Multispecies cropping system with rubber: a preliminary report.

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Abstract

A cropping system experiment, which included diverse annual and perennial intercrops with rubber, was started at the Central Experiment Station of the Rubber Research Institute of India and State Farming Corporation of Kerala, Punalur, India in 1993. Rubber was planted in paired rows at a spacing of 9.0m with a distance within paired rows of 5.1m. Banana, pineapple, pepper and cocoa were planted in the wider interrow spaces and a *Pueraria phaseoloides* legume cover was established in the narrow interrow spaces. Teak and fodder grasses were grown along the boundaries. An increase in organic matter and available phosphorus and a decline in available potassium content of the soil was noticed after 30 months. Growth of rubber was significantly superior in the present system compared to that in monoculture. The nutrient budget of the system indicated a net gain of all nutrients. Land utilisation pattern of the present system indicated a possibility of increasing the density of the component crops. Benefit cost ratio of banana, pineapple and fodder grass were 2.58, 2.26 and 2.07, respectively, indicating the economic feasibility of growing banana and pineapple as intercrops with fodder grass along the boundaries during the initial three years.

Introduction

Multiple cropping with two or more species is a practice in the warm humid tropics and subtropics, where climatic factors are congenial for cultivation throughout the year. The inclusion of different crops with varying growth habits in a cropping system results in increased production per unit area and better utilization of available resources. The availability of additional land remains static and so increases in the intensity of cropping through multispecies cropping is becoming more relevant.

Rubber which has a long immaturity period provides ample scope for cultivation of short duration crops in the interspaces. This helps to generate additional income during this unproductive phase. Banana, pineapple, ginger, turmeric and tubercrops are usually grown as intercrops in immature rubber plantations by smallholders.

The present investigation was taken up to evaluate a multispecies cropping system with both short duration and perennial crops in a rubber plantation and to study the effects on soil chemical properties, the growth of the rubber, the land utilization pattern and the cost:benefit ratio.

Materials and methods

The experiment was started in 1993 at the Central Experiment Station, Chethackal, Central Kerala (9° 22'N, 76° 50'E and 100m above MSL). The soil of the experimental area was laterite with 27.2, 2.05, 17.5 and 52.5% coarse sand, fine sand, silt and clay, respectively. The soil had an available water holding capacity of 12.29%. The chemical composition of the soil sampled before commencement of the experiment is presented in Table 1.

The experiment was laid out in an area of one hectare. Polybag plants of clone RRII 105 were used for planting. Banana (*Musa paradisica* Cv Nendran) and pineapple (*Ananas comosus*) were planted as the short duration crops and black pepper (*Piper nigrum*) and cocoa (*Theobroma cacao*) as the perennial crops. Erythrina was planted as the standard for pepper. Pepper and cocoa were established from polybagged planting material. Banana suckers with uniform size and age were used for planting. After completion of one crop, a second crop of banana was planted inbetween the points of the previous year.

Symposium on Farming Systems Aspects of the Cultivation of Natural Rubber (Hevea brasiliensis), 6 Nov 1996, IRRDB, Brickendon UK, pp

Table 1 *Chemical composition of the soil.*

Organic Carbon (%)	P	K	Mg	pH
		(mg/100g soil)		
2.12	0.3	8.82	1.78	5.2

A *Pueraria phaseoloides* cover crop was established within the paired rows of rubber. Teak (*Tectona grandis*) was planted along the boundaries on two sides where there was no adjacent plantation. Fodder grass (Guinea grass, Var Hamil) was also planted along the boundaries.

The orientation of rubber and intercrops in the experimental field is shown in Figure 1. Adjacent to the 1ha plot, 100 rubber plants of the same clone were planted at the same time, as a monoculture, at a spacing of 6.6 × 3.4m and the cover crop was established in the interspaces.

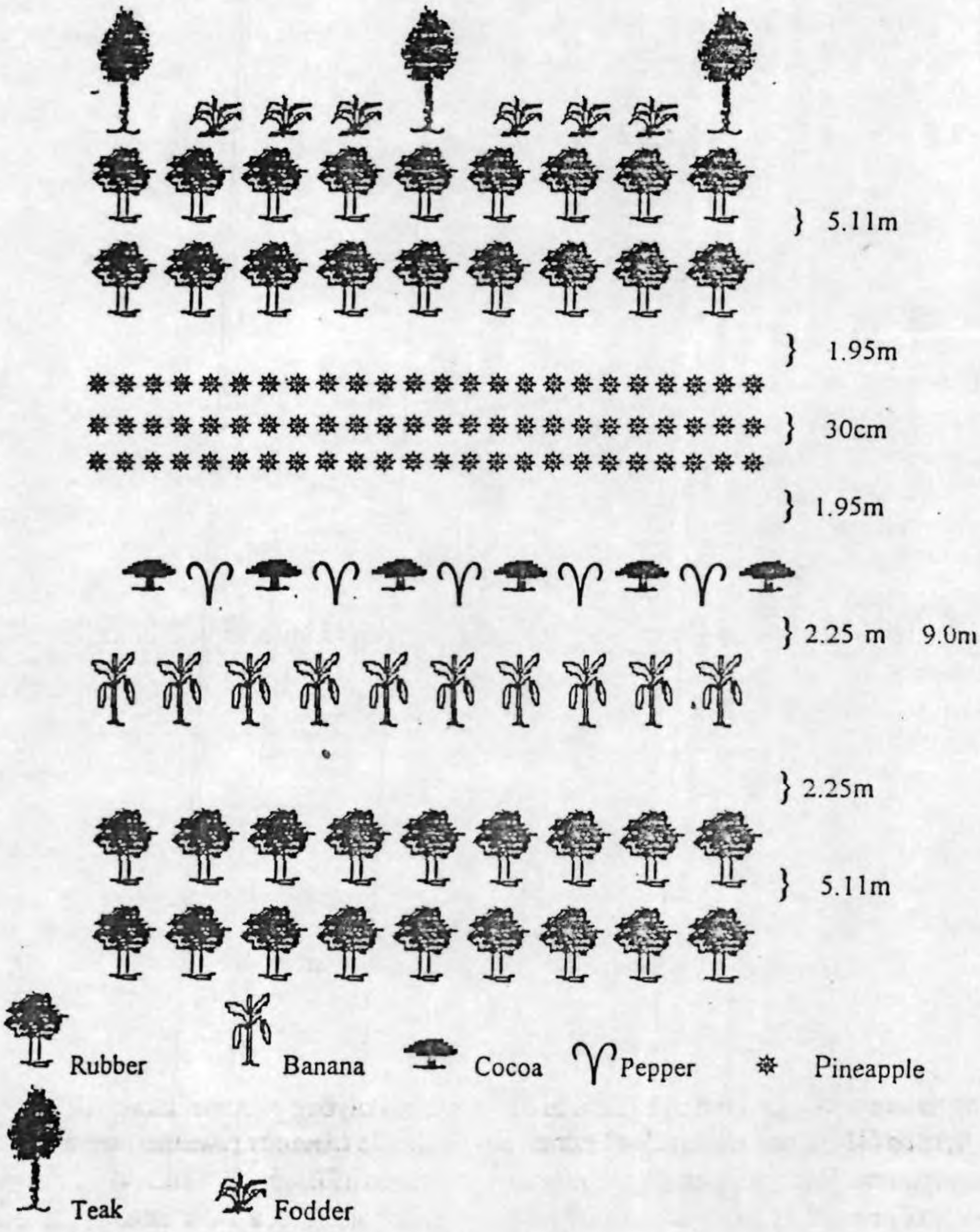

Figure 1 ***Orientation of rubber and component crops***

The general cultural operations and fertilizer application for rubber was done as per the recommendations of the Rubber Research Institute of India. For the other crops, a package of practice recommendations[1] was followed. All intercrops were fertilized separately. Manuring was done as Urea, Mussorie rock phosphate, Muriate of potash and Magnesium sulphate. The fertilizer schedule for the different crops and plant population are given in Table 2. Cowdung slurry was sprayed over the grasses twice/year after cutting. No fertilizers were applied to the teak.

Table 2 *Plant population and total nutrients applied for different crops*

Crop	Population/ha	Plant-to-plant spacing (m)	Nutrients (kg)				FYM
			N	P_2O_5	K_2O	Mg	
Rubber	406	3.4	90.3	103.1	36.1	13.6	-
Banana							1500
1st crop	250	2	47.5	28.8	75.0	-	
2nd crop	250	2	47.5	28.8	75.0	-	
Pineapple	5000	0.30	20.0	60.0	120.0	-	1500
Pepper	110	2.4	10.1	10.1	30.3	-	-
Cocao	110	2.4	22.0	8.8	30.8	-	-
Fodder grass 50m-2area	-	-	-	-	-	-	160
Teak	18	-	-	-	-	-	-

The average annual rainfall of the experimental area was 3000 - 3500mm. The bulk of the rainfall was received during the south-west monsoon season (June - August). The mean maximum temperature varied from 35.4°C in March to 29.0°C in July and the mean minimum temperature varied from 20.5°C in January to 23.1°C in April.

Soil samples were collected from six sites before the commencement of the experiments to study the spatial variability. Soil physical and chemical properties were determined. Soil samples were collected again after the harvest of the first crop of banana was over and before the harvest of the second crop, from 0 - 30cm, for chemical analysis. Samples were collected from the base of banana, between two banana plants (corresponding to the first crop of banana), between pineapple, between pepper and cocoa, between rubber and pineapple, between rubber and banana and rubber in the monoculture. The experimental design adopted was CRD with eight replications. The soil samples were analysed for organic carbon[2], available phosphorus using Bray II[3], available potassium using Morgan's reagent[4] and available magnesium using a colorimetric method[5]. A soil solution ratio of 1 : 2.5 was used for pH determination.

For determination of biomass production, four banana plants were selected at random at the time of harvest. The weight of the underground parts (rhizome) and the above-ground parts (pseudo stem, leaf stalks, leaves, bunch stalk and bunch) were recorded. The weight of suckers were also recorded. Subsamples were dried at 80°C for moisture determination and were analysed for nitrogen, phosphorus, potassium, calcium and magnesium[2,6].

In the case of pineapple, the weight of the below-ground and above-ground parts were recorded from 1m - two areas from four sites. Subsamples were dried and analysed as in the case of banana. Loppings of four erythrina plants (leaves, young twigs, older twigs) were weighed, subsamples taken, dried and analysed for nutrients. The weight of fodder grass was recorded and subsamples taken for moisture determination and chemical analysis. The total quantity of nutrients removed from the system through economic products, recycled through biomass and locked up in plant parts were determined.

The girth of rubber plants were recorded at 125cm from the bud union in January1995 (after completion of one crop of banana), July 1995 (during the active growth period of the second crop) and January 1996 (after completion of the second crop).

A similar experiment was conducted in a Government owned plantation of the State Farming Corporation of Kerala at Punalur to compare the yield of crops. The expenditure and income from both experiments were recorded and the mean values were used for determining the benefit-cost ratio.

Results and discusssion.

Soil chemical properties.

Pre-treatment soil analysis indicated that the soil of the experimental area was high in organic matter content, low in available phosphorus and medium in available potassium and magnesium (Table 1). The soil was acidic with a pH of 5.2.

Table 3 ***Available soil nutrients status 30 months after intercropping***

Treatments	OC (%)	P	K	Mg	CEC (Cmol/kg)	pH
		(mg/100g of soil)				
Rubber near pineapple	2.54	2.30	7.12	1.27	10.71	5.14
Rubber near banana	2.95	3.19	6.32	1.94	12.46	5.22
Rubber alone	2.77	3.75	5.67	2.66	11.57	5.27
Between Pineapple	3.05	1.84	6.15	1.83	12.36	5.28
Between Banana	2.89	3.23	4.07	1.16	13.01	5.18
Between Pepper and Cocao	3.00	1.97	6.44	1.39	11.20	5.17
SE	0.14	0.39	0.53	0.22	0.47	0.06
CD (P = 0.05)	ns	1.15	1.51	0.63	1.40	ns

Analysis of soil samples collected after 30 months of intercropping indicated an increase in the organic matter content of the soil (Table 3). This could be due to the addition of farmyard manure to the component crop and recycling of crop residues. Incorporation of crop residues have been reported to increase the organic matter content of soil by several workers[7]. The loppings from *Erythrina* which were applied as mulch also might have contributed to the enrichment of the organic matter content of soil. Kang et al[8] have also reported that retaining tree prunings on the soil surface increases the organic matter content of soils. No significant differences were noted between treatments even after addition of farmyard manure to banana. This could be due to the high addition of crop residues and mulching.

Before commencement of the experiment, the soil was low in available phosphorus content (Table 1). A significant build-up of phosphorus was noticed in all treatments after intercropping. Phosphate fertilizer for the different crops was applied as Mussorie rock phosphate and the residual effect of applied phosphorus might have resulted in considerable build-up of P in the soil. Highly significant residual effect of P throughout the cropping period was reported by Kwakye et al[9] in a continuously cropped forest soil. In Malaysia, Zainol et al[10] reported an increasing trend in available phosphorus content of soil in all treatments when rubber was intercropped with legume, peanut, corn, pineapple and papaya. Significant differences were also noticed between treatments with respect to the available P content. Maximum build-up was noticed near rubber followed by between two banana plants (corresponding to previous crop's stand) and between rubber and banana. Higher available P near rubber can be attributed to the high quantity of phosphatic fertilizers added to rubber (Table 2). The application of organic manure along with phosphatic fertilizer and recycling of the crop residues might have resulted in the high P content between two banana plants and between rubber and banana. The low P between pineapple can be attributed to P removal through fruits and that locked up in the biomass. The low quantity of applied P to pepper and cocoa may have resulted in the low available P between pepper and cocoa.

Available potassium content in the soil exhibited a slight decline after intercropping. A similar result was reported by Zainol et al[10] in Malaysia. Even after addition of a comparatively high amount of potassium to banana, the maximum decline was noticed between banana plants which corresponded with the position of the previous crop. The removal of K through bunches, suckers (Table 5) and leaching might have contributed to this decline. This indicates the need for adequate K fertilization to banana when grown as an intercrop with rubber. The depletion of available K was less severe for all other treatments.

The available magnesium content of the soil was medium prior to commencement of the experiment.This level was more or less maintained during the experiment period as well. The Mg content near rubber was significantly higher than that inbetween banana plants, which could probably be due to the application of magnesium sulphate to rubber and crop removal in banana.

The cation exchange capacity of the soil showed a significant difference between treatments. The lowest CEC was noticed between rubber and pineapple. This could probably be due to the lower organic matter content. The CEC between two banana plants showed highest values. Decomposing banana crop residue might have contributed to the high CEC. The component crops did not affect soil pH as there was no significant difference between treatments.

Growth of rubber

Intercropping of rubber with annual and perennial crops enhanced the growth of rubber significantly in the present system (Table 4). Rubber near to both pineapple and banana had significantly higher girth than rubber in monocropping when the girth was recorded after completing one crop of banana (January, 1995). However, during the active growth period of the second crop of banana, the girth of rubber near banana was comparable to that in monocropping (July, 1995). After completion of the second crop of banana, rubber near both banana and pineapple was significantly superior to rubber alone with respect to girth (January, 1996). This indicates that the component crops did not adversely affect the growth of rubber during the period of this study. The better growth of rubber also shows that favourable interactions occurred between rubber and component crops in the present system.

Table 4 *Girth of rubber (cm)*

Treatments	Jan `95	July `95	Jan `96
Rubber near Pineapple	16.31	17.40	21.27
Rubber near Banana	16.82	17.08	20.88
Rubber in monoculture	14.83	16.15	19.67
SE	0.35	0.33	0.371.10
CD (P = 0.05)	1.02	0.97	

Mathew et al[11] and Chandrashekara[12] have reported better growth of rubber when intercropped with banana. In Malaysia, Mohd. Noor et al[13] have also noticed a favourable effect of intercropping on the growth of rubber due to nutrient build-up and improved soil physical conditions under intercropping.

Performance of intercrops

Banana and pineapple were established and performed well in the present experiment as indicated by their growth and yield. Vacancies were supplied in the case of pepper. The erythrina standards were also established and grew well. However, cocoa failed to establish under the purely rainfed situation of the experiment. Teak and fodder grass established well in the boundaries. No pest and disease incidence was noticed in any of the component crops.

Nutrient recycling through short term crops

The nutrients recycled through banana residues, erythrina loppings, locked up in the pineapple biomass or removed from the system through economic products are shown in Table 5.

In this study the nutrient budget of the field was worked out with respect to the nutrients added to short term crops, removed as economic produce, locked up as biomass and recycled as crop residues. Other nutrient inputs and outputs to and from the system were not considered. The data clearly indicates that the total nutrients added to the system exceeded crop removal. It can also be seen that a substantial quantity of nutrients are returned to the system through crop residues. Maximum nutrient removal occurred in the case of potassium (157.09 kg) followed by nitrogen (41.87 kg) and calcium (18.45 kg).

Land utilisation pattern

The area occupied by rubber and the component crops, which include the plant and its platform for the component crops and the entire planting strip for rubber, was considered in order to assess the land utilisation pattern. Rubber occupied a land area of 16.22% in this cropping system (Figure 2) compared to nearly 18 20% in a rubber monoculture. The interplant area between rubber was occupied by the *Puraria phaseoloides* cover crop in about 35% of the area in the cropping system. The composition of component crops varied with pineapple occupying the largest share and teak the smallest. The unused area is the land area between the intercrops. Though this area appears to be sizeable, most of the above-ground area would be occupied by the canopy of the crops. It appears that there is scope for utilising the area unused, from the preliminary assessment of this system, by accomodating a higher density of component crops. This is in view of the fact that the girth of rubber plants in the intercropped area was significantly superior to that of the monocropped area for the first three years. However no attempt at modelling was done to estimate an optimum rubber-based cropping system.

Table 5 *Nutrient balance within the system*

	Dry weight	N	P (kg)	K	Ca	Mg
Nutrients recycled						
1. Banana residues	2176	27.41	2.52	125.87	10.86	3.40
2. Erythrina loppings	754	13.1	1.10	13.72	12.39	0.53
Nutrients removed						
1. Banana bunches	1876	17.27	1.74	14.44	5.44	3.75
2. Banana suckers	1225	9.76	1.03	66.48	4.00	2.07
2. Pineapple fruit	1852	1.27	0.22	57.97	5.45	1.80
3. Fodder grass	520	13.57	1.20	18.20	3.56	1.40
Nutrients locked up						
Pineapple	4429	45.71	5.24	71.65	40.11	6.52

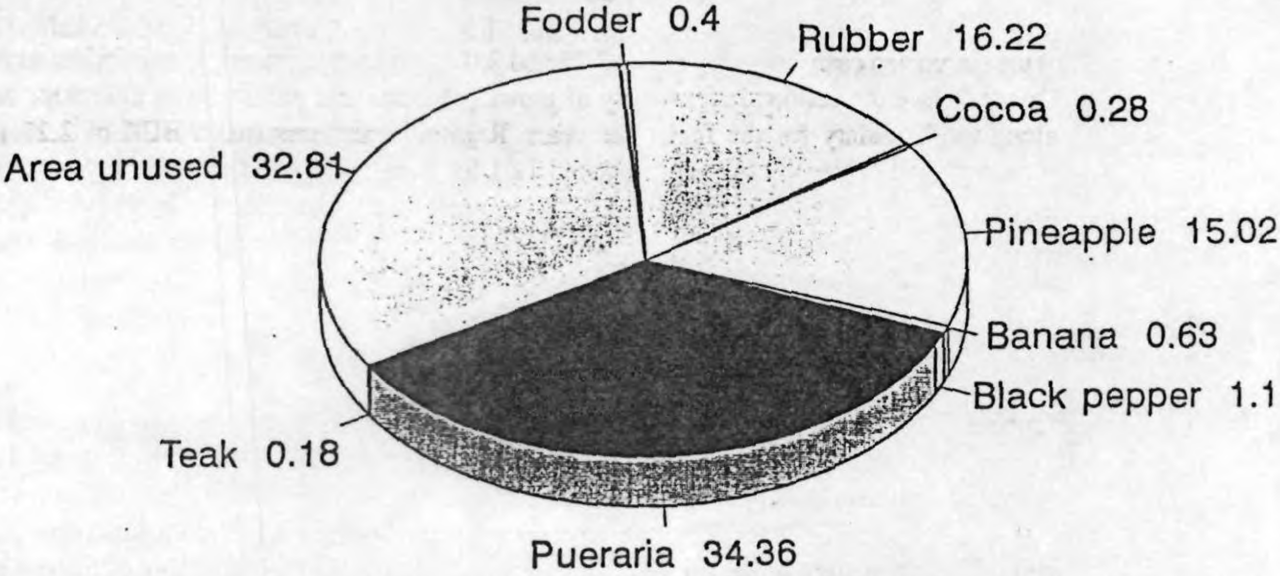

Figure 2 ***Land utilization pattern of the cropping system***

Benefit cost ratio of short term crops

Benefit and cost ratio of banana, pineapple and grass were worked out for the initial three years (Table 6). Gross income was calculated based on the average market price which prevailed during the period. Since the cost and returns were spread over a period of three years, cost streams and income streams were discounted at the rate of 13% for comparision.

Table 6 ***Benefit cost ratio of short tern crops***

	Banana		Pineapple			Fodder grass		
	I crop	II crop	I year	II year	III year	I year	II year	III year
Expenditure (Rs)						-		
Planting material	1000.0	-	2500.0	-	-	10.00	-	-
Transportation	-	-	350.0	-	-	-	-	-
FYM	1500.0	1687.5	-	-	-	-	80.0	100.0
Fertilizers	1148.0	142.5	760.2	765.5	823.5	151.4	-	-
Plant protection	360.0	-	-	-	-	-	-	-
Propping material	1000.0	-	-	-	-	-	-	-
Growth hormones	-	-	-	16.4	17.9	-	-	-
Labour charges	2043.4	2278.8	3292.1	1818.9	2036.1	-	126.9	141.9
Total	7051.4	5108.8	6902.3	2600.8	2877.5	161.4	206.9	241.9
Gross income	15,105	17,640	-	15,000	21,600	-	600	852.5
BCR	2.58			2.26			2.07	

The BCR of the discounted cash flow were 2.58, 2.26 and 2.07 for banana, pineapple and fodder grass, respectively. This indicates the economic feasibility of growing banana and pineapple as intercrops and fodder grass along the boundary for the first three years. Rajashekaran[14] reported a BCR of 2.27 for intercropping pineapple and Sreenevasan *et al*[15] reported 1.61 for banana in immature rubber plantations during the initial three years. Mohd Noor *et al*[13] also reported pineapple as an economically feasible intercrop in immature rubber plantations. The suitability of Nendran banana as an intercrop in rubber plantations was reported by Mathew *et al*[11].

Conclusions

Intercropping of rubber with banana, pineapple, pepper and cocoa for 30 months increased the organic matter and available P content of the soil. A decline in available K content was noticed in all of the treatments. The highest CEC was noticed between banana plants. The growth of rubber was significantly higher in the present system compared to that in monoculture. The nutrient balance of the system indicated a net gain of all nutrients. The land utilisation pattern of the present cropping system indicated the possibility of increasing the density of component crops. The benefit:cost ratios of banana, pineapple and fodder grass were 2.58, 2.26 and 2.07, respectively, indicating the economic feasibility of growing banana and pineapple as intercrops with fodder grass along the boundaries during the initial three years.

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soil and sand mixture (1:3). About 90% of the transferred regenerants survived in the field condition.

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Proceedings of the Seventh Kerala Science Congress, January 1995, Palakkad pp 167-169

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INVESTIGATIONS ON THE PROGENIES OF A GENETIC VARIANT OF PARA RUBBER TREE *(Hevea brasiliensis)*

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Abstract: The progenies of a morphological variant having compact crown isolated from a seedling population of para rubber tree *Hevea brasiliensis* exhibited four morphotypes. The possibility of exploiting the desirable morphotypes and incorporating the genetic variant in breeding programme of *Hevea* for altering the architecture of the tree are discussed.

1. Introduction

Hevea brasiliensis (Willd. ex. Adr. de. Juss) Muell. Arg., of the Euphorbiaceae is a perennial tree native of the forest of Brazil. It is a quick growing tree with characteristic rhythmic growth in which shoots have a marked endogenous periodicity of extension. However, a natural variant with short stature (dwarf), which was confirmed to be a genetic variant was isolated from PBIG seedling population for the first time in *Hevea* (Markose et al., 1981). Numerous reports in aggregate indicate that dwarf shoot stature is heritable and are wide-spread in fruit trees and nut species (Alston, 1975; Hansche and Beres, 1980). Scope for the exploitation of the genetic variant in *Hevea* breeding programme is discussed.

2. Materials and Methods

The materials comprised of open pollinated progenies of the natural variant consisting of the four morphotypes, dwarf (TI), semidwarf (T2), intermediate (T3), normal (T4) and a control (T5) (open pollinated progenies of clone Tjir 1). These were planted in the field adopting randomized block design with five replications and five plants per plot. Observations were taken on plant height, basal diameter, interwhorl length, petiole length and number of leaves during the first year after planting; test tap yield and girth during the fifth year after planting; girth, bark thickness, petiole length and leaf area during eighth year after planting. Analysis of variance and estimation of genetic parameters were done according to Singh and Chaudhary (1985). A growth index was computed during the first year and eighth year after planting following Mydin et al (1990).

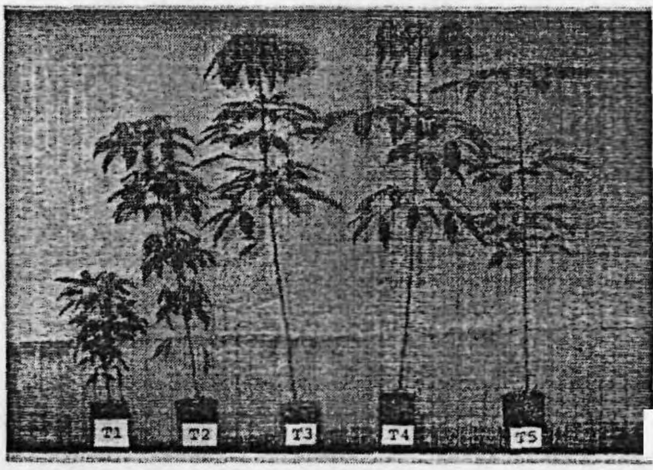
3. Results and Discussion

The materials under study exhibited significant variation for the different characters except for basal diameter during the first year after planting. Among the characters studied plant height exhibited the highest variation ranging from 21-172 cm whereas the range of variation was lowest for diameter (4.15-16.95 m m). The maximum coefficient of variation was expressed by interwhorl length (25%) followed by number of leaves (18%) and petiole length (12%). Girth and test tap yield during the fifth year of growth stage also exhibited significant variation between the morphotypes (Table 1). T4 exhibited the highest mean yield of 30.34 followed by T5 and T3 (mean yield 26.56 and 24.08 g/tree/tap respectively).

Growth parameters in the eighth year of growth stage also revealed significant variation between the different morphotypes. Leaf area exhibited the highest range (62.04-297.41 cm^2) followed by girth (8-87 cm) (Table 1). Maximum coefficient of variation was expressed by petiole length (26%) followed by girth (24%). Significant variation observed for most of the characters in the different growth stages indicate inherent genetic variation in the population under study and therefore suggests better scope for selection for growth characters.

Broadsense heritability and genetic advance over mean were estimated for all the characters. Among the parameters studied during the first year of growth stage, petiole length exhibited a heritability of 94 per cent with genetic advance of

Morphotypes of genetic variant and control



T1 Dwarf T2.Semidwarf T3.Intermediate
T4.Normal T5. Control

99 per cent whereas plant height exhibited a heritability of 83 per cent and a genetic advance of 45 per cent. Interwhorl length showed a heritability of 62 per cent coupled with a genetic advance of 52 per cent. Scrutiny of genetic parameters for test tap yield and girth at the fifth year of growth stage exhibited a heritability of 35 and 56 percentages with a genetic advance of 54 and 40 percentages respectively. High heritability with moderate genetic advance for girth and bark thickness (H^2%: 53, 51: GA% 39, 23 respectively) and moderate heritability with moderategenetic advance for petiole length (H^2%: 48 and GA% 36) was observed during the eighth year of growth stage (Table 1). In the present investigation high

Table 1. Genetic parameters for different characters during first, fifth and eighth year after planting

Characters	Mean	Variance ratio (F)	CV (%)	Heritability	GA% over mean
1. *First year after planting*					
Height (cm)	81.36	25.66*	10.71	83	44.59
Diameter (mm)	10.66	2.99	10.82	28	7.41
Interwhorl length (cm)	8.22	9.31*	24.79	62	51.7
Petiole length (cm)	9.05	83.96*	12.22	94	99.22
Number of leaves	22.02	6.72*	18.22	53	29.1
2. *Fifth year after planting*					
Yield ($g\ t^{-1}t^{-1}$)	19.70	3.69*	60.5	35	54
Girth (cm)	34.16	7.44*	22.16	56	40
3. *Eighth year after planting*					
Girth (cm)	42.07	6.57*	24.31	53	38.58
Bark thickness (mm)	6.77	6.24*	15.53	51	23.33
Petiole length (cm)	11.07	5.61*	26.15	48	35.86
Leaf area (cm^2)	159.94	1.61	21.75	10.8	5.12

*Significant at 1% level

Table 2. Growth index at first and eigth year after planting

Treatments	First year Growth index based on height, diameter, interwhorl length, petiole length and number of leaves.	Eighth year Growth index based on girth, bark thickness, petiole length and leaf area.
Dwarf (T1)	15.41	6.01
Semidwarf (T2)	14,37	6.80
Intermediate (T3)	21.21	8.63
Normal (T4)	21.22	9.73
Control (T5)	27.06	8.78
GM	19.85	7.99

genetic parameters for the characters like petiole length, interwhorl length and plant height reveals preponderance of additive gene action and hence selection based on these characters would be advantageous (Licy et al. 1992).

Growth index of the five morphotypes computed based on height,diameter,interwhorl length, petiole length and number of leaves during the first year after planting showed the highest index of 27.06 for T5 followed by T4 and T3 (21.22 and 21.21 respectively). Though the growth index for T4 and T3 was lower compared to T5 (control) it stands above the general mean of 19.85 (Table 2).Growth index computed based on girth, bark thickness, petiole length and leaf area during the eighth year of growth stage showed highest index 9.73 for T4 followed by T5 and T3 (8.78 and 8.63 respectively) (Table 2). The above results revealed T4 and T3 to be promising among the four morphotypes. Test tap yield during the fifth year of growth stage also suggested T4 and T3 to be superior in performance. Hence Type 4 and 3 (normal and intermediate) renders potential for further crop improvement.

Tyagi et al (1983) and Rao (1986) emphasised the scope for selection for the intermediate dwarf category and utilising the segregants in breeding programme. Incorporation of genetic varient in breeding programmes for generating desirable morphotypes with modified canopy architecture holds promise.

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