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RUBBER-BASED MULTISPECIES CROPPING SYSTEM UNDER RAINFED CONDITION OF NORTH EAST INDIA

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An experiment was conducted to evolve an appropriate rubber-based multispecies cropping system during the immature phase for North East India. A variety of annual and short duration intercrops (upland rice, okra, cowpea, *Amaranthus*, *Colocasia*, *Amorphophallus*, pineapple and banana) were grown in the rubber inter-row space under two different planting geometries. In the first model, rubber was planted in paired – rows 9.0 m apart. The distance within the paired-row was 5.0 m and between trees of a row 3.2 m. In the second model, rectangular system of planting (6.7 x 3.4 m) was followed. Among the diverse crops cultivated in the first year, performance of rice and cowpea was superior. The actual intercrop yield of rice was 240.5 kg/ha and 321.2 kg/ha and that of cowpea was 151 kg/ha and 160.3 kg/ha in Model I and II, respectively. In the second year of intercropping, tuber crops like *Colocasia* (192 kg/ha) and *Amorphophallus* (173 kg/ha) performed well in both models. Promising yield of banana (580 kg/ha) was also obtained from Model I. *Colocasia* had the highest benefit-cost ratio (BCR) of 2.67 followed by banana (2.47), cowpea and upland rice. The BCRs are 1.83 and 1.85 for cowpea and 1.83 and 1.80 for rice in Models I and II respectively. *Amorphophallus* was also promising with a BCR 1.64 in both models, indicating the economic feasibility of growing these crops as intercrops during the initial years.

Keywords: Benefit-cost ratio, Cropping system, *Hevea brasiliensis*, Planting geometry

INTRODUCTION

Rubber (*Hevea brasiliensis*) is a non-traditional crop for the north-eastern part of the country, but the crop has gained popularity due to its easy adaptability and high economic return. The lengthy gestation period has often served as a disincentive for investors in the business of rubber farming. However, rubber holdings provide ample scope for cultivation of a variety of intercrops having different stature, canopy shape, size and rooting habits, thereby making use of under-utilized soil space and solar radiation in the monocrop stand.

Planting geometry is also an important factor in the determination of optimum planting density. Rubber is generally planted at a wide spacing, 4.9 x 4.9 m on level lands and 6.7 x 3.4 m on sloping and undulating lands, which usually results in an under-optimal utilization of land and other resources during the immature phase

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(Jessy *et al.*, 2005). Multiple cropping of rubber inter-rows with two or more species prior to canopy closure will help in better utilization of resources like land, sunshine, moisture, *etc.* to the maximum extent possible and would add much biomass to the soil as well. Moreover, intercropping with locally preferable crops will help to meet a part of the food requirement of the farm family and in the effective utilization of family labour. It is a way of enhancing an early return on investment. Modification of the usual planting geometry with paired-row geometry with a wider spacing between the paired-rows, will make it possible to cultivate intercrops during the entire immaturity phase (Jessy *et al.*, 2005). In order to exploit the complete potential of intercropping, it is crucial to study the different crop combinations as well as their management and identify those which are best-suited for the local agroclimatic conditions. Hence, the study was undertaken with the main objective to identify the most remunerative and best rubber-based cropping system under rainfed conditions in North East India.

MATERIALS AND METHODS

The experiment was conducted at Taranagar Farm, Regional Research Station of Rubber Research Institute of India, Agartala (23°50'N, 91°25'E), Tripura in North East India over two cropping seasons in 2008-09 and 2009-2010. The experiment was initiated with two models. The density orientation of rubber and intercrops in both the models is given in Figures 1&2. The soil of the experimental area was sandy loam. Chemical analysis of the soil indicated that prior to cropping it was acidic (pH 4.02) and low in organic carbon (0.59%), available phosphorus (0.07 mg/100 g) and potassium (4.32 mg/100 g). The annual average rainfall was 1534 mm during the experimental period. The mean annual maximum and minimum temperatures were 30.93 °C and 20.94 °C respectively during the period.

Model I

The model was laid out in an area of 1.25 ha. Rubber was planted during June 2008 in paired-row system 9.0 m apart. The distance within the paired-row was 5.0 m and that between plants in a row was 3.2 m. Budded stumps of clone RRII 600 were used for planting. Sequential intercropping with rubber was done in one hectare and in the remaining area, rubber was cultivated as monocrop with *Pueraria phaseoloides* as ground cover. The wider space available (*i.e.* 9.0 m) between rubber paired-rows was filled with three rows of pineapple (*Ananas comosus*), one row of arecanut (*Areca catechu*) and one row of banana (*Musa paradisiaca* cv. *sabri*). In addition to this, one row each of the vegetables cowpea (*Vigna unguiculata*), okra (*Abelmoschus esculentus*) and amaranth (*Amaranthus* sp.) in the first year and species like elephant-foot yam (*Amorphophallus paeoniifolius*) in the second year (Fig. 3) in combination with legume cover crop (*P. phaseoloides*) were also grown. The narrow inter-row space (*i.e.* 5.0 m) within the paired-row was utilized for cultivation of upland rice in the first year and colocasia (*Colocasia esculenta*) and cowpea in the second year. *Gamhari* (*Gmelina arborea*) and acacia (*Acacia auriculiformis*) were planted on one side of the boundary where there was no adjacent plantation. One row of signal grass (*Brachiaria decumbens*) was planted along the boundary for fodder purpose.

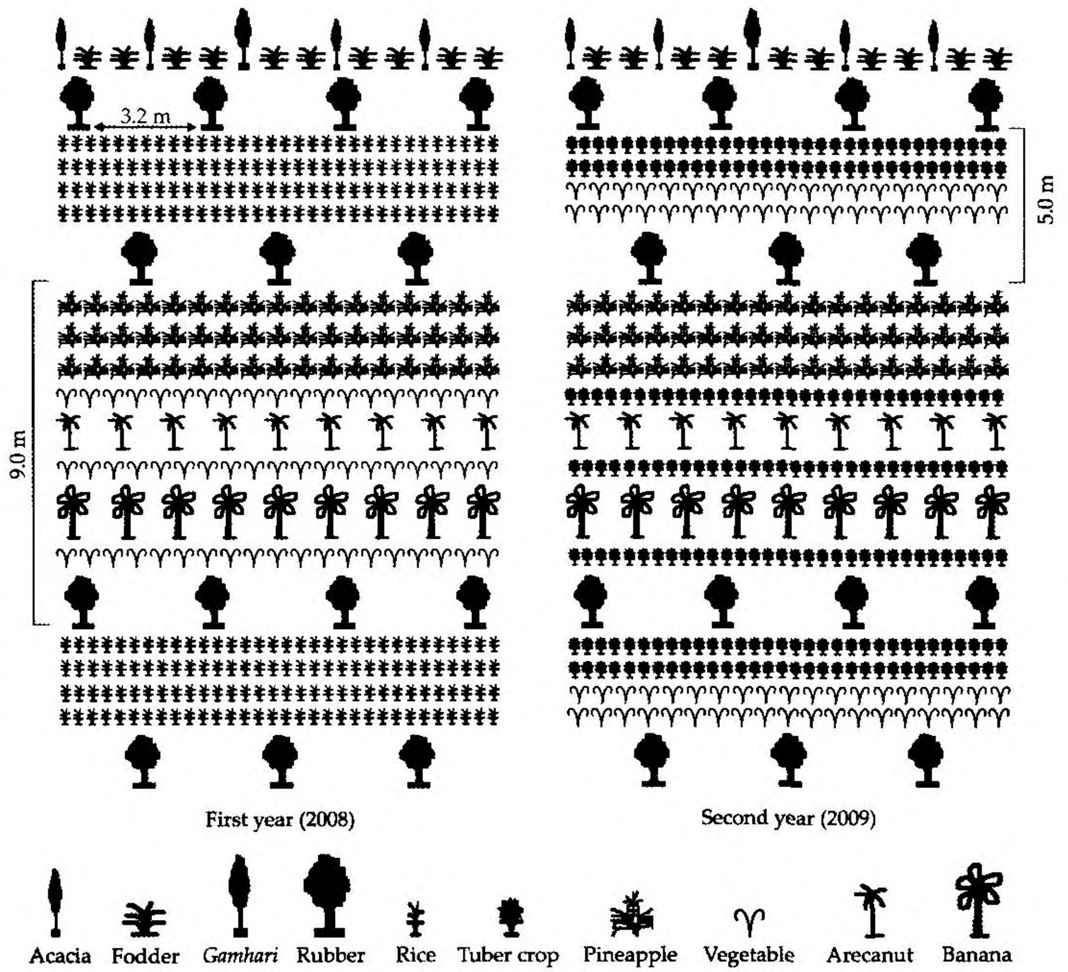

Fig. 1. Orientation of rubber and intercrops in Model I

Model II

A rectangular system of planting (6.7 x 3.4 m) was followed for rubber (RRIM 600) in this model (1.25 ha). Like Model 1, sequential intercropping was done in one hectare and in remaining 0.25 ha area, rubber was cultivated as monocrop with *P.phaseoloides* as cover crop. Every alternate inter-row space (6.7 m) was utilized for cultivation of pineapple and vegetables in the first year and only pineapple in second year. The other alternate inter-row spaces were utilized for cultivation of upland rice in the first year and cowpea and tuber crops in the second year. The boundary planting of *gamhari* and acacia with one row of signal grass on two sides of the boundary was done where there was no adjacent plantation.

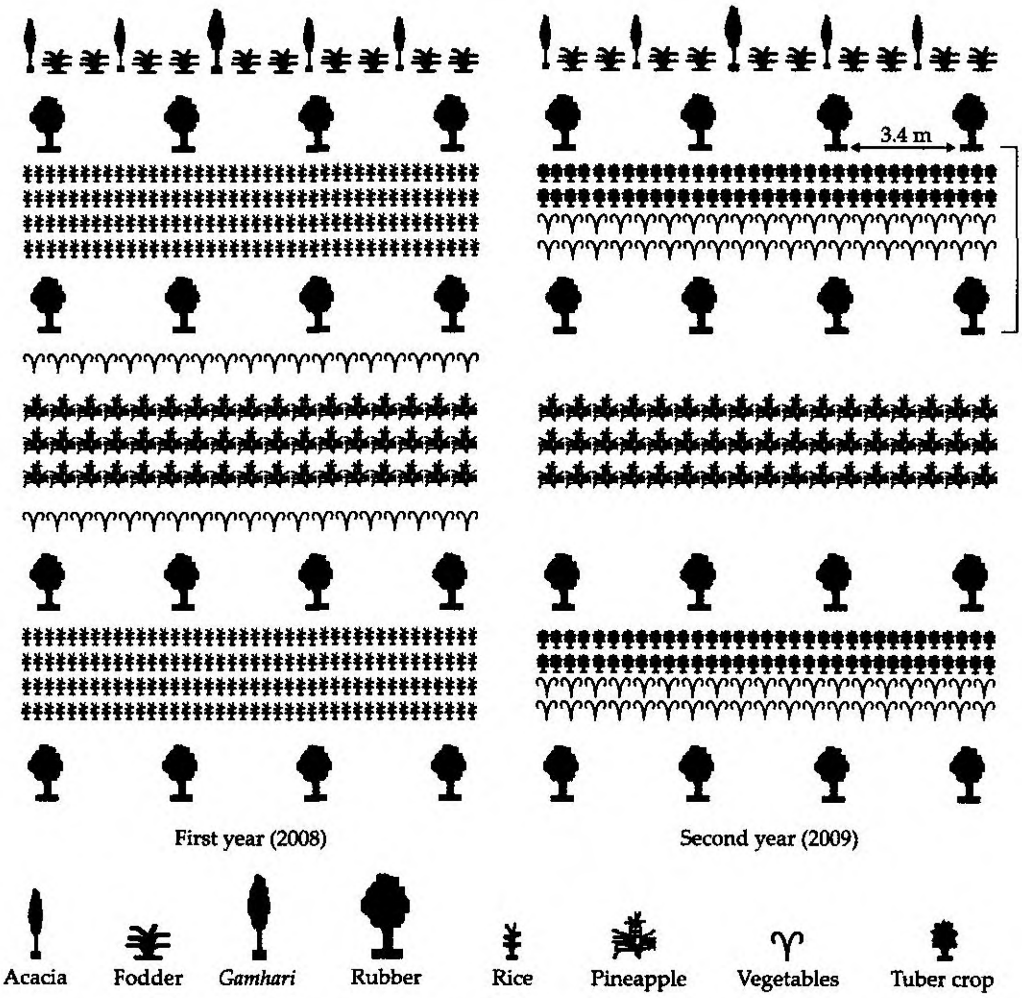

Fig. 2. Orientation of rubber and intercrops in Model II

The number of rubber plants in both the models was 440. The cultural practices were followed as per the recommendations (Rubber Board, 2007). For the other crops, the fertilizer recommendations of the ICAR (Chadha, 2001) was followed (Table 1). Fertilizer application was done separately for all the intercrops and these were cultivated across the slope under zero tillage conditions.

RESULTS AND DISCUSSION

Among the annual vegetable intercrops tried, cowpea performed better compared to okra and *Amaranthus* sp. Okra established well, however, flowering and fruit set were low. *Amaranthus* performed poorly under rainfed condition. Upland rice also performed well in the first year of intercropping. Laosuwan (1996) reported

Fig. 3. Rubber intercropped with banana, elephant-foot yam, arecanut and pineapple

that upland rice is the most favoured intercrop of rubber in south of Thailand. Tuber crops, pineapple and banana were also established. Economic viability of pineapple and banana in rubber plantations in Tripura was also reported by Roy *et al.* (2001). Among the tuber crops tested in the second year, *Colocasia* and *Amorphophallus* performed well. Better performance of *Amorphophallus* as an intercrop under immature rubber was also reported by Jessy *et al.* (2005). Along the boundaries, the two forest species acacia and *gamhari* established well. These species are fast growing and serve the purpose of firewood and generate additional income from timber in due course. Fodder grass (signal grass) which was grown in a single row along the boundary to meet the fodder requirement for raising livestock, also performed well. The total yield of signal grass was 252 kg in two cuttings from 300 m row. The yield of different intercrops in Model I and II both in first and second year is given in Table 2 and 3.

Mean girth of rubber in Model I increased from 4.74 to 6.74 cm in intercropped plots and from 4.80 to 5.91 cm in monocropped plots. In Model II, mean girth of rubber increased from 4.50 to 6.39 cm in intercropped plots and from 4.20 to 5.06 cm in monocropped plots. The increase in mean girth in intercropped plots over sole crop plots could be attributed to the positive effect of intercropping in the immature stage.

Economic viability

Among the intercrops tried in both models in the first year, the gross return was

Table 1. **Cultivation details of the intercrops**

Year	Intercrop	Variety	Sowing time	Method of planting	Spacing (cm)	Nutrient applied (kg/ha)		
						N	P_2O_5	K_2O
2008	Upland Rice	TRC 87/225	June-July	Line sowing	45 x 10	80	40	40
	Cowpea	Local	June-July	Line sowing	30	20	50	50
	Okra	Local	June-July	Line sowing	30	150	50	50
	Amaranthus	Local	June-July	Line sowing	30	150	50	50
	Pineapple	Queen	June-July	Row planting	70 x 30	516	172	516
	Banana	Sabri	June-July	Row planting	250	300	50	600
2009	Cowpea	Local	June-July	Line sowing	30	20	50	50
	Colocasia	Local	May-June	Row planting	30	80	60	60
	Amorphophallus	Gajendra	May-June	Pit planting	100	80	60	80

Table 2. **The yield of different intercrops (First year, 2008)**

Crop	Model I		Model II	
	Area (m^2)	Actual yield (kg/ha)	Area (m^2)	Actual yield (kg/ha)
Rice	2000	240.5	3000	321.2
Cowpea	216	151.0	216	160.3
Amaranthus	144	2.5	144	3.5
Okra*	216	13.9		

*Okra not included as an intercrop in Model II.

the highest for upland rice (Rs. 6012) followed by cowpea, okra and *Amaranthus*. The initial investment was higher for upland rice compared to other vegetable intercrops. The gross income from each intercrop was worked out by considering the prevailing rates in the market (Table 4). Benefit-cost ratio (BCR) was calculated to assess the return per rupee invested taking into account the minimum agriculture labour wage rate for Tripura State (MoL & E, 2009) and also other material costs like seeds, fertilizers, fungicides and pesticides prevailing in the market. In the second year of intercropping, gross return was maximum for banana followed by pineapple, *Amorphophallus*, *Colocasia* and cowpea but the total cost of cultivation was also higher for banana and pineapple than *Amorphophallus*, *Colocasia* and cowpea. After two years of intercropping, the BCR proved to be the highest for *Colocasia* (2.67) followed by banana (2.47) and cowpea (1.83 in Model I and 1.85 in Model II). Upland rice also proved to be a suitable intercrop having a BCR of 1.83 and 1.80 respectively in Models I and II. *Amorphophallus* also proved to be a viable intercrop in immature rubber and BCR was calculated to be 1.64 in both models. Better performance of *Amorphophallus* as an intercrop in immature rubber has also been reported by Jessy *et al.* (2005). This experiment established the economic feasibility of growing these crops under immature rubber in the non-traditional region of NE India. BCR was low for okra and *Amaranthus* due to the poor yield under zero tillage and rainfed condition. Pineapple also performed well and BCR was found to be 1.2 and 1.1 in Models I and II respectively.

Table 3 . **The yield of different intercrops (Second year, 2009)**

Crop	Model I		Model II	
	Area (m^2)	Actual yield (kg/ha)	Area (m^2)	Actual yield (kg/ha)
Cowpea	216	50	216	56
Colocasia	384	192	384	192
Amorphophallus	640	173	640	173
Pineapple	1300	877	1300	812
Banana	1600	580		

Table 4. **Cost of intercrop cultivation and benefit-cost ratio (BCR)**

Crop	Model I				Model II			
	Employment generation (Man-days/ ha/year)	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Benefit-cost ratio (BCR)	Employment generation (Man-days/ ha/year)	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Benefit-cost ratio (BCR)
Rice(one crop)	25	3281	6012	1.83	33	4438	8028	1.80
Cowpea(two crops)	30	2970	5455	1.83	30	2970	5523	1.85
Okra(one crop)	04	519	570	1.09				
Amaranthus(one crop)	04	468	50	0.10	04	468	70	0.14
Colocasia(one crop)	08	1438	3840	2.67	08	1438	3840	2.67
Amorphophallus (one crop)	10	3165	5190	1.64	10	3165	5190	1.64
Pineapple*(one crop)	20	5117	6122	1.20	20	5117	5669	1.10
Banana*(one crop)	30	6700	16600	2.47				

*BCR calculated from discounted values

Since the cost and return were spread over a period of two years, cost streams and income streams were discounted at the rate of 5% per annum for comparison. Noor *et al.* (1991) also reported pineapple as an economically feasible intercrop in young rubber. Similar observations have also been reported by Rajasekharan (1989) and Jessy *et al.* (1998).

Employment generation

The employment generation in each intercropping system was calculated in terms of man-days/ha/year (Table 4). Employment generation in the first year increased from 312 man-days/ha/year in rubber alone to 406 and 385 man-days/ha/ year in Model I and II respectively. Similarly, in the second year of intercropping, employment generation increased from 152 man-days/ha/year in rubber alone to 189 and 184 man-days/ha/year in Models I and II respectively. So there is a total increase of 131 and 105 man-days in Model I and II over a period of two years due to intercropping. Among the intercrops, banana and upland rice recorded higher employment generation in both models in the first year and *Amorphophallus* recorded higher employment generation in both models in the second year. If family labour was used for intercropping, the gross return in the first year would have increased by a total amount of Rs. 7708 and Rs. 5986 in Model I and II respectively (Rs. 82/man-day). Similarly, in the second year, an increase in gross return to the tune of Rs. 3700 would have been realized in Model I and Rs. 3200 in Model II (Rs.100/ man-day) if family labour was used.

CONCLUSION

Experimental results collected so far have given convincing evidence that intercropping in immature rubber is important economically and agronomically. Intercropping with banana, upland rice, cowpea, *Colocasia* and *Amorphophallus* proved to be more productive and remunerative than other crops tested under the zero tillage and agroclimatic conditions of North East India. The experiment will be continued for entire immaturity period and yield data from pineapple and other crops will be collected subsequently.

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