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AN UPDATE OF AGROMANAGEMENT IN RUBBER CULTIVATION

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In a tree crop like rubber (*Hevea brasiliensis*) with a long gestation period, adoption of appropriate crop management practices is necessary for achieving a uniform stand of trees ready for tapping in the minimum possible period. The potential of high yielding clones can be realized only through scientific field management. An attempt is made to update and consolidate the scientific practices in various agromanagement aspects viz. planting materials, density of planting, soil conservation, fertilizer and weed management, intercropping, irrigation and farm mechanization.

INTRODUCTION

Crop management in rubber is aimed at shortening its immaturity period and optimizing growth and yield. Rubber is a long duration crop with a gestation period of about seven years under South Indian conditions. While climatic and soil factors have profound influence on the rate of growth and productivity of rubber, adoption of appropriate crop management practices can favourably modify the effect of these factors.

The use of good quality polybag plants of uniform size is likely to hasten growth and result in a uniform stand of trees. Weed management is aimed at minimizing competition for nutrient and moisture during critical periods. Proper manuring will ensure sustained growth and productivity.

Cultural practices like shading, mulching, white washing followed during the early stages of growth of rubber will help in shortening the gestation period. Maintenance of legume ground cover helps in preventing weed growth in the plantation, enriching soil nitrogen and organic matter and in minimizing soil erosion during rains in the immaturity phase.

The potential of modern high yielding clones can be fully exploited only if all the scientific crop management practices are followed in time. Adoption of soil conservation measures will go a long way in maintaining the soil as a permanent natural resource for the successful cultivation of rubber.

PLANTING

Planting material

The use of good quality planting material is considered to be important for the successful establishment of a rubber plantation. Polybag plants of adequate growth and health are recognized as suitable materials to reduce vacancies in the field and to ensure a uniform stand (Punnoose and Lakshmanan, 2000). From a survey on use of planting materials in the traditional rubber-growing belt, Joseph *et al*.,. (2001) reported that polybag plants must have at least three whorls at the time of planting to shorten the immaturity period.

It is generally observed that disease free and healthy three whorl polybag plants are ideal planting material for the successful establishment of a plantation. Careful selection has to be exercised to see that only the good quality polybag plants are used for planting. This is likely to reduce vacancies in the field and achieve a uniform stand. Planting in the field is best done soon after the south west monsoon has established so that the full advantage of the rainy season can be made use of.

Planting density

The planting density should be in such a way as to provide sufficient sunlight for development of the canopy and adequate volume of soil for the spread of the root system (Punnoose *et al.*, 2000). It has been noticed that within certain limits, the yield per hectare is higher when the density is high but the yield per tree is lower. On the contrary, a lower density will lead to a lower yield per hectare but a higher yield per tree (RRII, 1994). A planting density of 450-500 is generally acceptable. When family labour is utilized for tapping, it is desirable to have a higher stand.

SOIL AND WATER CONSERVATION

Soil erosion is the slow and gradual process of removal or washing away of the productive top soil. The degree of erosion depends on the slope of the soil surface, intensity of rainfall, cultivation practices and the protective measures adopted. The two major factors, which predispose the rubber growing soils to erosion, are the undulating topography and the high intensity of rainfall. Table 1. indicates that majority of the rubber growing areas in Kerala and Tamil Nadu are located on undulating terrain.

Table 2. **Rainfall distribution in Kerala**

South west monsoon	4 months	67% of annual
North east monsoon	2 months	16% of annual
Total rainy season	6 months	83% of annual
Off season	6 months	17% of annual

Table 1. **Topography of rubber growing areas in Kerala and Tamil Nadu**

Topography	Slope (%)	Per cent of total area
Level land and gentle slope	<5	07.4
Moderately sloping	5-10	18.3
Strongly sloping	10-15	37.6
Moderately steepy sloping	15-25	24.1
Steepy sloping	25-33	09.5
Very steepy sloping	>33	03.1

Source: NBSS & LUP (1999)

About 83 per cent of the annual rain is received in the two rainy seasons, (Table 2) which are concentrated in a period of about six months. The high intensity nature of the rain makes the soil further more vulnerable to erosion. It is, therefore, very essential to take up appropriate conservation measures in rubber plantations and holdings to minimize soil erosion. The practices generally adopted for this purpose are providing contour terraces, silt pits, contour bunds (edakayyalas), drainage channels, maintenance of ground cover and mulching.

Contour terraces

It is generally accepted that planting should be done along contour terraces when the general slope of the land is above 8 per cent (Punnoose and Lakshmanan, 2000). Contour terraces should be of 120-150 cm width with an inward slope of 20-30 cm. During rains, the water, which flows down carrying fine soil particles, is interrupted by the contour terraces, where they get a chance to settle down. Thereafter, the relatively clear water flows down to the next contour. During this process more rain water is allowed to percolate into the soil.

Silt pits

Silt pits help in trapping water and silt during rains. Apart from checking soil erosion, silts pits help in increasing the

Table 3. **Effect of silt pits on soil conservation, growth and yield of rubber**

No. of pits/ha	Quantity of soil conserved (t/ha)	Girth increment (cm)*	Yield (kg/ha)**
0	0.00	5.39	1145.40
100	4.02	6.63	1112.10
150	6.09	7.68	1184.00
200	6.89	8.42	1215.30
250	9.02	9.14	1271.80
SE	0.30	0.58	121.94
CD	1.00	2.00	NS

Source: RRII (2002)
*1998-2002
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quantity of water percolating down the soil profile. Pits of size 120 cm length, 45 cm width and 75 cm depth are usually taken with the longer sides across the slope of the land. The results of a field experiment started during 1998 to study the effect of silt pits on the quantity of soil conserved and on the growth and yield of rubber are presented in Table 3. It is noticed that increasing the number of pits from 100 to 250/ha has resulted in significant increase in the quantity of soil conserved. A maximum quantity of 9.02 tonnes of soil was conserved with 250 pits/ha, which would otherwise have been lost from the soil in a period of one year. It is also observed that the growth of rubber trees has been significantly enhanced by the presence of silt pits as indicated by the girth increment during 1998-2002. The yield of rubber was also positively influenced by the presence of silt pits, though it was not statistically significant.

Contour bunds

Stone pitched contour bunds (*edakayyalas*) are constructed at suitable intervals. The distance between such bunds depends on the degree of slope of the land, greater the slope lesser the distance.

Drainage

Proper drainage of the soil is required for the successful establishment of rubber plants. Drainage is particularly important for flat areas with a seasonal or permanent high water table. The natural drainage channels existing in the field may be strengthened and maintained.

Maintenance of ground cover

A barren soil surface permits more erosion than a soil covered with a surface vegetation. In the early years of a rubber plantation, growing of a legume ground cover is an accepted practice. In the absence of a systematic legume cover, the existing flora may be permitted to grow close to the ground surface. The growth of such natural cover should be regulated by periodic slashing. The presence of such surface vegetation helps not only in the conservation of soil, but also in more rain water percolation into the soil enriching the ground water reserves.

Mulching

Spreading of dead organic materials or synthetic materials like polythene in the basins of young plants helps in reducing erosion and conservation of soil moisture. It also helps in suppressing weed growth and minimizing soil temperature during summer. The use of organic materials as mulch also helps in enriching soil organic matter.

FERTILIZER MANAGEMENT

Plants take up nutrients from soil. All soils invariably contain different plant nutrients in varying quantities. Plant nutrients are being added to the soil through application of manures and fertilizers, weathering of rocks and minerals etc.

Nutrients in the soil get depleted through absorption by plants, leaching through soil,

Table 4. **Dry matter production and nutrient accumulation by two-year-old cover crops**

Cover crop	Dry matter production (t/ha)	Nutrient accumulation (kg/ha)				
		N	P	K	Ca	Mg
Pueraria phaseoloides	5.46	174.17	13.08	103.84	65.35	18.03
Mucuna bracteata	7.62	236.21	15.21	79.08	55.71	14.57

water, run off losses etc. Application of manures and fertilizers is aimed at the restoration and maintenance of soil fertility so as to maintain the soil as steady supplier of the required quantities of nutrients for plant growth.

Like other crops, rubber also needs manuring due to reasons stated above. However, the rubber ecosystem is different from others owing to its special characteristics. During its immature phase, legume ground cover is established and maintained which gives a net addition of nitrogen and helps in the recycling of all plant nutrients. It enriches the organic matter status of the soil and improves its physical, chemical and biological properties. The quantities of dry matter production and nutrient accumulation by two legume ground covers in a period of two years is given in (Table 4).

In grown up rubber plantations, about 5-6 tonnes of leaf litter per hectare is added every year due to wintering, which helps in recycling considerable quantities of plant nutrients (Table 5). Due to the closed canopy and zero/minimum tillage practiced in the plantation, the rate of oxidation of organic matter will be low in soils under rubber and hence the organic matter content stabilizes at a higher level compared to other crops. The nutrient removal from the system through latex is comparatively less as seen from Table 6 (Punnoose 1993). Due to these reasons the rubber system can be considered as an almost sustainable system with low requirements for nutrient inputs from external sources.

Table 5. **Leaf litter of rubber and nutrient addition (kg/ha/year)**

Weight of litter	Nutrients		
	N	P	K
5000	88	2	45

Table 6. **Average nutrient removal through latex for 2000 kg dry rubber yield**

Nutrients removed (kg/ha/year)		
N	P	K
12.4	2.8	11.4

The quantities of various fertilizers for the supply of plant nutrients to be applied to rubber plantations of varying growth stages have been arrived at through long periods of field experimentation (Punnoose *et al.*, 1975 and Potty *et al.*, 1976). The object of manuring the nursery is to obtain the maximum number of planting materials in a definite period of time. Young plantations are manured to speed up growth and to bring the trees to tapping in the shortest possible time. The object of fertilizing the mature plantation is to maximize yield and to get sustained growth.

The Rubber Board has formulated general fertilizer recommendations (GFR) for adoption by rubber growers. The recommendations for ground seedling nursery and immature plantation up to four years include application of fertilizers containing the nutrients viz. nitrogen (N), phosphorous (P), potassium (K) and magnesium (Mg). During the subsequent period of immaturity and the mature phase, fertilizers containing N, P and K are recommended (Karthikakuttyamma *et al.*, 2000).

It is easy for farmers to follow the general fertilizer recommendations. Ready to use fertilizer mixtures are available in the market, which can be directly used. One can also buy straight fertilizers, mix in required proportions and apply in the field.

However, the general fertilizer recommendations do not take into consideration, the variation in the inherent soil fertility status of individual fields and the current nutrient status of the rubber trees. The discriminatory fertilizer recommendation (DFR) for rubber has been evolved as an improvement over the general fertilizer recommendation (Pushpadas *et al.*,1974).

Fertilizers

Plant nutrients are supplied through straight fertilizers, fertilizer mixtures and complex fertilizers. Common straight fertilizers and their nutrient contents are given in Table 7. The use of straight fertilizers is cheaper than that of fertilizer mixtures and complex fertilizers. Common fertilizer mixtures used for rubber at different growth stages are given in Table 8. The use of fertilizer mixtures is convenient for farmers since there is no need for purchase of different ingredients and subsequent mixing. Complex fertilizers which contain either N and P or N,P and K can also be used in the absence of straight fertilizers. Complex fertilizers and fertilizer mixtures are costlier than straight fertilizers. Some complex fertilizers are listed in Table 9.

Table 7. **Common straight fertilizers and their nutrient contents**

Name of fertilizer	Nutrient content (%)			
	N	P_2O_5	K_2O	MgO
Urea	46			
Indigenous rock phosphate	–	18-20	–	
Muriate of potash	–	–	60	–
Magnesium sulphate	–	–	–	16
Magnesite	–	–	–	40

Table 8. **Fertilizer mixtures**

Grade (NPK/NPK Mg)	Stage of growth of rubber
10-10-4-1.5 & 12-12-6	Seedling nursery and young rubber upto 4 years
15-10-6 & 12-12-12	Young rubber from 5th year
10-10-10	Mature rubber

Table 9. **Complex fertilizers**

NP complex	NPK complex
Ammophos (20-20)	15-15-15
Ammophos (16-20)	17-17-17
Diammonium phosphate (18-46)	19-19-19
	10-26-26

Rock phosphates

Rock phosphates, which contain phosphorus in the water insoluble form, are considered as appropriate fertilizer materials for direct application in the acid soils of rubber plantations in the country. The slow availability of P from rock phosphates is advantageous due to the perennial nature of the crop (Karthikakuttyamma *et al.*, 2000). They are also cheaper than the water soluble materials like super phosphate.

An experiment conducted to study the suitability of different indigenous and imported rock phosphates on the growth of rubber seedlings indicated that all the sources are suitable (RRII, 1996). The results are given in Table 10. On the basis of similar field studies and laboratory evaluations, the

Table 10. **Effect of different P sources on diameter of rubber seedlings**

Treatment	Diameter (mm)
No Phosphorus	11.65
Mussoorie RP	14.29
Gafsaphos*	13.84
Maton RP	14.69
Jordan RP*	13.78
Rajphos	13.48
Megaphos	14.03
SE	0.53
CD	1.56

* Imported

Board has recommended the use of the following indigenous sources of rock phosphates (Punnoose *et al.*, 1995; George *et al.*, 1997 and Syamala *et al.*, 1999) as given in Table 11. All these sources have been found to be equally effective. Imported rock phosphate containing 29-34% P_2O_5 have also been found suitable for direct application in rubber plantations.

Table 11. **Recommended sources of indigenous rock phosphates**

Source	P_2O_5 (%)	Origin
Mussorie rock phosphate	18-20	Uttar Pradesh
Rajphos	18-20	Rajasthan
Maton rock phosphate	18-20	Rajasthan
Megaphos	18-20	Madhya Pradesh

Bowl sludge

Bowl sludge, which is obtained as a waste product from latex centrifuging factories is a rich source of phosphorous. The average nutrient content of bowl sludge is given in Table 12.

Table 12. **Nutrient content of bowl sludge (%)**

Nutrient	Content
N	5.1
P_2O_5	32.7
K_2O	0.8
MgO	14.8

Source: George *et al.*, 1994

The production of latex concentrate in India during 2000-01 is reported as 65,975 tonnes (Indian Rubber Statistics, 2001). Considering an average turn over of 0.6%, the availability of bowl sludge from this is estimated as 396 tonnes for the year 2000-01.

George *et al.*, (1991) reported that the uptake of P_2O_5 from bowl sludge was significantly higher than that from Mussorie rock phosphate when applied to *Pueraria phaseoloides* and budded stumps of rubber. A higher growth rate was also noticed for rubber plants in the above study when supplied with bowl sludge. Bowl sludge has been found to be equally effective as a source of phosphorus as mussorie rock phosphate and super phosphate for growth of rubber (George *et al.*, 1994). Similar results for growth and yield were also reported later (RRII, 2001) as indicated in Table 13. The results of an unreplicated trial conducted for six years indicated that bowl sludge is on par with Mussorie rock phosphate as a source of P with respect to yield as given in Table 14.

Table 13. **Effect of P sources on growth and yield of rubber**

Source	Girth (cm) 1999	Girth increment (cm) 1989-99	Yield (kg/ha)
Super phosphate	58.38	53.68	1626
Mussorie rock phosphate	57.83	52.58	1668
Sludge	58.92	54.57	1759
No P	52.86	49.15	981
SE	1.56	1.21	127.4
CD	4.67	3.62	381.9

Table 14. **Effect of P sources on yield**

Year	Yield (kg/ha) Bowl sludge	Mussorie rock phosphate
1994	1223	1221
1995	1365	1480
1996	1407	1275
1997	1726	1699
1998	1187	1207
1999	1250	1284
Total	6935	6945
Mean	1387	1389

Source: George, E. S. (2002), (Personal communication)

Organic manures

Organic manures like cattle manure and compost are of plant and or animal origin, which contain plant nutrients in small quantities. Their major bulk is organic matter itself, which has a major role in improving the physical, chemical and biological properties of soils. Application of organic manures is advantageous in soils with poor physical properties and in soils where intensive cropping is practised with large quantities of chemical fertilizers regularly being used.

Rubber growing soils are generally rich in organic matter compared to soils under other crops. Under this circumstance, the recommendation for organic manures in rubber is limited to application in planting pits and nurseries. Preliminary results from field trials also did not indicate beneficial effects from organic manure application on the growth of rubber plants (RRII, 2002). The chances of improvement of soil properties through organic manure addition in rubber growing soils are limited. Since latex is an industrial raw material, organically produced rubber does not appear to have much practical significance.

Legume ground cover

Establishment of legume ground cover in rubber plantations during the immature phase contributes to a great extent in the nutrition of rubber. The legume covers fix atmospheric nitrogen and help in economizing fertilizer use (Punnoose *et al.*, 2000). A large quantity of biomass is being added to soil, which in turn will improve the physical, chemical and biological condition of the soil and help in the recycling of plant nutrients in soil. *Pueraria phaseoloides* and *Mucuna bracteata* are popularly grown in rubber plantations. Philip *et al.*, (2002) made detailed study on the dry matter accumulation and nutrient addition by *P. phaseoloids* and *M. bracteata* under different age groups. Substantial quantity of biomass and plant nutrients are added to the soil by the two cover crops in a period of two years (Table 4).

The benefits from growing of legume ground cover are of long term in nature. It has been observed that when legume covers are grown, the fertilizer requirement of rubber during the later period of immaturity and during the early years of tapping are less compared to areas grown without legume cover (Potty *et al.*, 1978; Mathew *et al.*, 1989 and Punnoose *et al.*, 1994).

Discriminatory fertilizer recommendation

Though general fertilizer recommendations can be practised on all occasions, specific and need based fertilizer recommendations for individual fields can be arrived at by assessing the nutrient status of the tree and fertility status of the soil and considering the agromanagement situation of the particular field. This necessitates the analysis of soil and leaf samples from the field and collection of detailed case history.

This method eliminates possibilities of over use and under use of fertilizer and nutrient imbalances of the tree and economizes fertilizer use. It helps in minimizing wind damage of trees by avoiding over growth of the crown, panel coagulation, late dripping and improves the quality of latex by preventing pre-coagulation.

The discriminatory fertilizer recommendation service for large estates is available at RRII, Kottayam, while that for small holdings is also available at the Regional Laboratories situated in different parts of the traditional rubber growing belt. Regional laboratories are available at Nedumangad, Adoor, Pala, Kanjirapally, Muvattupuzha, Thrissur, Kozhikode and Thaliparamba. In addition to the above, mobile laboratories are also operating from RRII, Kottayam, and the laboratories at

Table 15. **Number of recommendations offered during last 10 years**

Year	Number of recommendations offered	
	Estate sector	Smallholding sector
1992-93	665	3882
1993-94	468	4550
1994-95	727	3972
1995-96	930	5838
1996-97	963	6609
1997-98	970	5460
1998-99	706	10289
1999-2000	695	7368
2000-01	665	3682
2001-02	580	4110

Source: Karthikakuttyamma, M. (2002), (Personal communication)

Table 16. **Number of field programmes of mobile units (1996-2002)**

Year	No. of programmes
1996-97	115
1997-98	55
1998-99	70
1999-00	69
2000-01	47
2001-02	58

Source: Karthikakuttyamma, M. (2002), (Personal communication)

Adoor, Muvattupuzha and Kozhikode. In the north-eastern region of India these facilities are also available from the Regional Research Stations located at Agartala and Guwahati. The number of recommendations offered during the last 10-year period is furnished in (Table 15). The four mobile soil testing laboratories in the traditional belt have undertaken field programmes during 1996-2002 as given in (Table 16). Rubber growers in the large and small sectors showed interest in getting this service from the Board. However, during the last two years, viz. 2000-01 and 2001-02 the response was slightly less, probably due to the low market price of rubber.

Soil survey and development of soil series wise fertilizer recommendation

The reconnaissance soil survey of the rubber growing soils of Kerala and Kanyakumari district of Tamil Nadu was undertaken in collaboration with the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP). Research work has been initiated to formulate soil series wise fertilizer recommendations on the basis of the soil survey report and field experiments.

WEED MANAGEMENT

The concept of weed management in rubber plantations is to manage the weeds in such a way that they do not adversely affect the growth of rubber. The eradication of the entire weed flora from the field is not attempted. The weeds are only prevented from competing with rubber plants.

The establishment of legume ground cover in the plantation is widely accepted as a practice and in such cases the inter-rows (interspaces) of rubber are occupied by the cover crop. When the legume cover has spread in the field, it will eliminate the growth of weeds in the interspaces. This is a classical example of cultural method of weed management.

Weeding is important in the plantation, during initial one year in the entire area. During subsequent years weeding can be restricted to plant basins or planting strips (contour terraces) and selective weeding in the interspaces. By the second year, the legume covers might have completely occupied the interspace areas in the plantation and dominated /eliminated the weeds.

For economic reasons, the weeds in the plant basins/planting strips can be pulled out or removed by scraping or through application of herbicides during the initial

Table 17. **Schedule of herbicide use**

Name of chemical	Brand name/s	Dose per effective hectare*	Rounds per year	Target weeds pecies	Spray volume per effective ha*
Paraquat + 2,4-D	Gramoxone Fernoxone	2.25 L 1.25 kg	4 rounds at 6-8 weeks interval	Broad leaved weeds	500-600 L
Glyphosate	Glycel Round up Weed off	2.00 L	2-3 rounds at 3 months interval	Grass weeds and overall weed control	400 L

* Since herbicide is applied only on planting strips, in a young plantation, which occupy only 1/5 of the total area, this dose will be sufficient for 5 ha plantation. For mature plantation, the actual area sprayed should be taken into consideration. The spray volume is made up with water.

two years and in subsequent years, it is enough to restrict their growth by periodic slashing. When legume covers and intercrops are not grown in the plantation, the weeds in the interspaces (between planting lines/terraces) can be controlled by slashing and occasional herbicide application. Since legume ground covers and intercrops (if grown in the interspaces) are sensitive to all available herbicides, their use is restricted to application in the planting strips/contour terraces during the immaturity period. The area of planting strips in a plantation is approximately 1/5 of the total area. Therefore, in one hectare of plantation, herbicide is applied only in 1/5 of a hectare area. Extensive research has been carried out by the RRII in this line and the schedule of herbicide application is given in (Table 17).

An integrated approach combining manual and chemical weed control methods and legume ground cover establishment can be adopted for optimizing the weed management process. Herbicide application in the plant basin and slash weeding the remaining inter-plant area along the contour terrace in an immature plantation was found to be effective in controlling the weeds most economically (Philip *et al.*, 1998). Manual weeding and herbicide application can also be done in rotation for effective weed control and for better environmental safety.

Herbicides are usually sprayed using knap sack sprayers fitted with flood jet nozzles. Alternatively, controlled droplet applicators (sprayers) can also be used for spraying translocated herbicides viz. glyphosate where the volume of spray (using water) can be reduced to 15-40 liters/ha.

During the first one-year period after planting, it is safer not to use herbicides in the plantation, since the young rubber plants may be affected by the spray drift. It is also safer to use spray-shields attached to the tip of the spray lance, to direct the spray to the target area and to minimize spray drift. Herbicide spraying is most effective when done during sunny weather and also when there is no high wind.

In mature plantations weeds appear depending on availability of sunlight on the soil surface. Large vacant patches will be pockets of weed growth. Weeding in mature plantations should not be for beautifying the plantation, but only to facilitate free movement of tappers and others for various operations and for general supervision.

INTERCROPPING

During the initial years of establishment of a rubber plantation, plenty of sunlight is available in the interspaces. The light availability decreases from 97% during the first year to 7%during the seventh year

(Joseph, 1999). Intercropping when properly done, enhances the growth of rubber plants also (Punnoose *et al.*, 2000).

A variety of intercrops can be grown during the initial two to three years. Banana, pineapple, ginger, turmeric, vegetables and tuber crops like amorphophallus, colocasia and dioscorea are popular intercrops in rubber plantations. Intercrops should be selected based on the topography of land, marketability and price of the produce and the domestic requirement. On level lands and gentle slopes (less than 5 per cent) a variety of crops can be grown. But on slopes, soil disturbing crops should be avoided. From the third year onwards the light availability in a plantation decreases considerably and only shade tolerant intercrops will be suitable thereafter.

Banana has been identified as an ideal intercrop for the initial two to three years (Mathew *et al.*, 1978 and Jessy *et al.*, 1998). Pineapple can be grown on gentle to moderate slopes, where the rows are oriented across the slope. Pineapple is moderately shade tolerant and can be retained up to three to four years (RRII, 1998).

When intercropping is done, care should be taken to manure the intercrops separately and adequately and to return all the crop residues to the soil. Bulky organic manures like cattle manure or compost should be liberally applied to the intercrops with a view to maintain the organic matter status of the soil. Soil disturbing operations should be restricted to the minimum possible extent (minimum tillage).

In mature rubber plantations, the light availability is limited and only shade tolerant intercrops can be cultivated. In an interplanting experiment, coffee gave limited success. Pepper showed moderate vegetative growth, but flowering and fruit setting were scanty (Rubber Research Institute of India, 2001). Shade tolerant medicinal plants like *Strobilanthus haenianus* (Karimkurinji), *Adathoda vasica* (Valiyaa Adalodakom) and *Plumbago rosea* (Chuvanna Koduveli) can also be grown in rubber plantations with moderate topography.

IRRIGATION

In the traditional belt, rubber is being grown as a rain fed crop. However, only a few rains are received during the summer months (December to April) when a moderate water stress is experienced by the plants (Punnoose *et al.*, 2000).

Jessy *et al.*,(1994) compared the effect of drip and basin methods of irrigation, given during summer season and reported that the growth rate of rubber during immature phase was improved by both the methods in relation to unirrigated plants in the traditional belt. Jessy *et al.*, (2002) also reported that summer irrigation through the drip method enhanced the growth of rubber plants during the immaturity period. It is, in general, observed that irrigation during summer months in the traditional belt could reduce the immaturity period marginally by 6 to 12 months. However, the availability of water for irrigation during summer is noticed as a problem in many cases.

In non-traditional areas like the North Konkan, where the summer is longer and the total annual rainfall is much less, the benefits from summer irrigation have been found to be substantial. Vijayakumar *et al.*, (1998) reported that the immaturity period of rubber plants could be brought down from 10 years to 6 years by irrigation under North Konkan conditions.

FARM MECHANIZATION

Some farm machinery, which can help in undertaking certain field operations, are now available in the market. The advantages of mechanization are that the labour engagement can be considerably reduced and that the operation can be completed in short time.

Tractor mounted 'hole digger' can be used for taking planting pits for rubber. This facility is now being utilized by some growers particularly in the large estate sector. The equipment can take pits of size 60 cm diameter and a depth upto 90 cm. Since this equipment is mounted on tractor, it can work only on level lands and moderate slopes. In places where the tractor cannot move, pits have to be taken manually.

Weed cutting machines are now available which can do the job of weeding in plantations. They have separate attachments for cutting soft and hard weeds. A single man can operate the equipment. The performance of this machine is under evaluation by the Rubber Board.

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