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INTERCROPPING OF BANANA AND PINEAPPLE IN RUBBER PLANTATIONS IN TRIPURA

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The effect of two cropping systems involving two intercrops, banana and pineapple, on soil chemical properties, growth of rubber, biomass production, nutrient recycling, productivity and returns was investigated during the first four years (1996-97 to 1999-2000) growth period of rubber in North-Eastern India, Agartala, Tripura. In the first system (Model I), intercrop strip consisting of five rows of pineapple and two rows of banana was planted in between four strips of rubber with a stand of 550 rubber plants per ha and in the second system (Model II), one row of banana and two rows of pineapple were planted in alternate gaps with 470 rubber plants per ha. Continued fertilizer use under these two systems showed increase in available phosphorus and calcium. The growth of rubber was better and biomass production as well as nutrient recycling was higher in Model I. High yield and benefit : cost ratio of banana and pineapple established the economic feasibility of growing these intercrops. The maximization of yield and returns from the intercrops was possible by increasing the plant density (as in Model I) without adversely affecting the soil properties.

Key words : Banana, Benefit-cost ratio, *Hevea brasiliensis*, India, Intercropping, Non-traditional region, Pineapple, Tripura.

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INTRODUCTION

Rubber (*Hevea brasiliensis*) is a perennial tree that has economic and social importance in many tropical and subtropical countries. In India it has been grown traditionally in Kerala and Kanyakumari district of Tamil Nadu. Of late, cultivation of rubber is becoming a very popular means of livelihood for the people of Tripura in North East India. Rubber takes approximately 7-8 years to attain maturity (Sethuraj *et al.*, 1989; Vinod *et al.*, 1996). It is possible to utilize the inter-row spaces in rubber plantations for growing suitable intercrops to provide remuneration to the growers until the trees are brought to tapping.

Banana and pineapple, being popular fruits in North East India, could serve as good intercrops. Information on the economic feasibility of growing pineapple and banana as intercrop with rubber in this region is not available. This investigation was carried out to evaluate the effect of these intercrops on the growth of rubber, soil chemical status, biomass production, yield and returns.

MATERIALS AND METHODS

The experiment was conducted at Taranagar Farm of Rubber Research Institute of India, Regional Research Station, Agartala (23° 53'N, 91° 15'E) in North-East India over four cropping seasons in 1996-97, 1997-98,

Table 1. Weather parameters

Year	Annual rainfall (mm)	Mean temperature (°C)	
		Maximum	Minimum
1996	1729	31	20
1997	1826	30	20
1998	1901	30	21
1999	1753	31	21
2000	2008	30	20

1998-99 and 1999-2000. The rainfall and temperature recorded during the period are provided in Table 1.

Soil of the experimental site (0-30 cm) contained 21 per cent clay, 25 per cent silt and 54 per cent sand. CEC of the surface soil was 5.4 cmol (+) per kg of soil. The initial nutrient status of the soil is presented in Table 2.

Table 2. **Nutrient status of surface soil (0-30 cm)**

	Organic Carbon (%)	P	K	Ca	Mg	pH
		(mg/100 g of soil)				
Model I						
Initial (1996)	0.86	0.69	3.87	11.83	1.12	4.50
Final (1999)						
Between banana	0.95	1.05	2.68	14.06	0.93	4.72
Between pineapple	0.89	0.93	2.52	10.97	0.55	4.71
Between rubber	0.87	1.40	3.32	11.56	0.67	4.54
Model II						
Initial (1996)	0.98	0.63	2.79	10.68	2.68	4.74
Final (1999)						
Between banana	0.85	0.82	3.09	15.49	1.06	4.85
Between pineapple	0.78	0.52	3.91	10.49	0.56	4.55
Between rubber	0.83	1.10	4.13	09.71	0.65	4.70

Model I

This 0.85 ha model was designed with three clones RRIM 600, GT 1 and PB 235 planted in four row bands aligned in a northwest-southeast direction, so as to ensure that rubber plants withstand the high speed winds prevalent in this region, especially during March to May. The spacing of plants within a single band was 4.0 x 3.7 m to ensure high planting density and a gap of 7.4 m was kept between two bands. The wider interspaces were filled with five rows of pineapple (*Ananas comosus* cultivar Queen) with a spacing of 0.6 x 0.3 m, and two rows of banana (*Musa* AAB group, cultivar Sabari) with a plant to plant distance of 2 m (Fig. 1). Legume cover of *Pueraria phaseoloides* was established in the narrow interspaces.

Model II

In this model the same three clones as in Model I were planted in an area of 1.17 ha with a spacing of 4.6 x 4.6 m. One row of banana (*Musa* AAB group, cultivar Sabari) at a plant to plant spacing of 2 m and two rows of pineapple (*Ananas comosus* cultivar Queen) at spacing of 0.6 x 0.3 m were planted in alternate gaps between two rows of rubber (Fig. 2).

Table 3. **Nutrient doses applied to the crops**

Crop	Year	Nutrients applied (g/plant) N	P_2O_5	K_2O	FYM (kg/ha)
Rubber	1	60	57	30	-
	2	120	113	60	-
	3	133	144	72	-
	4	114	114	52	-
Banana		10	4	12	2400
Pineapple		160	100	300	2100

Cultural operations and fertilizer application for rubber were followed as per recommendations of the Rubber Board (Karthikakuttyamma *et al.*, 2000). Tripura state Government recommendations were followed for the intercrops (Department of Agriculture, 1994). Manuring was carried out with urea, rock phosphate, single super phosphate and muriate of potash. The nutrient doses for the different crops are given in Table 3.

Soil samples were collected from six different sites before commencement of the experiment in 1996 and after three years. Samples for physico-chemical studies were collected from narrow interspaces between two banana plants, two pineapple plants and two rubber trees. The soil samples were analysed for organic carbon, available P, K, Ca and Mg as per the method outlined by Jackson (1973). A soil:water suspension (1:2.5) was used for pH determination. The data was analysed in completely randomized design.

Nitrogen content of plant samples were determined by Kjeldhal technique. The samples were ashed at 600°C for 18 h and the ash was dissolved in hydrochloric acid. The solution was used for the determination of Mg and Ca by an atomic absorption spectrophotometer (Hitachi polarized Zeeman Z-6100), P content by UV spectrophotometer and K by flame photometer.

Assessment of above ground dry matter yield at fruit ripening stage was undertaken by

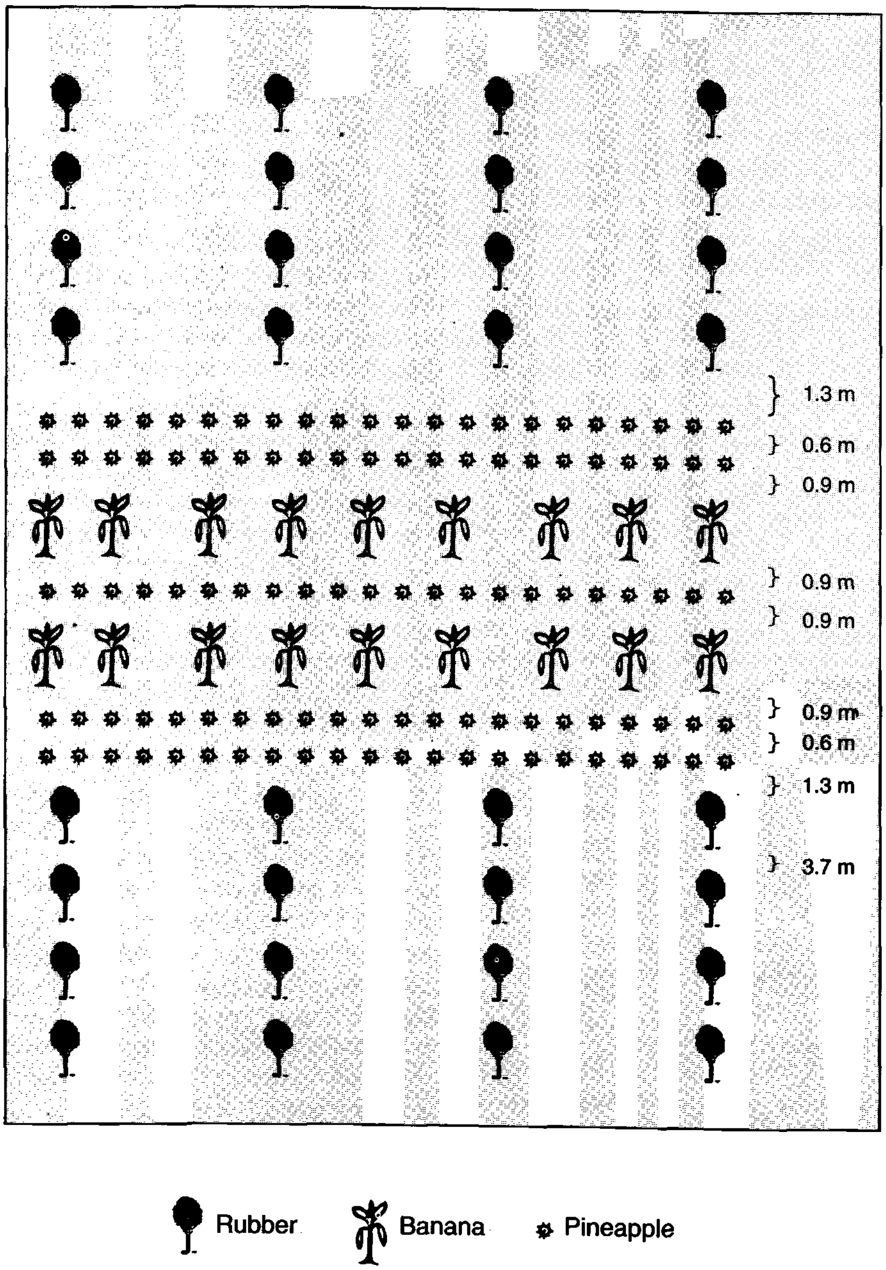

Fig. 1. Orientation of different components in Model I

representative sampling after cutting the plants at ground level. Sample portions at maturity, i.e., fruit and leaves in case of pineapple and bunch, pseudostem and leaf in case of banana were dried at 80°C for 48 h in an oven and milled to pass through a 1 mm sieve. Girth of rubber plants was recorded at 150 cm from the bud union at six month intervals.

Expenditure and income from intercrops were recorded separately for the two models to calculate the benefit cost ratio (BCR) with prevailing average market prices. Cost and income streams were discounted at the rate of 13 per cent for comparison, as the cost and returns were spread over a period of five years.

RESULTS AND DISCUSSION

Soil nutrient status

The nutrient status of the surface soil (0-30 cm) irrespective of models and crops showed little change over the three-year period since the plantation was in an immature stage as also reported by Zainol *et al.*, 1993. Organic C content of surface soil layer under banana, pineapple and rubber at the end of three years were 0.95, 0.89 and 0.87% respectively, indicating an increasing trend in Model I (Table 2). But in the case of Model II organic C content decreased slightly in soils under intercrops. In Model I the greater root volume of crops per unit volume of soil might have added more organic matter by way of dead roots.

Available phosphorus build up under all crops irrespective of models except pineapple in Model II (0.52 mg/1090 g) was observed. This increase may be attributed to the use of phosphatic fertilizer.

Available K exhibited a declining trend in model I irrespective of crops and soil depths. Higher plant population and effective land utilization in Model I resulted in higher utilization of available K. The soil K content generally decreases with intense

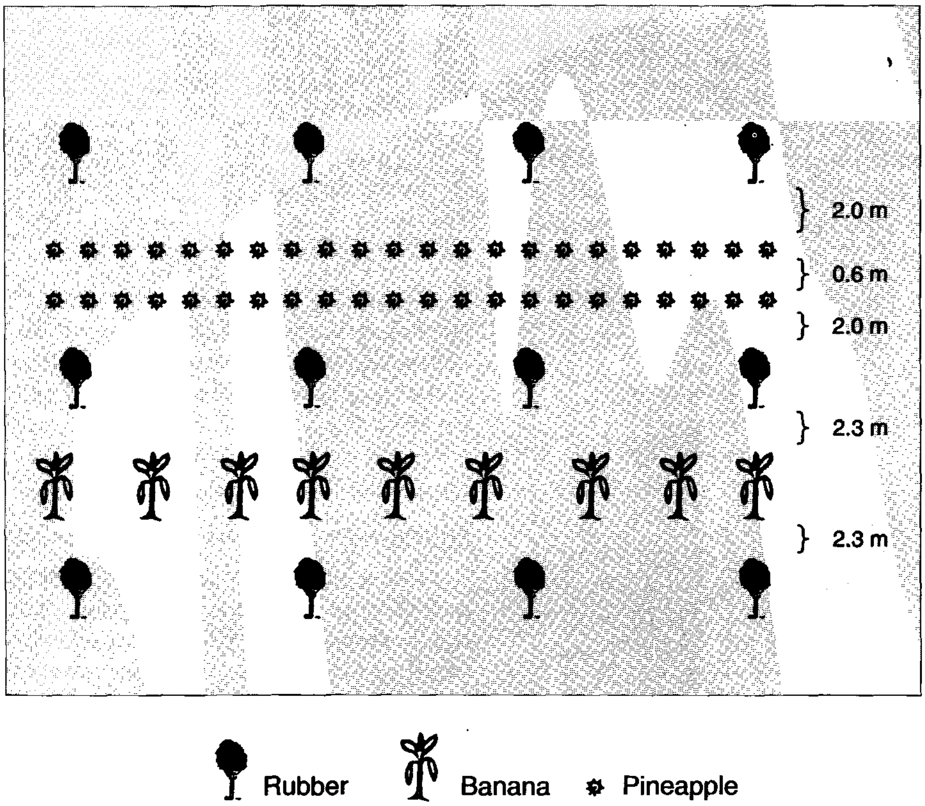

Fig. 1. Orientation of different components in Model II

Table 4. **Nutrient balance within the models (kg/ha)**

Particulars	Dry weight		N		P		K		Ca		Mg	
	M I	M II	M I	M II	M I	M II	M I	M II	M I	M II	M I	M II
Nutrient recycled												
Banana residues	861	818	21.16	.18.42	0.95	0.76	10.08	11.99	2.37	2.44	0.55	0.34
Nutrient removed												
Banana bunches	140	127	1.26	1.24	0.17	0.16	2.37	2.17	0.14	0.14	0.05	0.05
Pineapple fruit	259	217	1.61	1.22	0.18	0.16	1.80	1.59	0.72	0.61	0.20	0.18
Nutrient locked up												
Pineapple plants	1335	819	16.55	9.50	1.33	0.82	18.42	11.30	12.95	6.47	2.14	1.39

cropping (Cox and Uribe, 1992). However, the soils under all crops in Model II showed increase in soil available K where the total plant population was less when compared to Model I.

Change in available Ca content is basically governed by the amount of Ca added through phosphatic fertilizers. The higher level of this bivalent nutrient in the soil under banana irrespective of models could be due to this. Available Ca content as high as 14.06 and 15.49 mg/100g has been recorded under banana in Models I and II respectively. Juo and Lal (1977) reported significant increases in exchangeable bases when the plant residues were returned to the soil. In the case of pineapple and rubber there was little decrease in both the models.

In rubber and intercrops decrease in available Mg content has been noted in both the models. Removal of Mg through fruits of intercrops could be one of the reasons.

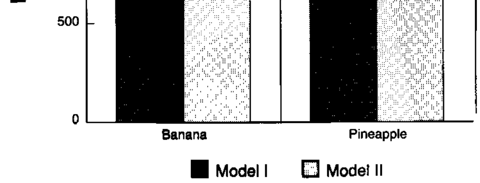

Fig. 1. Biomass generated by intercrops

There was a slight increase in soil pH in Model I, whereas in Model II the soil under banana showed an increase while a declining trend was observed with other crops.

It is evident from the observations that the crop and its associated inputs directly governed the chemical properties of the soil.

Table 5 **Girth increment in rubber in Model I and Model II in different years**

Clone	Girth increment (cm)					
	Model I			Model II		
	1997-98	1998-99	1999-2000	1997-98	1998-99	1999-2000
GT 1	4.60	8.23	0.09	4.82	8.87	10.55
PB 235	4.60	9.64	10.60	4.50	9.14	09.14
RRIM 600	5.44	10.44	12.15	4.64	8.16	10.53
Mean	4.88	9.56	10.61	4.65	8.87	10.07
CD ($P \leq 0.05$)	NS	0.99	1.61	NS	NS	NS

NS = Not significant

Continued fertilizer use under intercropping system also showed resultant favourable soil chemical properties when compared to pre-cultivated (Sanchez *et al.*, 1983). The build up in soil organic C and P indicates the improvement in soil fertility in Model I which had higher stand per unit area.

Nutrient recycling through intercrops

Total nutrients added through fertilizer and manure exceeded the nutrient removal. A substantial quantity of the nutrients were returned to the system through crop residues and the nutrient locked up in the form of pineapple plant parts, would also eventually be added to the system. Maximum nutrient removal occurred in the case of K followed by N (Table 4). Recycling of all nutrients except K and Ca were higher in model I. Nutrients locked up in the form of pineapple plants were higher in model I compared to that in model II, due to higher stand per unit area.

Growth of rubber

The girth of *Hevea* was recorded to gauge the performance of the main crop in relation to the intercrops and the cropping system adopted (Table 5). The girth increment of rubber in model I was slightly higher than model II. Mathew *et al.* (1978) and Chandrasekhara (1984) reported better growth of rubber in rubber-banana intercropping system. The difference in girth between the two models is likely to increase with increasing canopy closure as the legume cover will start to decompose in model I, releasing high amounts of nutrients (Zainol *et al.*, 1993).

Biomass production within the system

The total biomass produced by the intercrops is presented in Figure 3. The total biomass production by pineapple was higher than banana in both the models. As a whole, intercrops produced a higher amount of biomass in model I, mainly due to a higher stand per unit area. The cover crop present in the model I produced 647 g of above ground biomass per m^2. Addition of nitrogen through root nodulation of the cover crops was an advantage in model I. Contrary to model I, absence of cover crop resulted in weed growth leading to the extraction of nutrients and moisture from the land available between rubber rows and intercrops and produced an amount of 559 g of biomass per m^2. This also led to an increase in expenditure on weed management.

Table 6. **Yield of intercrops**

Cropping system	Year	Pineapple No./ha	Pineapple Kg/ha	Banana No./ha	Banana Kg/ha
Model I	1997	1690	1294	240	1084
	1998	2271	1576	170	654
	1999	1873	1179	90	325
	2000	1517	1342	-	-
	Mean	1838	1347	167	688
Model II	1997	1437	1165	221	1030
	1998	1634	1226	151	645
	1999	1540	1041	74	289
	2000	889	651	-	-
	Mean	1375	1020	149	655

Yield of intercrops

The intercrops, banana and pineapple, showed normal growth, though banana suffered from water stress during the dry months. The intercrops were not effected by any disease or pest attack during the period of study. Average yield of intercrops was

Table 7. **Benefit cost ratio (BCR) of intercrops**

Banana	Model I I crop	Model I II crop	Model I III crop	Model II I crop	Model II II crop	Model II III crop
Expenditure (Rs.)						
Planting material	1428	-	-	1248	-	-
FYM	1200	-	-	1050	-	-
Fertilizers	2132	1056	1076	1863	922	941
Labour charges	1945	2627	2276	1893	2302	1958
Total	3875	3835	3430	6207	3358	2958
Gross income (Rs.)	16096	10593	7114	13549	9808	6354
BCR		2.40			2.37	

Pineapple	Model I I crop	Model I II crop	Model I III crop	Model I IV crop	Model II I crop	Model II II crop	Model II III crop	Model II IV crop
Expenditure (Rs.)								
Planting material	714	-	-	-	554	-	-	-
FYM	223	-	-	-	173	-	-	-
Fertilizers	630	656	680	693	487	508	531	541
Growth hormones	-	31	32	32	-	24	25	25
Labour charges	2212	1496	1716	1705	1980	1161	1284	1404
Total	3556	2183	2398	2520	3021	1693	1840	1970
Gross income (Rs.)	3556	6813	5619	4551	3233	4902	4620	2667
BCR		1.45				1.36		

higher in model I compared to that in model II (Table 6). The yield of banana decreased over the years. In case of pineapple, there was an increase in yield during the second year, but the yield decreased during third and fourth years. The decrease in yield was due to ageing of the plants.

Benefit cost ratio of intercrops in the system

The benefit cost ratio (BCR) calculated after three harvests were 2.40 and 2.37 for banana in Models I and II respectively (Table 7). The BCR of pineapple after four harvests were 1.45 and 1.36 in Model I and Model II respectively. This established the economic feasibility of growing these intercrops. Similar observations were also made by Sreenivasan *et al.* (1987), Rajasekharan (1989) and Jessy *et al.* (1998).

The performance of banana in Model I was comparatively better than that of Model II. In case of pineapple, BCR indicated that Model I was better in terms of economic returns. Banana cultivation as an intercrop in Tripura seems to be more remuneratire with assured marketing facilities.

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