Indian Journal of Natural Rubber Research, **14**(2) : 93 - 101, 2001

A COMPARATIVE ANALYSIS OF THE IMMATURE PHASE OF POLYBAGGED PLANT AND BUDDED STUMP PLANTED FIELDS OF *HEVEA*

Toms Joseph, M. D. Jessy, K. I. Punnoose and K. Tharian George

Joseph, T., Jessy, M.D., Punnoose, K.I. and George, K.T. (2001). A comparative analysis of the immature phase of polybagged plant and budded stump planted fields of *Hevea*. *Indian Journal of Natural Rubber Research*, **14**(2): 93 - 101.

The study analyses the commercial realisation of the experimentally proven difference in the duration of immature phase between polybagged plants and budded stumps of *Hevea brasiliensis* under smallholding conditions and its variations under different cultural practices. The database consisted of secondary information obtained from Rubber Plantation Development (RPD) files related to 1814 polybagged plant and 471 budded stump planted fields, collected from 23 regional offices of the Rubber Board located in Kerala, Tamil Nadu and Karnataka in India. The pattern of the adoption of major cultural practices in both categories was comparatively assessed. On an average, polybagged plant and budded stump planted fields reported a duration of immature phase of 6.99 and 7.19 years respectively and the difference (73 days) was statistically significant. However, it was found that the difference in duration of immature phase was not economically significant as fields of polybagged plants required an advantage of at least 150 days to realise an annuity equivalent to that of budded stump planted fields. But an assumed 2.6 per cent higher yield in the former gave an annuity equivalent to that of the latter fields. Hence the economic advantage of fields with polybagged plants may have to originate from the cumulative economic impact of shorter immature phase, lower vacancy, uniform establishment, higher tappability and higher yield rather than from shorter immaturity period alone.

Key words: Budded stumps, Economic analysis, *Hevea*, Immaturity period, Planting material, Polybagged plants.

Toms Joseph (for correspondence), M. D. Jessy, K. I. Punnoose and K. Tharian George, Rubber Research Institute of India, Kottayam-686 009, Kerala, India (Email: rrii@vsnl.com).

INTRODUCTION

Natural rubber (*Hevea brasiliensis*) is a perennial tree crop with a prolonged immature phase ranging from five to ten years, depending on the type of planting materials, agro-ecological factors and management practices. The history of commercial planting of rubber in India began with the use of unselected seeds followed by selected seeds. Later, the traditional unselected/selected seedlings were replaced by clones with the commercialisation of vegetative methods of propagation during the early 1920s. Simultaneously, changes occurred in the type of planting materials used from seed at stake to seedling stumps and thereafter to budded stumps and advanced planting materials. The advanced planting materials consisted of polybagged plants, stumped buddings and soil core stumps. However, the most popular among the advanced planting materials were polybagged plants. The budded stumps are planted in the field before the development of buds and the growth of the plant takes place entirely in the field. But in the case of polybagged plants, a part of the growth is effected in the nursery thus reducing immaturity period in the field, though the cost is relatively higher

(Marattukalam and Saraswathyamma, 1992). Several studies have reported that the adoption of polybagged plants reduces the duration of immature phase (DIP)·by six months to one year (Sivandyan *et al.*, 1973; Marattukalam and Nair, 1982; Nair *et al.*, 1992). Other pronounced advantages of polybagged plants are uniform growth, better establishment, lower vacancy, higher survival rate and tappability and better tolerance to adverse weather conditions during the early years of planting.

In India, the Rubber Board has been popularising the use of polybagged plants under the Rubber Plantation Development (RPD) Scheme with financial incentives since 1980 (Krishnakumar and Nair, 1999). An earlier sample survey covering fields planted during 1980-84 period reported that the area under polybagged plants was only 18 per cent in the smallholding sector (Joseph and Haridasan, 1993). A recent study covering fields of small growers planted during 1987 reported that 77.9 per cent of the holdings and 83.5 per cent of area had been planted with polybagged plants (Krishnakumar and Nair, 1999). Another survey showed that more than 90 per cent of the area planted in Kerala during the period from 1992 to 1995 under the RPD Scheme was with polybagged plants (Rubber Board, 1996). Despite the reported higher extent of adoption, there are serious reservations among the extension officers and growers on the field level realisation of the experimentally proven reduction in the DIP of polybagged plants under smallholding conditions. Commercial experience in the estate sector of India was that polybagged plants attained tappable girth three to six months in advance compared to budded stumps (Abraham, 1986). From the very beginning, doubts had been raised regarding the growth of planting materials raised in polybags after establishment in the field (Templeton, 1967). There had been arguments in favour of and against polybagged plants in India during late 1980s (Cherian, 1987). It was in this background that a detailed study was initiated with the active support of the Rubber Production Department of Rubber Board. The main objectives of the study were: to record the differences in cultural practices adopted in polybagged planted fields (PBPF) and budded stump planted fields (BSPF); to estimate the duration of immature phase realised in PBPF and BSPF under different situations; to analyse the relationship between number of whorls of polybagged plants and the DIP; and to evaluate the comparative economic viability of PBPF based on the survey results.

MATERIALS AND METHODS

The data source consisted of secondary information gathered from 23 regional offices of the Rubber Board located in three states in South India *viz.*, Kerala, Tamil Nadu and Karnataka. The data were collected from 125 field inspection reports of each regional office compiled in the RPD files related to the disbursement of planting subsidy to small growers. The collected schedules were edited for consistency, eliminating the deficient ones which numbered 590. The final sample size was 2285 with 1814 PBPF and 471 BSPF related to plantings done during 1986 and 1987 (Table 1). The sample was proportional as the distribution of the regional offices was in direct correspondence with that of the rubber planted fields. The

Table 1. **Composition of sample units**

Sample details	No
Sample size	2285
Polybag planted fields	1814
Budded stump planted fields	471
Fields planted during 1986	1599
Fields planted during 1987	686
Mean size of fields of polybagged plant (ha)	0.61
Mean size of budded stump planted fields (ha)	0.48 **

** Mean difference significant at P $\leq$0.01

differences in the pattern of the adoption of prominent cultural practices such as selection of clone, time of planting, initial plant density, size of planting pit and spacing, fertilizer application, cover cropping, intercropping *etc.* were also compared to check whether the observed differences in the DIP could be attributed to the type of planting material used or to the specific differences in the cultural practices followed. The DIP reported in fields following different cultural practices was compared. The relationship between DIP of PBPF and the number of whorls of polybagged plants was analysed. Statistical tools of correlation and mean difference analysis were employed. Since the sample was large, z test was applied to check the significance of the mean differences. As the comparative economic viability is independent of the statistical mean difference, an economic analysis was carried out on the basis of the reported DIP (Rae, 1977). The economic life, yield profile, maintenance and exploitation cost during mature phase, price of rubber and salvage value were assumed to be uniform for both categories. The development cost estimates worked out during March 1998 by the Cost Accounts Division of Rubber Board for polybagged plants and budded stumps separately were used. These estimates have accounted the differences in the cost of planting materials, field planting, vacancy filling, staking *etc.* between PBPF and BSPF. The annuity was estimated using the equation

$$A_{(n)} = NPV\,[\,r\,(1+r)\ /\ (1+r)\ -1\,]$$

where

$$NPV\ (\text{Net present value}) = \sum_{t=1}^{n} CB/\,(1+r)^{t}$$

CB = Cash balance

t = age

n = life

r = discount rate (13% in this study)

RESULTS AND DISCUSSION

Adoption of cultural practices

The adoption of polybagged planting was higher in larger fields as indicated by the statistically significant ($p \leq 0.01$) difference between the mean size of PBPF (0.61 ha) and BSPF (0.48 ha) (Table 1). A substantial share of the planting with both types of planting materials was carried out during June and July, which are the ideal months for planting rubber in South India (Potty, 1980).

Table 2. **Composition of fields according to month of planting**

Month of planting	PBPF (%)	BSPF (%)
Up to May	2.7	4.9
June	31.3	23.4
July	49.8	48.7
August	10.9	17.5
September to December	5.3	5.5

However, the share of planting during the recommended season in PBPF was relatively higher at 81.1 per cent compared to 72.1 per cent in BSPF (Table 2). The budded stumps had a relatively higher share of planting during the period beyond July (23.0%) compared to polybagged plants (16.2%), though the recommendation is to undertake such late planting preferably with polybagged plants. The non-availability of polybagged plants late in the season and lack of enterprise on the part of late planting growers appeared to be the reasons for utilising budded stumps.

The clone RRII 105 accounted for more

Table 3. **Clone-wise composition of fields**

Clone	PBPF (%)	BSPF (%)
RRII 105	90.0	95.8
RRII 105 + PB varieties	3.6	0.8
RRII 105 + GT 1	0.9	0.6
RRII 105 + RRIM 600	1.2	1.1
RRIM 600	0.6	0.2
GT 1	0.6	-
PB varieties	0.9	-
Others + mixed	2.2	1.5

than 90 per cent in both types of planting materials (Table 3). The extensive monoclonal planting practised in rubber smallholdings with RRII 105 has already been reported (Veeraputhran *et al.*, 1998). Clones other than RRII 105 had a relatively higher share in PBPF as large holdings tend to adopt multiclonal planting. The major source of procurement of planting materials (Table 4) was commercial nurseries as the share of own source was only 4.3 and 3.4 per cent in PBPF and BSPF, respectively. The initial planting density of PBPF was slightly lower and the mean difference was significant (P=$\leq$0.05). It may be noted that in both the categories the initial planting density was higher than the recommended maximum of 445 plants and permitted limit of 500 plants per ha. The pit size in both categories was mainly 75"X75"X75". No significant difference was noticed in spacing as it is independent of the type of planting material used. The extent of discriminatory fertilizer application was very low in both categories and the adoption of mulching was relatively higher in BSPF.

Table 4. **Comparative adoption of cultural practices**

Cultural practice	PBPF	BSPF
Procurement of planting materials from own source (%)	4.3	3.4
Stand per ha (No.)	561	570*
Pit size (%)		
75"X75"X75"	97.3	99.6
90"X90"X90"	2.7	0.4
Spacing (%)		
15'X15'	27.8	26.1
20'X10'	37.8	30.2
14'X14'	5.0	10.8
Others	29.4	32.9
Contour spacing (%)	41.2	45.6
Discriminatory fertilizer application (%)	3.5	5.1
Mulching (%)	62.5	71.7

* Mean difference significant at P$\leq$0.05

The adoption of cover cropping was notably higher in PBPF (Table 5) and *Pueraria* was the preferred cover crop (96.5 %) in both categories. In PBPF the intercropped cases reported an obviously higher level of adoption of cover cropping (56.5 % compared to 44.7 % in non-intercropped fields) while the same rate of adoption of cover cropping (31.0 % each) was observed in intercropped and non-intercropped cases in BSPF. Thus the adoption of intercropping did not inhibit the adoption of cover cropping in both categories. In a majority of PBPF, cover crops were established during the first year of planting itself. The share of fields in which cover crop was established during the third year or after was 40.2 in BSPF compared to 24.9 per cent in PBPF. Late cover cropping noticed in BSPF might be due to the inefficiency of the growers as in the late cover cropped fields the extent and period of intercropping were observed to be comparable to the early cover cropped fields. Generally, PBPF reported higher extent of adoption as well as early establishment of cover cropping. The mean longevity of cover crop was significantly higher in PBPF (4.11 years) compared to that in BSPF (3.45 years). The superiority of PBPF with regard to life of cover crop can be mainly attributed to the early establishment. The correlation coefficient between the longevity of the cover crop and year of establishment indicated a strong inverse relationship ($r = -0.5; p \leq 0.01$).

Table 5. **Extent and pattern of cover cropping**

Item	PBPF	BSPF
Extent (%)		
Intercropped fields	56.5	31.0
Non-intercropped fields	44.7	31.0
Total	49.1	31.0
Year of establishment (%)		
First year	40.3	23.1
Second year	34.8	36.7
Third year	17.3	23.8
Fourth year & above	7.6	16.4
Mean longevity (years)	4.11	3.45 **

** Mean difference significant at P$\leq$0.05

The extent of intercropping was marginally higher in PBPF (Table 6). A substantial portion of fields in both categories was intercropped only during the first year of the immature phase. Among the PBPF, in 91.5 per cent of cases, intercropping was confined to the first three years of

Table 6. **Extent and pattern of intercropping**

Item	PBPF	BSPF
Extent (%)	37.7	34.8
Period (%)		
1st year only	43.5	39.6
1st - 2nd year	19.5	20.1
1st - 3rd year	28.5	18.9
1st - 4th year & beyond	8.5	21.4
Type (%)		
Banana	55.1	36.6
Tapioca	6.5	11.0
Banana + other annuals	11.4	15.9
Ginger + other annuals	4.7	11.6
Others	22.3	24.9

planting. But in BSPF, in more than one fifth of the cases, intercropping was practised even beyond the third year of planting which may be an indirect indication of poorer canopy coverage. Banana was the most preferred intercrop and its share was notably higher in PBPF. Tapioca and mixed cultivation of other annuals with banana or ginger as major intercrops were relatively higher in BSPF.

Number of whorls of polybagged plants

A vital aspect of polybag plants is the number of whorls at the time of field planting. The mean number of whorls at the time of planting was 2.78 and 42.9 per cent of the fields had an average of two whorls (Table 7). The fields with four or more whorls was 17.5 per cent and the case of one whorl was limited to 3.5 per cent of the PBPF. The highest mean number of whorls was observed in North Central Kerala and the lowest in Karnataka. In Central and North Central Kerala, which are the important traditional rubber growing areas, fields with three or more whorls had comparatively higher shares. The North Central Kerala had a noticeably higher share of fields with four or more whorls (36.0 %).

Table 7. **Region-wise differences in the number of whorls of polybagged plants**

Region	Number of whorls (% of fields) 1	2	3	≥4	Mean
Tamil Nadu	4.5	51.3	29.5	14.7	2.63
South Kerala	4.0	46.9	33.2	15.9	2.70
Central Kerala	5.1	28.2	49.5	17.2	2.80
North Central Kerala	2.2	20.7	41.1	36.0	3.29
North Kerala	2.0	62.7	23.7	11.6	2.56
Karnataka	4.4	84.5	8.9	2.2	2.09
Mean	3.5	42.9	36.1	17.5	2.78

Duration of immature phase

The DIP of PBPF and BSPF in different agro-climatic regions are presented in Table 8. As a whole, PBPF had a DIP of 6.99 compared to 7.19 years of BSPF and the difference was statistically significant at one per cent level. The DIP ranged from 6.69 years in Central Kerala to 7.78 years in Karnataka for PBPF and from 6.88 years in Tamil Nadu and Central Kerala to 8.17 years in Karnataka for BSPF. The difference between PBPF and BSPF was more pronounced in South Kerala and less in Tamil Nadu. South Kerala reported longer DIP within Kerala with regard to both PBPF and BSPF. This may be attributed to the predominance of smaller sized holdings among the samples in this region, agro-climatic factors and topography.

Table 8. **Region-wise duration of immature phase**

Region	Duration of immature phase (years) PBPF	BSPF	Difference in DIP (PBPF-BSPF) (days)
Tamil Nadu	6.78	6.88	36
South Kerala	7.43	8.01	212
Central Kerala	6.69	6.88	69
North Central Kerala	6.75	7.13	139
North Kerala	7.26	7.61	128
Karnataka	7.78	8.17	142
Mean	6.99	7.19 **	73

** Mean difference significant at $P \leq 0.01$

The difference in DIP between PBPF and BSPF increased with the size of the field (Table 9). However, no significant relationship could be established between the size of the field and DIP in general. The difference in DIP between the two categories increased with initial planting density. A positive though non-significant relationship was observed between initial planting

Table 9. **Duration of immature phase**

Category	Duration of immature phase (years)		Difference in DIP (PBPF-BSPF)
	PBPF	BSPF	(days)
Size class (ha)			
0-1	6.96	7.09	47
1-2	7.01	7.39	139
≤2	6.95	7.38	157
Initial planting density (No/ha)			
< 500	6.97	7.07	37
500 - 600	6.98	7.17	69
> 600	7.03	7.24	77
Month of planting			
Up to May	7.01	7.55	197
June	7.00	7.16	58
July	7.03	7.19	58
August to December	6.87	7.11	88
Clone			
RRII 105	7.01	7.17	58
Others	6.88	7.50	226
Mean	6.99	7.50 **	73

** Mean difference significant at $P \leq 0.01$

density and DIP. The difference between PBPF and BSPF in DIP was uniform and lower when planting was undertaken during the recommended months of June and July but notably higher in early planted (January to May) fields and moderately higher in late planted (August onwards) fields. This indicates that the comparative advantage of PBPF in DIP is more pronounced in early and late plantings. The late planted fields reported lower DIP in both cases compared to the rest which might be due to the pattern of rainfall observed during 1986 and 1987 extending up to early December in Central Kerala where most of these fields happened to be located. The difference between PBPF and BSPF was more pronounced in other clones compared to RRII 105, which is mainly on account of the longer DIP of other clones in BSPF. Nothing conclusive can be drawn from these results as fields with other clones were less in number and they were also mainly combinations with RRII 105 itself. However, it was observed that PB varieties with shorter DIP had a major share in PBPF whereas RRIM 600 had been responsible for the higher DIP of BSPF in other clones category.

A comparison of DIP between PBPF and BSPF under different situations of intercropping and cover cropping (Table 10) shows the DIP of cover cropped fields to be lower in both categories and the difference between PBPF and BSPF to be more pronounced in cover cropped fields compared to the non-cover cropped fields. The DIP in intercropped fields was lower to that of the non-intercropped fields. The difference between PBPF and BSPF was more obvious in intercropped fields. In both categories lowest DIP was observed where both intercropping and cover cropping were practised. The growers who adopted cover cropping and intercropping might be more progressive resulting in better management of the main crop leading to shorter DIP. The highest DIP in PBPF was found where neither intercropping nor cover cropping was adopted which may be attributed to the poor level of management. In BSPF, cases where intercropping was practised without the adoption of cover cropping reported the highest DIP. In both categories, fields intercropped up to the third year recorded comparatively lower DIP compared to fields with shorter period of intercropping. The results indicated that the adoption and duration of intercropping did not adversely affect the growth of rubber plants. Intercropping with ginger and other annuals reported the lowest DIP of 6.59 and 7.07 years in PBPF and BSPF respectively. Earlier experiments had shown that intercropping with banana did not affect the growth of rubber plants adversely. In both categories, intercropping with tapioca resulted in noticeably higher DIP in conformity with earlier findings (Mathew *et al.*, 1978; Jessy *et al.*, 1996).

Table 10. Duration of immature phase under different situations of cover cropping and intercropping

Category	Duration of immature phase (years)		Difference in DIP BSPF - PBPF (days)
	PBPF	BSPF	
Cover cropped	6.89	7.13	88
Not cover cropped	7.12	7.24	44
Intercropped	6.88	7.18	109
Not intercropped	7.08	7.23	55
Intercropped but not cover cropped	6.93	7.26	120
Cover cropped but not intercropped	6.92	7.20	102
Intercropped and cover cropped	6.82	7.00	66
Neither intercropped nor cover cropped	7.19	7.17	(-)7
Intercropped during 1st year	7.01	7.23	80
Intercropped during 1 - 2 years	6.81	7.23	153
Intercropped during 1 - 3 years	6.75	6.87	44
Intercropped with banana	6.81	7.12	113
Intercropped with tapioca	7.30	7.55	91
Intercropped with banana and other annuals	6.82	7.13	113
Intercropped with ginger and other annuals	6.59	7.07	175
Total	6.99	7.19 **	73

** Mean differerence significant at p≤0.01

Number of whorls and duration of immature phase

The number of whorls at the time of field planting is believed to have a strong influence on the growth of polybagged plants and DIP. The DIP of PBPF with two whorls was significantly higher compared to those with three whorls and four or more whorls (Table 11). But the mean difference between the DIP of PBPF with three and four or more whorls was insignificant. Hence it may be stipulated that a polybagged plant must have at least three whorls at the time of planting to shorten the DIP. It may be seen that the DIP of PBPF with two whorls was almost equal to that of BSPF. The relationship between number of whorls and DIP was inverse and significant at one per cent level. However, the negative relationship observed between number of whorls and DIP was not significant when the initial planting density was above 600 per ha and in the case of early and late planted fields. It can be surmised that number of whorls can influence DIP only when planting is undertaken according to the recommendations related to time and density of planting.

Table 11. Number of whorls and duration of immature phase of fields planted with polybagged plants

Duration of immature phase (years)		
A. PBPF with 2 whorls	- 7.20	
B. PBPF with 3 whorls	- 6.87	
C. PBPF with 4 or more whorls	- 6.82	
Mean difference A & B ** A & C **		
r between number of whorls and DIP		
General	(–)0.16 **	(n = 1814)
Initial planting density (No/ha)		
< 500	(–)0.18 **	(n = 343)
500 - 600	(–)0.22 **	(n = 988)
≥ 600	(–)0.04	(n = 483)
Month of planting		
upto May	(–)0.17	(n = 49)
June	(–)0.18 **	(n = 567)
July	(–)0.20 **	(n = 904)
August	(–)0.01	(n = 198)
Sept. to December	(–)0.02	(n = 96)

** Significant at P≤0.01

Economic analysis

Although the observed superiority of PBPF in DIP underlines the basis for popularisation of polybagged planting materials, the small growers across the regions are confronted with the decision making from an economic angle arising from the relative profitability expressed in terms

Table 12. **Comparative economics of PBPF and BSPF**

Annuity of BSPF (Rs)	2586
Annuity of PBPF (Rs)	2086
Required DIP of PBPF to get an annuity equivalent to BSPF (years)	6.78
Required yield increment in PBPF to get an annuity equivalent to BSPF (%)	2.6

of estimated annuity. Despite the superimposed data limitations on a foolproof estimate of the annuity from PBPF and BSPF, an attempt has been made to compare the prospective economic returns based on the available data to provide broad indications on the relative performance. (Table 12) The economic analysis estimated an annuity of Rs.2586 for BSPF and Rs.2086 for PBPF indicating that other things remaining the same, the reported lower DIP of PBPF did not give it any edge over BSPF from an economic point of view. Analysis to identify the DIP at which PBPF would generate an annuity equivalent of BSPF gave a value of 6.78 years. Hence it may be concluded that given the DIP of BSPF at 7.19 years, there should be a reduction in DIP by more than 150 days for PBPF to obtain economic advantage compared to the currently reported difference of 73 days.

CONCLUSION

The reduction of immaturity period in PBPF by 73 days may be seen against the fact that in all the cultural practices for which comparable data were available, except in the case of mulching, PBPF had superiority over BSPF. The results of the economic analysis may be treated with caution as higher yield prospects of PBPF from uniform growth and higher survival rate and tappability could not be included in the economic analysis due to non-availability of relevant data. A field experiment showed that in the ninth year of planting the tappability of PBPF was higher at 92.8 per cent compared to 83.5 per cent of BSPF (Marattukalam and Nair, 1982). Another survey conducted among the small rubber growers reported six per cent higher plant retention in the seventh year for PBPF (Joseph and Haridasan, 1993). It is observed that a 2.6 per cent increase in yield of PBPF over BSPF can give an equivalent annuity. Hence the economic advantage of fields planted with polybagged plants may have to originate from the cumulative economic impact of shorter immature phase, lower vacancy, uniform establishment, higher tappability and higher yield rather than from the often proclaimed sole virtue of shorter immaturity period.

ACKNOWLEDGEMENT

The authors are grateful to Dr. M.R. Sethuraj, former Director, RRII and Dr. A.K. Krishnakumar, Rubber Production Commissioner for suggesting this study in an earlier interaction with the extension officers. We express our sincere thanks to the extension officers of the 23 regional offices of the Rubber Board for the valuable efforts in collecting the data.

REFERENCES

Abraham, M.S. (1986). New developments in rubber production and processing: Two advanced planting materials. *Rubber Board Bulletin*, 18(4) : 6-8.

Cherian, P.P. (1987). Advanced rubber planting materials: Do they shorten immaturity consistent with longevity? *Rubber Board Bulletin*, 23(3) : 19-23.

Jessy, M.D., Philip, V., Punnoose, K.I. and Sethuraj, M.R. (1996). Multi-species cropping system with rubber : A preliminary report. *Proceedings of the Symposium on Farming System Aspects of the Cultivation of Natural Rubber (Hevea brasiliensis)*, 1996, Beruwela, Sri Lanka, pp. 81-89.

Joseph, T. and Haridasan, V. (1993). Resource use in rubber smallholdings. *Indian Journal of Natural Rubber Research*, 6(1&2) : 43-49.

Krishnakumar, A.K. and Nair, P.M.M.K. (1999). Transfer of technology in the Indian rubber plantation sector. *International Rubber Digest*, 53(6) : 12-16.

Marattukalam, J.G. and Nair, V.K.B. (1982). Comparative growth performance of polybagged plants and brown budded stumps. *Proceedings of the Fifth Annual Symposium on Plantation Crops*, Central Plantation Crops Research Institute, Kasaragod, pp. 158-162.

Marattukalam, J.G. and Saraswathyamma, C.K. (1992). Propagation and planting. In : *Natural Rubber: Biology, Cultivation and Technology* (Eds. M.R. Sethuraj and N.M. Mathew). Elsevier, Amsterdam, pp. 164-199.

Mathew, M., Potti, S.N., Punnoose, K.I. and George, C.M. (1978). Intercropping in rubber plantations. *Proceedings of the First Symposium of Plantation Crops (PLACROSYM I)*, Rubber Research Institute of India, Kottayam, pp. 431-437.

Nair, C.S.J., Kumar, V.J., Sreekumaran, V., Nair, K.H. and Iyer, R.S. (1992). Performance of different planting materials of rubber (Clone RRII 105) in tribal holdings of Amboori. *Journal of Plantation Crops (Supplement)* **20** : 52.

Potty, S.N. (1980). Nursery establishment and field planting. In : *Handbook on Natural Rubber Production in India* (Ed. P.N. Radhakrishna Pillay) Rubber Research Institute of India, Kottayam, pp 113-131.

Rae, N.R. (1977). Crop management economics. Crosby Lockwood Staples, London, pp. 282-284.

Rubber Board (1996). Adoption of polybagged plants for planting rubber in traditional areas. Rubber Board, Kottayam, 9 p. (Unpublished).

Sivandyan, K, Mussa, B.M.S., Woo, Y.K., Soong, N.K. and Pushparajah, E. (1973). Agronomic practices towards reducing period of immaturity. *Proceedings of the RRIM Planters' Conference*, Kuala Lumpur, Malaysia, pp. 226-242.

Templeton, J.K. (1967). Comparison of nursery methods for budded planting materials. *Planters' Bulletin*, **92** : 221-232.

Veeraputhran, S., Viswanathan, P.K. and Joseph, T. (1998). Trends in the adoption of planting materials in the rubber smallholding sector in India. In : *Developments in Plantation Crops Research* (Eds. N.M. Mathew and C. Kuruvilla Jacob). Allied Publishers, New Delhi, pp. 324-327.