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SHORTENING THE IMMATURE PHASE OF NATURAL RUBBER THROUGH IMPROVED PLANTING MATERIAL AND AGROMANAGEMENT PRACTICES

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The lengthy unproductive immature phase of natural rubber is a matter of concern among rubber farmers, especially the smallholders. Majority of the rubber plantations in India takes about seven to eight years to attain tappable girth. This paper focuses on the results of a field experiment initiated to evolve an agronomic package to shorten the immaturity period of rubber in which the treatments included combinations of two types of planting material *viz.* green-budded stumps raised in polybags and plants raised by direct-seeding in polybags and two management options *viz*. current recommended package of practices, and an integrated management comprising enhanced nutrient application, selective manuring and conservation-oriented tillage. The results showed significant difference in the performance of two types of planting material. Direct- seeded green- budded plants were significantly superior to plants raised from green - budded stumps throughout the period under study. The effect of agromanagement practices was reflected in growth of rubber. The girth of the plants under integrated management was superior to that of respective type of planting material under current recommended practice. The soil nutrient status *viz*. the organic carbon and available K contents was significantly improved under integrated management. A higher canopy width was maintained by the direct seeded green-budded plants under integrated management. The soil moisture storage was also positively influenced by integrated management. Thus direct-seeded green-budded plants under integrated management was significantly superior to all others and 68 per cent of the plants reached tappable girth in five years and nine months as against 19 per cent in the control (budded stumps raised in polybags under the current recommended practices). The study revealed that the gestation period of natural rubber could be brought down to less than six years through the use of direct-seeded green-budded plants and adoption of integrated agricultural practices.

Key words: Growth, *Hevea*, Immaturity period, Integrated management, Planting material

INTRODUCTION

Hevea brasiliensis is the main source of raw material for tyre and non-tyre industry which has a great contribution to Indian economy. The natural rubber plantation industry in India is dominated by small holdings accounting 91 per cent of area and 92 per cent production (Rubber Board, 2016). Notwithstanding the fact that productivity has considerably increased (doubled within two decades) applying available technology, Indian rubber growers are not able to

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compete with their counter parts from major rubber growing countries for economic production which signifies the importance of cost-effective production.

Productivity increase and cost-effective production demand substantial investment in the generation of the technology strategic areas such as reducing the immaturity period, increasing the economic life span of the tree, breeding for disease, pest and stress resistance to save on cultural practices *etc*. The need for reducing the gestation period of rubber attained importance from the day commercial planting was started. The attractiveness of new investments in rubber planting has been unfavourably influenced by two physiological aspects of *H. brasiliensis*, *viz*. the lengthy immature period and the slow speed with which high yield level is achieved (Lim *et al.*, 1973). The long gestation period of rubber locks up the initial investment till the commencement of economic yield and shortening the gestation period is required to help quick recovery of returns to investment.

The extent of gestation period of natural rubber is mainly governed by the inherent clonal characteristics, type and quality of planting materials used, edaphic and environmental factors, agromanagement practices adopted and biotic and abiotic stresses. Of these, the planting material, its type and quality, is of special significance as the extent of reversibility is limited considering the long gestation phase and the life span of 25 to 30 years. The effect of some good agricultural practices on growth and gestation period has been studied individually and in combination and it was found that improved agromanagement practices had great influence on the performance of rubber plants (George *et al.*, 2013). Since early 1960s, priorities of research have been directed to shorten the period of immaturity through refinements of various propagation techniques to produce advanced planting materials (Hurov, 1960; Marattukulam and Saraswathiyamma, 1992; Soman *et al*., 2002). A study was undertaken focusing on the effect of combination of chosen planting material with the options of current recommended practice and an integrated agromanagement package on shortening the gestation period of *H. brasiliensis.*

MATERIALS AND METHODS

A field experiment was initiated during 2008 at the Central Experiment Station, Chethackal (9^0 22′ N, 76^0 50′E, 50 m AMSL) of the Rubber Research Institute of India to study the effect of type of planting material and different agromanagement practices on growth of immature rubber. Typical warm humid tropical climate is experienced at Chethackal. The average annual rainfall of the area ranges from 3000 to 3500 mm.

The treatments comprised combinations of two types of planting materials *viz*. green - budded stumps raised in polybags and direct-seeded green- budded plants and two management options *viz*. standard practice (current recommendation *i.e.* 20:20:8:3, 40:40:16:6, 50:50:20:7.5 and 40:40:16:6 kg N,P,K and Mg ha^{-1} $year^{-1}$ in two equal splits, respectively during the initial four years, Punnoose and Lakshmanan, 2000) and an integrated management which included enhanced nutrient application *i.e.* pit manuring @ 500 g bone meal per plant, application of 1.5 times the recommended dose of fertilizers in four splits and 10 kg FYM, 500 g bone meal and 500 g groundnut cake as top dressing for the initial four years, selective manuring *i.e.* application of 0.75 times the recommended dosage of fertilizers in three splits to the weak plants for the initial four years and conservation - oriented tillage *i.e.* forking the plant basin followed by heavy mulching and taking water conservation pits @ 250 pits per ha. Thus there were four treatments and green-budded stumps raised in polybags + standard practice was treated as control.

The polybag plants used in the study were prepared by two different methods *viz*. vegetative propagation of rubber plants through bud-grafting followed by raising the budded stump in polybag. Alternatively, germinated seeds were planted in polybags and bud-grafted *in situ*.

Black polythene bags (55 x 25 cm) were filled with top soil (10 kg) to raise direct-seeded polybag plants. Seeds germinated within 10 days of sowing were planted in the polybags. Simultaneously germinated seeds were planted in ground nursery. The plants in the polybags and ground nursery were raised following the recommended package of practices (Rubber Board, 2009). The direct-seeded plants were also supplied with 100 ml cow dung slurry fortified with groundnut cake (50 kg cow dung + 5 kg groundnut cake in 200 L of water and fermented for 2-3 days) at weekly intervals. Green budding was done in the polybag and ground nurseries with the clone RRII 105 four months after planting. Green- budded plants were opened 21 days after budding and cutting back was done at one month after opening. Another set of polybag plants was raised using green-budded stumps of clone RRII 105 produced from the ground nursery. The planting of green-budded stumps was done on the same day when cutting back of direct-seeded plants was undertaken.

The soil of the experimental site was sandy clay loam in texture, acidic in reaction (pH 4.86), high in organic carbon status (2.47 %), medium in available phosphorus and calcium (12 and 132 mg kg^{-1}), high in available K and Mg (193 and 36.6 mg kg^{-1}). Polybag plants of clone RRII 105 (both green-budded stumps raised in polybags and plants raised by direct-seeding in polybags) were planted as per the treatment during June 2008 at a spacing of 6.7 x 3.4 m. *Pueraria phaseoloides* was established as cover crop and maintained during the immature phase. All cultural operations for rubber were done as per the recommendations of the Rubber Board (Punnoose and Lakshmanan, 2000). The experiment was laid out in RBD with six replications. The gross plot size was 24 plants with a net plot size of six.

Soil (0-30 cm depth) and leaf samples were collected periodically from the experimental plots. The soil samples were analysed following standard procedures as outlined in Jackson (1958). The leaf samples were analysed for N, P and K (Piper, 1966).

The girth of the plants was recorded annually at a height of 150 cm above the bud union. Bark thickness was measured using a bark gauge. Observations on soil moisture content (gravimetric method), canopy width and percentage tappability (Vijayakumar *et al*., 2000) were recorded and disease assessment was done periodically.

RESULTS AND DISCUSSION

Growth of plants

Growth of rubber plants was significantly influenced by the type of planting material and improved agromanagement practices throughout the experimental period. There was significant difference in the performance of the two types of planting material. The growth of direct-seeded green- budded polybag plants was found to be significantly superior to that of plants raised from green-budded stumps in polybags (Table 1). Vigorous, good quality planting materials with high growth potential could be generated through the technique of direct seeding in polybags followed by *in situ* budding and managing them with nutritional inputs through integrating chemical fertilizers and organic manures (Syamala *et al.*, 2010). Root system plays an important role in capturing the below-ground resources, water and nutrients (Gaur *et al.*, 2008). The above-ground biomass production is always associated with the root development. By ensuring rapid and healthy development of root system of field-planted rubber, it is possible to make substantial contribution towards reducing the immaturity period of rubber. Preparation of polybag plants through direct-seeding and *in situ* budding did not place any limitation on the development of root system and a well-developed root system was always associated with the direct-seeded plants (George *et al.*, 2011).

The effect of agromanagement practices was reflected in the growth of the plants (Table 1). The girth of the plants under integrated management was found to be superior to that of the respective type of planting material under standard practice throughout the experimental period.

The addition of organic manures enhance the plant growth through improving the physical and chemical properties of the soil. Integration of chemical fertilizers with farmyard manure in 25:75 ratio significantly improved the girth of rubber plants and leaf nutrient status (Philip *et al.*, 2012). The use of crop residues as mulch helped in lowering the soil temperature, preventing wind and water erosion, improving water infiltration in soils, increasing soil water storage in the root zone and managing weeds (Samarappuli *et al.*, 1992; George *et al.*, 2013). All these practices along with the *in situ* water harvesting through conservation pits might have contributed towards the increased growth. Tillage involves loosening of the soil mass such that the infiltration of rainfall and aeration are increased and the soil strength is decreased. Tillage and mulching enhanced the growth of young rubber plants (Eusof, 1998). Significant improvement was observed in soil moisture status, plant height, diameter and number of whorls of immature rubber in the presence of conservation pits (George *et al.*, 2006).

Experiments have proven that agronomic practices have a profound influence in reducing the immaturity period of *H. brasiliensis* (Samarappuli *et al.*, 1992; George, *et al.*, 2013) and the performance of future stand is pre-determined by the selection of good quality planting material to a great extent. In the present experiment attempts

Table 1. **Effect of planting material and agromanagement practices on growth of rubber**

Treatment	Girth (cm)				
	Feb 2011	Jan 2012	Jan 2013	Mar 2014	July 2015
Green - budded stumps raised in polybags + Standard practice	20.7	28.2	38.5	46.9	49.2
Green - budded stumps raised in polybags + Integrated management	22.0	30.4	41.3	48.3	52.5
Direct-seeded green- budded plants + Standard practice	23.9	31.6	42.3	47.8	53.6
Direct-seeded green- budded plants + Integrated management	26.2	34.1	44.8	50.6	56.6
CD ($P < 0.05$)	0.7	1.2	0.88	1.4	1.9

Table 2. **Effect of planting material and agromanagement practices on canopy width**

Treatment	Canopy width (m)
Green - budded stumps raised in polybags + Standard practice	2.4
Green - budded stumps raised in polybags + Integrated management	2.6
Direct seeded green - budded plants + Standard practice	2.9
Direct seeded green - budded plants +Integrated management	3.2
CD (P < 0.05)	0.22

have been made to reduce the gestation period through refinement of various agronomic inputs and nursery techniques, adopting an integrated approach. The plants responded positively to both and the growth of the direct-seeded green-budded plants under integrated management was significantly superior to all others throughout the experiment. This was manifested in the observations on canopy width (Table 2) and earlier observations on Leaf Area Index (LAI) (George *et al*., 2006). The direct-seeded plants receiving integrated management recorded the highest canopy width and LAI which were significantly superior to all others. The bark thickness was also positively influenced (Fig. 1). The highest bark thickness was also observed for the direct-seeded plants under integrated management. Thus 67 per cent of the direct-seeded plants under integrated management reached tappable girth in five years and nine months as against 19 per cent in the control (budded-stumps raised in polybags under the current recommended practices, Fig. 2). The corresponding percentage tappability

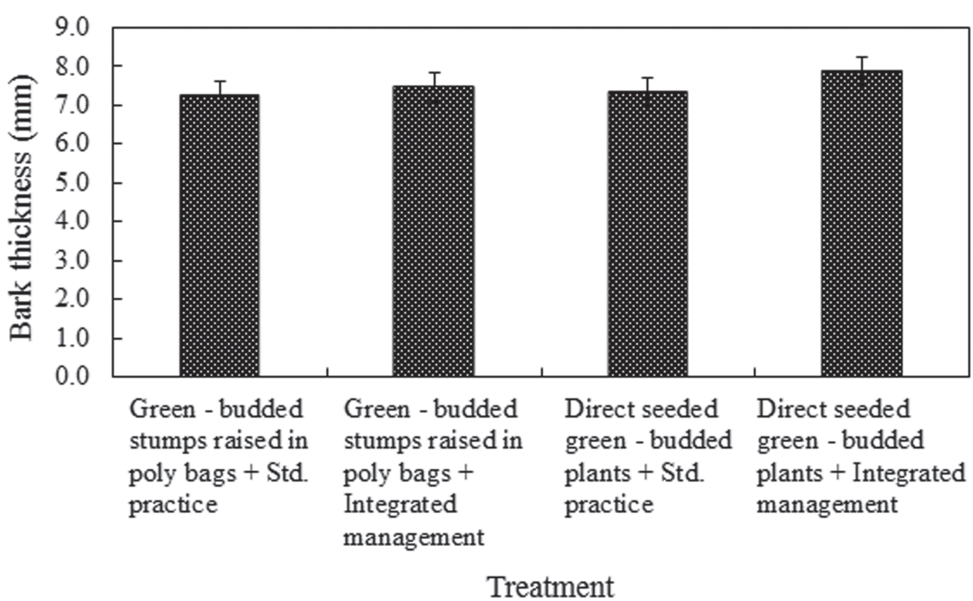

Fig. 1. Effect of planting material and agromanagement practices on bark thickness. The vertical bars indicate LSDs

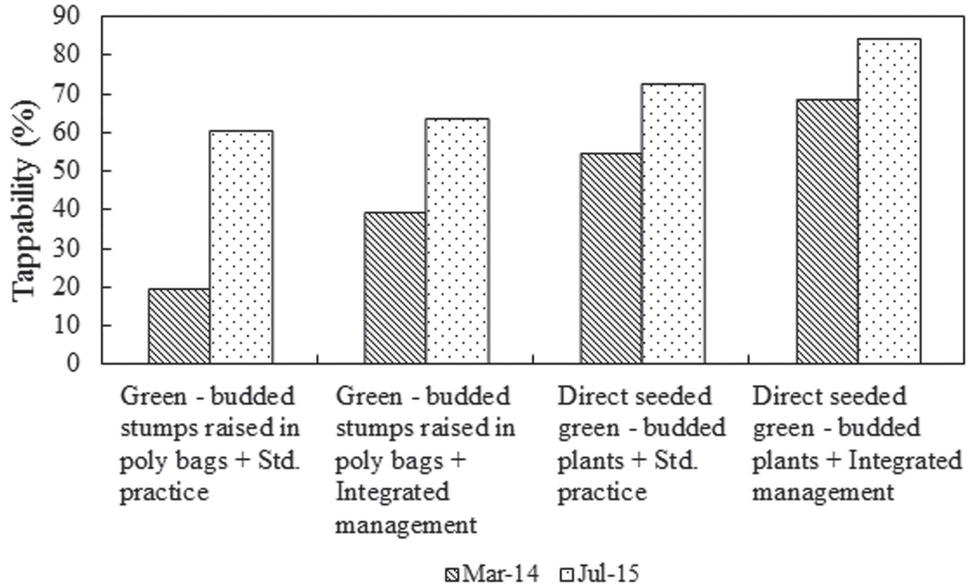

Fig. 2. Effect of planting material and agromanagement practices on mean percentage tappability

for the direct-seeded green-budded plants under the recommended practices and budded-stumps raised in polybags under integrated management was 54 and 39, respectively which indicated the substantial influence of ideal planting material on the performance of rubber plants in field.

Soil moisture status

The soil moisture content during summer of 2012 in the lower layer (8-16 cm) was significantly higher in the treatment where conservation practices like tillage, mulching, conservation pits and enhanced fertilizer application along with the use of organic manures were integrated with direct - seeded green-budded plants, compared to the plots where plants raised from budded stumps were planted following existing package of practices (Table 3). The moisture content in the surface layer (0-8 cm) of the treatment also exhibited a positive trend.

Integrated management irrespective of type of planting material was associated with significantly higher soil moisture content. Mulching or covering the plant basin with

Table 3. **Effect of planting material and agromanagement practices on soil moisture status**

Treatment	Jan (0-8 cm)	Jan (8-16 cm)
Green - budded stumps raised in polybags + Standard practice	24.2	23.6
Green - budded stumps raised in polybags + Integrated management	26.3	28.7
Direct - seeded green- budded plants+Standard practice	24.0	22.7
Direct - seeded green- budded plants +Integrated management	27.0	28.6
CD (P < 0.05)	NS	2.8

Table 4. **Effect of planting material and agromanagement practices on soil pH and nutrient availability**

Treatment	pH	Available nutrients (mg kg^{-1})		
		P	Ca	Mg
Green - budded stumps raised in polybags + Standard practice	5.06	157	149	53.7
Green - budded stumps raised in polybags + Integrated management	4.92	229	170	52.6
Direct seeded green- budded plants + Standard practice	5.05	185	167	68.6
Direct seeded green- budded plants + Integrated management	4.97	248	214	52.1
CD ($P < 0.05$)	NS	NS	NS	NS

dry leaves, cover crop and grass cuttings or paddy straw is an important agronomic practice in rubber plantations to conserve soil moisture and protect the soil around the base of plants from direct impact of heavy rains and sunlight causing soil degradation (Samarappuli *et al*., 1992). Mulch has an additional advantage that there is no competition for moisture unlike in the case of live ground covers. Conservation pits act as an efficient runoff management system wherein a part of the runoff is conserved and reused for crop production (George *et al*., 2011).

Soil and leaf nutrient status

The effect of agromanagement practices on the availability of nutrients in the surface

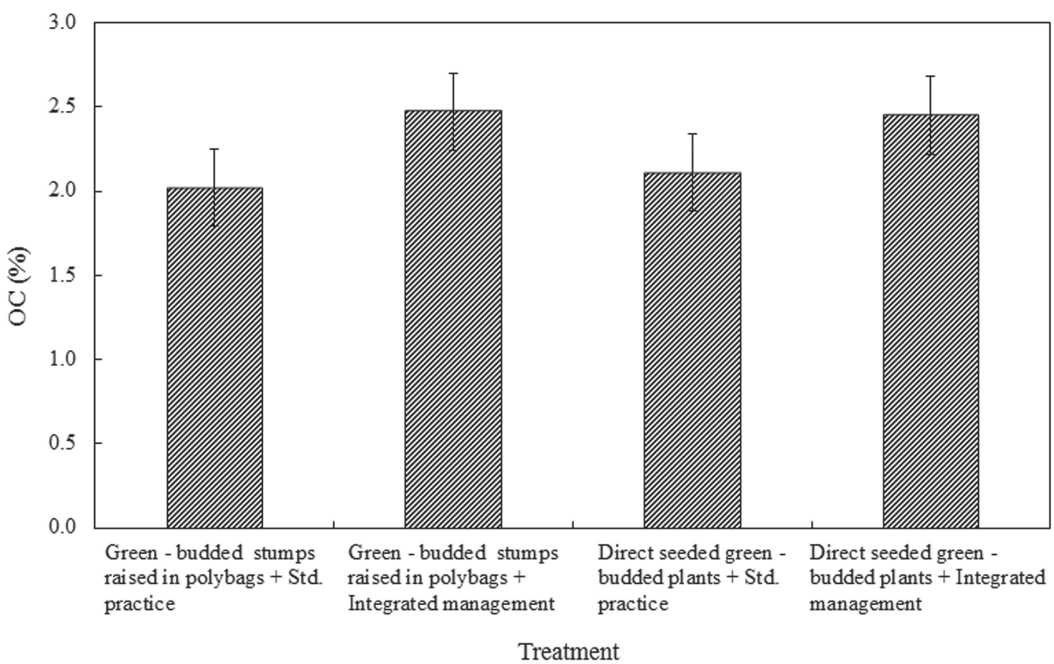

Fig. 3. Effect of planting material and agromanagement practices on soil OC. The vertical bars indicate LSDs

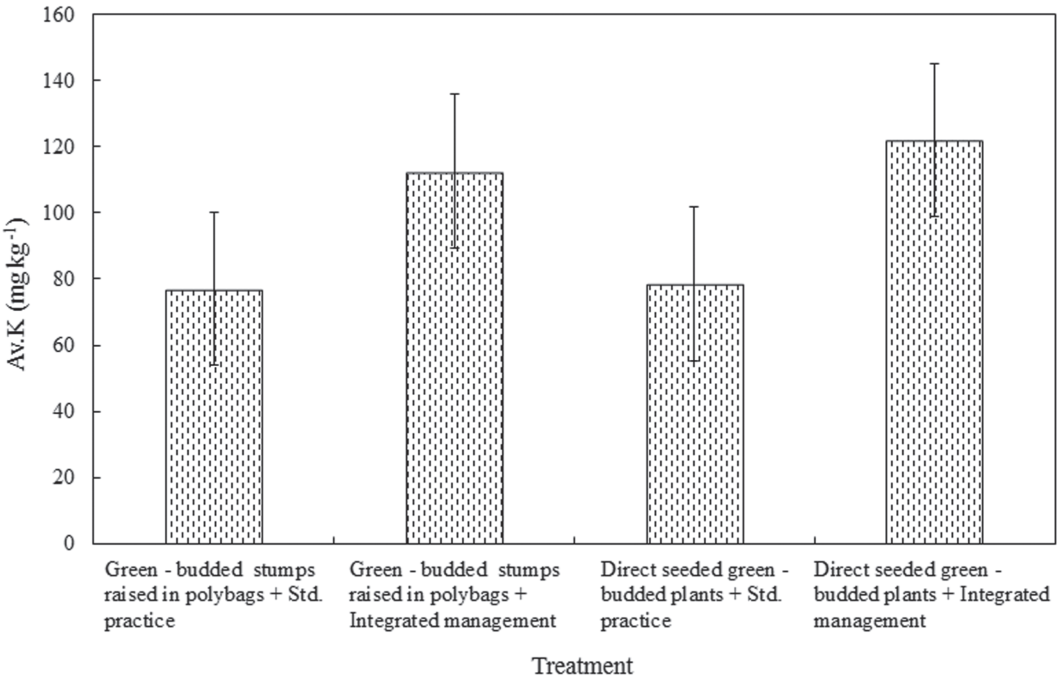

Fig. 4. Effect of planting material and agromanagement practices on soil av. K. The vertical bars indicate LSDs

soil after completing the treatment imposition (2013) showed that pH, available P, Ca and Mg were not influenced by the additional doses of fertilizers and organic manures (Table 4) whereas soil organic carbon (Fig. 3) and available K (Fig. 4) status were significantly improved. The soil organic carbon (SOC) was significantly higher in plots receiving farmyard manure, bone meal and groundnut cake along with enhanced doses of chemical fertilizers over those receiving only the recommended doses of inorganic fertilizers. The mean SOC increased to 2.46 per cent in integrated management as compared to 2.07 per cent in standard practice. Beneficial effect of integrated use of chemical fertilizers along with organic manures is due to the incorporation of organic matter in the soil which stimulate the population and activity of microorganisms

Table 5. **Effect of planting material and agromanagement practices on leaf nutrient status**

Treatment	Leaf nutrient content (%)		
	N	P	K
Green - budded stumps raised in polybags + Standard practice	3.0	0.18	0.83
Green - budded stumps raised in polybags + Integrated management	3.5	0.18	0.88
Direct - seeded green - budded plants + Standard practice	3.2	0.18	0.93
Direct - seeded green - budded plants + Integrated management	3.4	0.19	1.06
CD (P < 0.05)	NS	NS	0.08

(Philip *et al.*, 2012) and better regulation of organic carbon dynamics in soils. Better crop growth with concomitant greater root biomass generation and the plant residue addition through mulching also lead to improvement in organic carbon status of the soil under integrated management.

Integrated management significantly increased the available K content of soil during 2013 *i.e.* immediately after the cessation of treatment imposition. The higher availability of K may be ascribed to the addition of increased quantities of inorganic fertilizers and the reduction of K fixation and release of K due to the interaction of organic matter with clay (Varalakshmi *et al.*, 2005).

The leaf nutrient concentration assessed during the same period (2013 and 2016) did not show any significant difference in N, P and K contents except for a significantly higher K content in the leaves of direct-seeded plants under integrated management in 2013 (Table 5). The integrated approach as well as direct seeding resulted in better root development which extracted higher amount of nutrients from soil (Philip *et al.*, 2012).

Disease intensity

Though the occurrence of foliar diseases like Phytophthora leaf fall, shoot rot and Colletotrichum leaf disease, which are known to affect growth, was noticed, their incidence was mild as they were managed effectively with timely prophylactic measures. However, pink disease, an important stem disease of rubber occurring during south- west monsoon period affecting the plant vigour was prevalent, but severity was not influenced by the treatments.

CONCLUSION

The study revealed that with the use of direct-seeded green-budded plants and adoption of improved agromanagement practices, it is possible to shorten the gestation period of rubber to less than six years compared to the normal gestation period of seven to eight years in the traditional belt. However, it is necessary to assess the techno-economic feasibility of the management options from the angle of the planting community especially under the current scenario of low rubber prices and increasing cost of cultivation.

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