associated with adequate fertilizer applications. The analyses of soil samples taken right after land clearing and three years later indicated that the amount of N, P, K, Mg, Mn, Cu and Zn decreased due to the uptake by intercrops but those of the control (plot without intercrops except weeds) remained at the same levels (Laosuwan et al., 1987b). However, with the exception of N and P, the levels of other necessary nutrients were still higher than their respective critical levels.

Possible Yield and Income Obtained from Intercrops

Crops suitable for intercropping should have marketing potential or are needed by farmers for their consumption. Most farmers grow upland rice in the first and second years of rubber replanting for family consumption rather than for cash income. Earlier intercropping studies were confined mainly to the selection of suitable crops with little emphasis on economic viability rather than inductive effect of intercrops on growth and yield of rubber. Therefore, yield measurement and income were often overlooked and experiments on input technology is scarce.

Laosuwan et al. (1984) calculated net cash income from their experiments with fertilizers applications as shown in Table 6. These crops were grown continuously from the first year and thus this calculation was averaged over experiments and years. Their results showed that banana and pineapple gave the highest net benefit of 28,288 and 14,728 Baht/ha/year, respectively. This study recommended that the application fertilizers are necessary to obtain high yield from intercrops. Higher net benefits were demonstrated by the Rubber Research Center from growing vegetables such as cauliflower, broccoli, chinese cabbage, tomato, etc. as intercrops of young rubber. These studies showed that intercropping

Table 5. Effect of intercropping systems on girth increments of young rubber at different stages of growth.[1]

	Age of rubber (years)				Yield at 57 months
	2-3	3-4	4-5	5-6	
	(cm/30days)				(ml/plant)
Natural cover (weeds)	0.65	0.74	0.94	0.76	52.2
Legume cover	0.61	0.90	1.09	0.83	54.0
Mungbean-Soybean	0.65	0.69	0.92	0.73	56.5
Mungbean-Peanut	0.65	0.72	0.92	0.75	61.3
Upland rice	0.66	0.73	0.97	0.75	57.1
Corn	0.61	0.74	0.95	0.75	53.2
Banana	0.70	0.72	0.97	0.75	72.4
Pineapple	0.62	0.83	1.03	0.84	67.5

[1] *Adapted from Laosuwan et al. (1988b).*

Table 6. Net cash income from different intercrops.

Intercrop	Income (Baht/ha/year)
Field crop[1]	
1. Mungbean	491 - 2,076
2. Soybean	3,550 - 8,251
3. Groundnut	2,492 - 3,846
4. Upland rice	2,855 - 3,628
5. Corn	2,527 - 3,609
6. Banana	28,288
7. Pineapple	14,728
Vegetable[2]	
1. Cauliflower	242,725
2. Broccoli	210,169
3. Chinese kane	178,738
4. Tomato	130,894
5. Chinese cabbage	83,481
6. Yard long bean	36,619

[1] *Adapted from Laosuwan et al. (1984).*
[2] *Adapted from RRC (1991a).*

provided substantial net benefit to small land-holders during the immature stages of rubber (RRC, 1991a and 1991b).

Recommendations for Intercropping

1. Recommended Systems

Areas planted to rubber are usually characterised by having long rainfall distribution which takes about 6-7 months. The most important area of rubber lies on the eastern plains of southern Thailand where the rainy season starts in April or May and lasts until late December. However, the crop suitable for intercropping in the first year is upland rice which is planted before the onset monsoon rains. In the second year, most of the small rubber holders will plant upland rice again for home consumption. However, in the second year, a number of alternative crops could be grown between the months of April and September. These crops are vegetables such as cauliflower, chinese cabbage, tomato, sweet corn, cucumber, baby corn, etc. which do not require high rainfall but supplementary irrigation and field crops such as mungbean and groundnut. These crops are suitable to be grown in the first peak of the rainy season and may be followed by other crops or even upland rice in the second peak. Many crops such as field corn, tobacco, cassava, etc. were not recommended in the first year due to their tall growth habit that might retard the growth of young rubber trees. These crops may be introduced into the system in the second year. In certain circumstances in which labour and cash inputs are limited, many farmers plant biennial crops such as bananas, pineapples, papaya, forage crops, black pepper, cardamon, sweet potato, etc. which are not labour intensive. Recent investigations suggested that semi-perennial or even tree crops such as rattan, Zallacca, long-gong, gumpada etc. could be introduced into the system as multi-storey intercropping. These recommendations are summarized in Table 7. In most cases, farmers are urged to include legumes in their pattern to improve nutritional balance and soil conditions. However, for all the systems to be effective, application of fertilizers at adequate rates should be practiced for all crops. The Rubber Research Institute has provided the following guidelines for intercropping practices:

1. Crops suitable for intercropping should not exhibit adverse effect on the growth and development of rubber
2. Only annual and biennial crops are recommended.
3. Intercropping should be done only during years 1-3.
4. Intercropping is not recommended in poor soil and steep soil
5. The application of adequate rates of fertilizers is urged for all intercropping systems.

Wongsukon et al. (1978) and Laosuwan et al. (1988a) investigated the performance of different cropping patterns or rotations between rows of young rubber trees. These systems were designed to ultilize all the annual growing period and arable areas between rows of young rubber. It is assumed that legume-legume combinations would promote the growth of rubber but cereal-cereal combinations would be deleterious to the main crop. However, this was proved to be incorrect. Almost all crops and rotation sequences are now recommended by the Rubber Research Institutes (Training Center, RRI, 1988; RRI., 1989; Jewtrakul, 1990; RRI 1991a)

2. Cultural Practices for Intercrops

The cultural practices for each intercrop between rows of young rubber trees have to be made systematically from planting until harvesting. The fraction of the interrow suitable for intercropping is prepared for each intercrop by respective conventional procedures. Fertilizer application and liming are often necessary since the soils planted to rubber are usually acidic.

Table 7. Planting dates of different crops or cropping systems between rows of young rubber.[1]

Crop	Early rainy season	Late rainy season
Upland rice	-	Songkhla : Sep - Feb Trang : Aug - Jan Yala : Oct - Mar West coast : May - Dec
Corn	-	Songkhla : Oct - Jan
Groundnut	Songkhla : April - Jul Trang : April - Jul	Songkhla : Oct - Jan -
Mungbean	Songkhla : April - Jun Trang : April - Jul Yala : May - Aug	
Sweet corn	For all locations the same as mungbean	
Water melon	Songkhla : Dec - Feb Trang : Nov - Feb Yala : Jan - Mar	
Vegetables	For all locations, vegetables should be planted in the early rainy season with supplementary irrigation or otherwise in the late rainy season	

[1] *Adapted from Templeton (1974a), Buranatham and Jewtrakul (1983) and Laosuwan et al. (1988a).*

In the first and second year the root zone of rubber is less than 1 m in diameter. Therefore, land preparation including ploughing, chemical treatments, etc. should avoid this zone. Intensive recommendations on the field lay-out for different intercrops are demonstrated by RRI (1991a), Buranatham et al. (1989). The recommended planting distances of the intercrops from the rubber rows are about 1 to 1.5 m for field crops and vegetables and about 2 m for biennial crops such as bananas. Popular spacing for rubber is 7 m between rows, thus the strip of 5 m will be available for all intercrops.

Regular spacing and conventional cultural practices should be applied to respective intercrops (RRI, 1989). For example, for field corn popular varieties such as Suwan-1 were recommended with spacing of 75x50 cm between rows and between plants. For certain crops such as pineapple, paired rows leaving ample space between pairs should be used to facilitate cultural practices and other crop management activities such as weed control, fertilizer application, chemical treatments, crop thinning and harvesting. In general, field crops and vegetables occupy the interrow area to within one metre of the rubber rows in the first and second year. These would reduce to 1.5 m of unplanted strip in the third year and fourth year. For biennial or perennial intercrops such as bananas, rattan, certain fruit trees, the planted area should be limited to one or two rows. The intercropping period for crops which require intensive land preparation involving ploughing or hand hoeing should not be extended to the fourth year to avoid mechanical damage occurred to the rubber root. For biennial or fruit trees the period may be longer or they may by planted as companion crops if adequate income is feasible.

Conclusion

Experimental results collected so far have given convincing evidence that intercropping of immature rubber is important economically and agronomically. It can provide substantial income to small farmers during the immature stage of rubber. Intercropping exhibits no adverse effect on the growth and yield of rubber trees and in many instances the growth of

rubber has been actually improved. This is due to the continuous activities performed by farmers in cultural practices, fertilizer application and weed control.

Almost all annual crops, forage crops and biennial crops are suitable for intercropping provided that inputs in terms of fertilizer application, weed control, pest managements and for certain crops supplementary irrigation, are adequate. However, food legumes or other leguminous species should be included in the system as they are believed to stimulate the growth of rubber.

The intercropping can be practiced continuously or annually in the first three years in order to make full use of family labour. Special care should be practiced for land preparation in the third year to avoid root damage. However, fertilizers and other micronutrients should be applied to sustain the soil fertility and to stimulate the growth of intercrops. In certain cases, intercropping can be extended into the fourth or fifth year if the intercrops are shade tolerant.

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