# INFLUENCE OF COVER CROPS ON GROWTH OF RUBBER AND ON SOIL FERTILITY STATUS


By

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## DISSERTATION

Submitted in partial fulfilment of the requirement for the

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## DECLARATION

I hereby declare that this dissertation entitled **"Influence of Cover Crops on Growth of Rubber and on Soil Fertility Status"** submitted in partial fulfilment of the course 'Post Graduate Diploma in Natural Rubber Production' of Kerala Agricultural University, is a bonafide record of research work done by me and that the dissertation has not previously formed the basis of the award to me any degree, diploma, associateship, fellowship or other similar title of any University or Society.

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# CERTIFICATE

Certified that the dissertation **"Influence of Cover Crops on Growth of Rubber and on Soil Fertility Status"** is a record of research work done by **Smt. Sushama Kumari, K.R.** under our guidance and supervision and that it has not previously formed the basis for the award of any degree or diploma to her.

We, the undersigned members of the Committee of **Smt. Sushama Kumari, K.R.**, a candidate for the Post Graduate Diploma in Natural Rubber production, agree that the dissertation entitled **"Influence of Cover Crops on Growth of Rubber and on Soil Fertility Status"** may be submitted by Smt. Sushama Kumari, K.R., in partial fulfilment of the requirement of the Diploma.

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# Introduction.

# INTRODUCTION

Establishment and maintenance of ground cover in the rubber plantation is an accepted agromanagement practice for rubber cultivation. Leguminous species are used as ground covers and these plants, have the capacity to fix atmospheric nitrogen in their root nodules in association with a group of bacteria belonging to the genus Rhizobium. In India, rubber is cultivated mostly on hilly areas which receive fairly high rainfall. Undulating topography and torrential rains can cause severe soil erosion if the surface of the land is unprotected. Leguminous cover protects the soil from the beating action of rain and effectively control surface runoff thus minimising soil erosion. A well established ground cover will also help in conserving the soil moisture. Moreover leguminous cover helps in the suppression of undesirable weed growth in plantation, there by reducing expenditure on weeding. This is important during the first few years of the development of young rubber plantation. The leguminous cover returns to the soil a large amount of litter. In nature, the plant litter is subjected to biological degradation by numerous soil microorganisms thereby increasing the organic matter content of soil. The humus formed as a result of microbial degradation, serves as a store house of nutrients and slowly releases them into the soil. It also improves soil aggregation and water holding capacity.

Studies conducted at RRII and RRIM have shown that leguminous ground cover helps in better growth of *Hevea* during immature phase, can improve the structure and other physical properties of soil and this practice is being recommended widely. Though the leguminous cover crops like *Pueraria phaseoloides*, *Calopogonium mucunoides* and *Centrosema pubescens* are recommended to be raised in rubber plantations, the most popular one is *P. phaseoloides*. *Mucuna bracteata*, a wild type introduced from Tripura, was identified as a suitable ground cover and this species is also gaining popularity among rubber growers. The advantages of *M. bracteata* over the others are that it is fast growing, drought resistant, shade tolerant and non palatable to cattle. This creeper has deep roots and shows luxuriant growth even during summer months which sometimes leads to the apprehension that it would compete with rubber for soil moisture. *P. phaseoloides*, commonly known as tropical Kudzu has, a shallow root system and is being extensively grown in most of the rubber plantations in India.

Raising of annual food or cash crop along with rubber during the initial years has become a common practice in many small rubber holdings in India since it fetches some return during the immaturity period.

The present study was undertaken to quantify the biomass and nutrient addition to the soil of rubber plantation by two cover crops *Pueraria phaseoloides*, the widely used ground cover and *Mucuna bracteata* the one which has recently become popular. The relative influence of these cover crops on the nutrient status and moisture regime of the soil and growth of rubber plants was compared with intercropped situation and also with that under natural cover.

# Review of Literature

## REVIEW OF LITERATURE

Clean weeding was the earlier practice in rubber plantation as it avoided competition of weeds with rubber for moisture and nutrients. In India rubber is being cultivated mostly on hilly areas where the top soil is eroded by the torrential rains. Later on, it was felt that some plants would be beneficial to the growth of rubber since they smother the weeds and check soil erosion. Thus legume covers were tried in the inter-rows of rubber during replanting and new planting. These legume species were expected to enhance soil fertility by fixing atmospheric nitrogen and adding organic matter to the soil. The available literature on cover crops with special reference to *Pueraria phaseoloides* and *Mucuna bracteata* are presented in this chapter.

### 2.1 Biomass yield

Babu (1983) reported that maximum amount of leaf litter production in *P. phaseoloides* is in the second year and that it showed a gradual decrease as age advanced. Singh (1983) reported that as the thickness of the cover crop was high, leaf litter addition was also maximum because of the death due to self shading effect. Kothandaraman *et al*. (1989) reported that *M. bracteata* developed a greater biomass than

P. phaseoloides. They also observed a higher shoot root ratio for M. bracteata (9.47) than that for P. phaseoloides (8.51).

Varghese et al. (1991) reported that rock phosphate from different geographical regions differed in their effect on dry matter yield and P uptake of Pueraria phaseoloides. Among the Indian source, mussorie rock phosphate was reported to be the most effective one for Pueraria phaseoloides.

**2.2 Effect of legume biomass on physical properties of soil**

Cover crop has a good influence on the physical structure of soil. Dijkman (1951) stated that shallow rooted vegetation has a beneficial influence on the physical condition of the top soil. Jeevaratnam (1961) indicated that cover plants and mulching materials vary in their ability to improve the fertility of soil, depending on the nature and amount of dry matter produced and on the chemical composition of different plants. The topography of rubber growing districts of Sri Lanka and the nature and amount of rainfall make it necessary for the land not to be kept bare of vegetation at any stage. Pueraria phaseoloides was preferable as it grows fast and lays down a good mulch. It is also stated that although the main purpose of establishing cover plants is to control erosion, the influence of cover plants on soil improvement is of considerable importance. Van Amson

(1961) found that the physical properties of a poorly drained low lying coastal sand were considerably improved by mulching with *Pueraria phaseoloides* and applying lime at 900 kg/ha. Experiments conducted at RRIM during 1977 showed that percentage aggregate was 94, bulk density 1.0 and permeability 110 in legume plots and percentage aggregate was 91, bulk density 1.1 and permeability 29 under natural cover. Soong (1980) studied the influence of soil organic matter on percentage aggregation and mean weight diameter of Peninsular Malaysian soil. He reported that the decomposed organic matter had pronounced influence on percentage aggregation (0.25) and mean weight diameter while the undecomposed forms such as particulate matter had little influence. Aggregate analysis carried out after complete oxidation of the organic matter in the twelve soils with $H_2O_2$ showed that almost all the water stable aggregates larger than 0.25 mm were broken down into micro aggregates and or primary soil particles. Krishnakumar (1989) indicated that leguminous cover crops help in the improvement of soil structure and other physical properties and also that it helps in the formation of large size aggregates and facilitating higher rates of infiltration.

## 2.3 Effect of leguminous cover crops on nutrient status of soil

Leguminous plants posses the unique ability of fixing atmospheric nitrogen needed for their growth. The process occurs in the root nodules through symbiosis with soil bacteria of the genus Rhizobium. Nitrogenous fertilizers are required in lesser amount, for establishment of the plants when compatable strains of the Rhizobia are present in the plant rhizosphere. Prilletwitz (1930) found that leguminous cover crop improve the chemical nature of the soil by their unique ability of fixing atmospheric nitrogen. According to Haines (1939) living cover crops act as a temporary storage of nutrient, which were gradually returned to the soil as and when the plants die.

Idnani and Chibber (1953) tabulated the NPK Mg content of leaves of 38 legume plants and found that leaf N ranged from 3 to 5 per cent. Watson et al. (1964) studied the N level of soil with rubber under various cover crops. At 2, 3 and 4 years after clearing jungles and planting with Hevea much higher level of nitrate and lower levels of organic carbon and cations were found in bare soil than that covered by either leguminous creepers, grass or naturally regenerated bushes. Under bare soil conditions nitrate concentration in the soil increased with depth suggesting a marked leaching process. In general, higher levels of $NH_4$, $NO_3$ and total N were found in soils under leguminous creepers than the other two covers. Mainstone (1969) found that the percentage content of all nutrients except calcium was higher due to legume covers. It was also observed that tree rooting was more prolific in plots previously planted with legume.

Wycherley and Chandapillai (1969) found that some natural or non-leguminous cover plants are also beneficial especially those whose litter has a low C:N ratio. The nutrients fixed in the plant body is released on decomposition and is available for other plants. Several experiments were conducted at RRIM to find out the quantity of nutrients released by different covers. Maximum release of N in third year was from legume followed by natural cover. Kothandaraman _et al_. (1980) reported that the total bacteria, fungi and actinomycetes were higher in soils under _M. bracteata_ when compared with those under _P. phaseoloides_. The population of _Beijerinckia_ sp., the non-symbiotic nitrogen fixing bacteria and phosphate solubilising micro-organisms were also found to be higher for _M. bracteata_. The latter might have caused the higher value of available phosphorous. Suresh (1983) reported that the pH, organic carbon and nutrient contents in terms of P, K, Ca and Mg were considerably reduced at lower depth. Kothandaraman _et al_. (1989) reported that the quantity of nutrients added were in the order of N, K, Ca, Mg and P. Jayasingh et al. (1989) reported the high potential of Pueraria phaseoloides to fix atmospheric nitrogen during early growth compared to its counterparts such as Mimosa invisa and Desmodium ovalifolium. With regard to major nutrient contents in the plant Pueraria phaseoloides was in parallel with the other legumes in percentage contents of phosphorous and potassium while percentage nitrogen content was significantly greater in P. phaseoloides compared to D. ovalifolium. Jayasingh (1991) reported that the use of leguminous cover crops is a standard practise in rubber plantations of Sri Lanka in order to improve the biological, chemical and physical properties of the soil. When rubber plants were grown in legume sown plots, the growth of the trees and the dry weight and nitrogen content of the leaves were higher than those of rubber trees grown in plots with natural cover. Decomposition products of the cover crops improved the nitrogen economy of the soils and imparted a beneficial effect on plantation soils.

## 2.4 Effect of leguminous cover crops on soil moisture

Hulpewassen (1939) stated that good rapidly growing cover crop checks erosion and prevent top soil from excessive exposure to solar radiation. Veen (1940) studied the effect of cover crops on moisture content of sandy soil in the dry monsoon of Java. He observed that if the cover crops are not slashed to act as mulch, the moisture content is less under cover crop (at 0-5 cm layer, moisture content under cover crop was 2.17% and under clean weeded soil 3.22%). Based on the results of the study he opined that the humidity under a cover crop was higher than in clean weeded soil making it possible to use fertilizer which breaks down slowly. Hopkinson (1971) studied the effect of *P. phaseoloides* as cover crop on the soil moisture content as compared to clean weeding. The surface soil tend to dry out faster when exposed by clean weeding but moisture in the profile as a whole was much depleted.

Pushpadas *et al.* (1976) reported that during dry period the moisture percentage in the slashed plot of *Mucuna* sp. was maintained at higher levels and also for a longer duration as compared to that in the unslashed plot. Not much variation in the soil moisture level during summer months between the two cover crops viz. *P. phaseoloides* and *M. bracteata* was observed by Kothandaraman *et al.* (1989). Both cover crops registered higher values compared to grass as ground cover. They opined that the thick mulch provided, deep rooted nature and the differences in evapotranspiration might have contributed to slightly higher soil moisture at the top layer for *M. bracteata*.

## 2.5 Effect of cover crops on growth and yield

Kaimal (1952) made some observations on the behaviour of *P. phaseoloides* and found it to be superior in relation with competition from grass. Mainstone (1963) stated that in a cover crop trial in rubber at Malaysia leguminous cover established area showed a higher yield as compared to that of trees with natural cover. Pushparajah and Chellapah (1969) reported that compared with grass cover, leguminous cover showed better growth of immature rubber. But, application of extra N to the trees in grass cover areas can compensate for absence of legumes but the residual effect of legume cover in enhancing soil C and N status and leaf N content was significant. Potty *et al*. (1976) observed that legume cover established plots with appropriate manuring recorded significantly higher yield compared to unmanured control plots. Response to application of phosphorous and potassium was obtained at higher levels. This may be due to the fact that large quantities of N released from dying legume require higher amount of P and K to keep the nutrient ratios at optimum level. Yogaratnam *et al*. (1977) had conducted studies on leguminous covers in Sri Lanka and reported marked increase in tree growth after six months response of 'P' applied to cover alone or to the cover crop and rubber trees. They also reported that when rubber plants were grown in sown legume area (*Pueraria* and *Desmodium*), the dry weight of tree and nitrogen content of the leaves were significantly higher than those of rubber trees grown in plots with natural cover. Mathew *et al.* (1989) stated that while making fertilizer recommendations, due consideration has to be given to the history of ground cover maintenance in the plantation. In area where legume cover is established, the additional yield obtained during the initial years of tapping will be more than the cost of establishment and maintenance of legume cover. In legume maintained area there is scope for saving a lot of fertilizers during the initial years of tapping and hence discriminatory fertilizer application should be necessarily followed. Power and Zachariassen (1993) indicated that when selecting a legume cover crop one should know its relative N fixing, N uptake capabilities as well as growth and water requirements.

# Materials and Methods

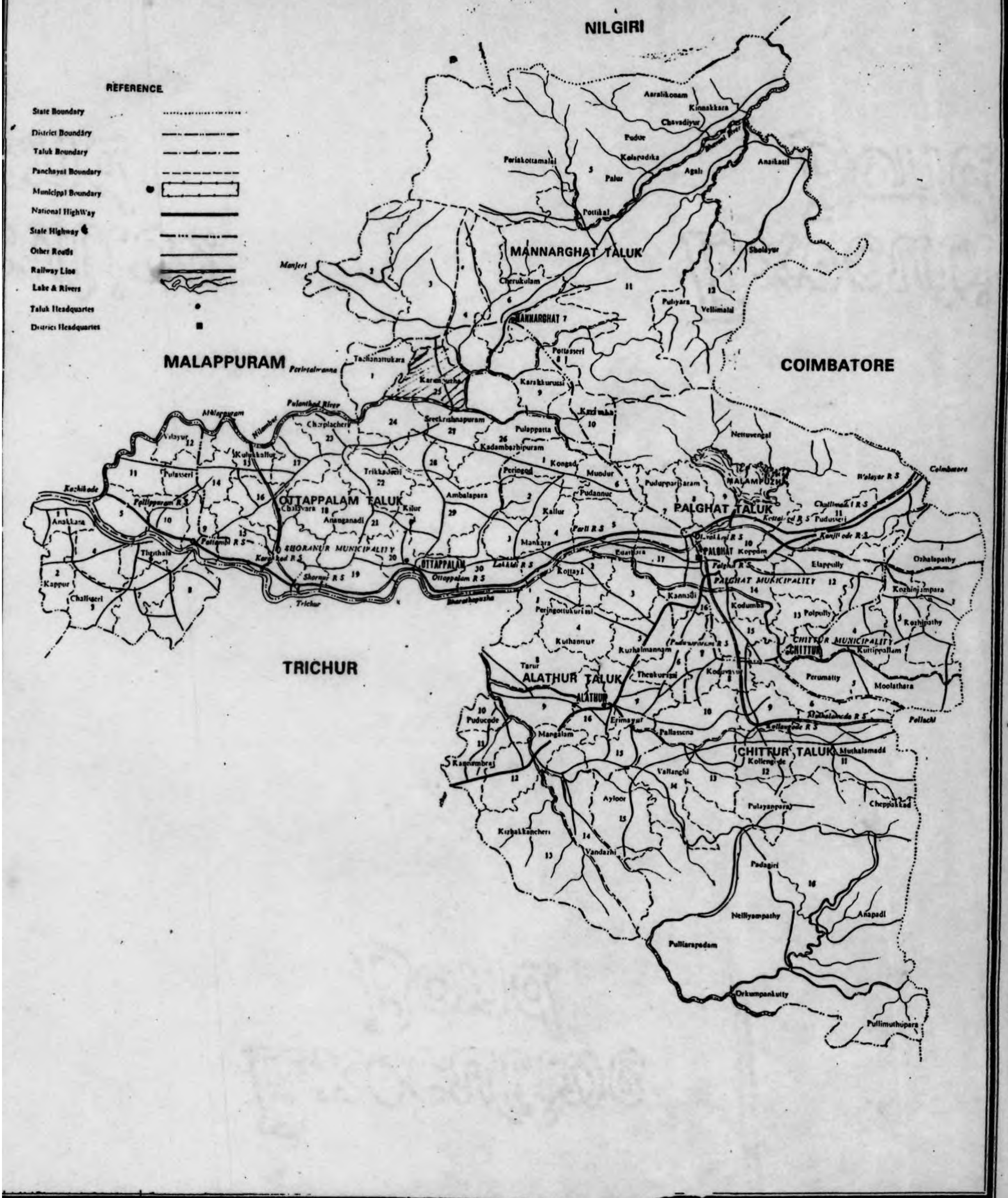
# MATERIALS AND METHODS

Palakkad district of Kerala state was chosen for the present investigations. This district lies between 10° 46'and 10° 59' north latitude and 76° 28; and 76° 39' east latitude. On the eastern side it is bounded by Coimbatore district of Tamil Nadu, on the north and north-west is Malappuram district and on the south Trichur district.

Palakkad district is one of the granaries of Kerala, and its economy is primarily agriculture based. The cultivated area is 2.84 lakh hectares, which represents 64 per cent of the geographical area. Rubber cultivation which was only 6111 ha in 1960-61, now spreads over an area of 22,815 ha.

The details were gathered from the rubber holding of 1990 planting of Pompra Estate owned by Sri. Sunny Mathew, Kayyalakkakam, Mannarcad, Perumpudi P.O. and Sri. Joseph Mathew, Thekkekandathil, Thatchampara P.O. The holding is located in Karimpuzha village of Ottappalam Taluk (Fig.1). The above holding was selected since majority of the growers in this region have planted Pueraria phaseoloides as cover crop and similar plots with Mucuna bracteata was available only in the above holding. The cover cropped area under

# PALGHAT DISTRICT




Central Survey Office Trivandrum 198?

P. phaseoloides and M. bracteata was 1.51 ha (3.75 acres) each. The extent of the plots intercropped with banana and natural cover was 2.40 ha (6 acres) each. All the above fields were planted with RRII 105 and belonged to the same year of planting.

### 3.1 Sampling

The entire area in the selected plantation was surveyed and four blocks were selected to get a uniform representation of the plantation. From each block, four samples of cover crop were collected during December. An area of 0.25 $m^2$ was pegmarked in the centre of four rubber trees and the total biomass was collected carefully by separating the above ground portion first and then uprooting the cover crops. Care was taken to exclude other extraneous matter from the sample.

### 3.2 Determination of biomass yield

Immediately after collection, the shoots and roots were separately transferred to pre-weighed, labelled polythene bags. The fresh weight of each sample was recorded. The samples were then transferred to preweighed brown paper covers and oven dried to constant weight and the dry weight was determined.

### 3.3 Determination of weight of litter

The leaf litter from an area of 0.25 $m^2$ was collected from Pueraria phaseoloides and Mucuna bracteata cover-cropped area during March. The weight was recorded after shade drying. Three samples for each cover crop were taken.

### 3.4 Sampling of soil

Soil samples were collected from the same area from where the biomass of cover crops were collected. Samples were collected separately at two depths 0-15 cm and 15-30 cm. Eight samples representing the two depths were collected for each of the cropping system. Thirty two soil samples were thus collected in total for soil analysis. The samples were air dried and sieved through 2 mm sieve.

### 3.5 Analysis of shoot and soil samples

The quantities of major mineral nutrients added through the shoots of Pueraria phaseoloides and Mucuna bracteata were analysed by following the procedure described in the "Laboratory Manual of Rubber Research Institute of India" (Karthikakutty Amma, 1989). N, P and K were analysed by using Autoanalyser and Ca and Mg by using Atomic Absorption Spectrophotometer.

The soil samples were analysed for organic carbon, available P, K and Mg. Analysis for organic carbon was done following Walkey and Black method and the P by Bray and Kurtz method (Jackson, 1958). Available K was estimated by flame photometric method and available magnesium by Atomic Absorption Spectrophotometry. All the chemical analyses were carried out at the Rubber Research Institute of India, Kottayam.

### 3.6 Soil moisture content

Soil samples were collected during April and May from the area under cover crops, intercrops and natural cover. Three samples representing each cropping system were collected for determining the moisture. The moisture content was determined by gravimetric method.

### 3.7 Growth of rubber

The girth of rubber trees under different systems of cropping and cover crops were recorded.

### 3.8 Statistical analysis

The data collected were statistically analysed using 't' test and Randomised Block Design (Panse and Sukhatme, 1978).

# Results and Discussion

# RESULTS AND DISCUSSION

The outcome of the comparative evaluation of the two cover crops (Pueraria phaseoloides and Mucuna bracteata) with respect to yield of biomass, leaf litter addition, nutrient composition, soil enrichment through added nutrients, moisture regime of the soil and their impact on growth of rubber in Palakkad district is presented in this chapter.

## 4.1 Biomass yield of cover crops

The yield of biomass from the two cover crops was quantified and presented in Table 1. M. bracteata recorded higher biomass yield both on fresh weight basis (29.18 tonnes $ha^{-1}$) and dry weight basis (7.56 tonnes $ha^{-1}$) than P. phaseoloides (12.32 tonnes $ha^{-1}$ and 4.4 tonnes $ha^{-1}$ respectively). Being in conformity with the findings of Kothandaraman et al. (1989) it is to be concluded that M. bracteata develops a higher biomass than P. phaseoloides. In the case of M. bracteata, shoot portion was considerably higher giving a high shoot root ratio (3.39) as against a higher proportion of roots in P. phaseoloides with lower shoot root ratio (1.29). A similar trend in the shoot root ratio was also reported by Kothandaraman et al. (1989). Dry matter accumulation in the roots of P. phaseoloides was also high as

Table 1. Estimated biomass yield of cover crops on per hectare basis

| Cover crop | Shoot | | Root | | Total Bio-mass | | Shoot root ratio | |
|---|---|---|---|---|---|---|---|---|
| | Fresh weight (kg) | Dry weight (kg) | Fresh weight (kg) | Dry weight (kg) | Fresh weight (tonnes) | Dry weight (tonnes) | Fresh | Dry |
| *Pueraria phaseoloides* | 6958.4 | 2104.8 | 5359.2 | 2296.0 | 12.32 | 4.4 | 1.29 | 0.92 |
| *Mucuna bracteata* | 22536.8 | 6112.8 | 6643.2 | 1448.0 | 29.18 | 7.56 | 3.39 | 4.22 |
| Inference using 't' test | S | S | NS | NS | NS | NS | | |

S - Significant NS - Not significant

indicated by a still lower shoot root ratio (0.92) on a dry weight basis as against an increment in the shoot root ratio (4.22) of M. bracteata. The total biomass yield (3.84 tonnes ha$^{-1}$) for P. phaseoloides during the 4th year reported by Singh (1983) is in close agreement with the present findings.

## 4.2 Nutrient status of shoots of cover crops

The content of nutrients such as N, P, K, Ca and Mg in the shoots of P. phaseoloides and M. bracteata were analysed (Table 2). It was observed that N, P and K were much higher in M. bracteata than P. phaseoloides and the difference was much evident in the case of N content. Calcium and magnesium contents were found to be higher in P. phaseoloides. Calcium content in M. bracteata was 0.73 per cent while in P. phaseoloides it was 1.13 per cent. But the dry weight of Mucuna was much higher than that of Pueraria phaseoloides. So the reduction in calcium content may be due to dilution effect.

## 4.3 Nutrient addition by the cover crops

The quantity of major nutrients added to the soil through the above ground parts of the cover crops are presented in Table 3. The data revealed that M. bracteata was much superior to P. phaseoloides with regard to the major nutrients added to the soil. Similar to the content of N,

Table 2. Nutrient status of shoot of the cover crops

| Cover crop | Nutrient Content | | | | |
|---|---|---|---|---|---|
| | N% | P% | K% | Ca% | Mg% |
| Pueraria phaseoloides | 2.39 | 0.10 | 1.37 | 1.13 | 0.25 |
| Mucuna bracteata | 3.02 | 0.12 | 1.52 | 0.73 | 0.24 |

Table 3. Nutrient addition to the soil by the cover crops

| Cover crop | Nutrient addition (kg $ha^{-1}$) | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| Pueraria phaseoloides | 50.30 | 2.10 | 28.83 | 23.78 | 5.26 |
| Mucuna bracteata | 184.60 | 7.33 | 92.91 | 44.80 | 14.85 |

marked difference was observed in the N enrichment through *M. bracteata* (184.60 kg $ha^{-1}$). This can be attributed to the higher quantity of biomass produced and high content of N, P, and K by *M. bracteata* indicated by this study and as observed by Kothandaraman *et al*. (1989). The quantity of nutrients added were in the order of N>K>Ca>Mg>P. The same trend of nutrient addition for *M. bracteata* and *P. phaseoloides* was also observed by Kothandaraman *et al*. (1989).

**4.4 Leaf litter addition from cover crops**

The leaf litter from the cover crops were quantified and presented in Table 4. It was evident from the data that *M. bracteata* produced significantly higher leaf litter (2324.09 kg $ha^{-1}$) compared to *P. phaseoloides* (1205.72 kg $ha^{-1}$). This finding is quite rational in the light of the higher biomass produced by *M. bracteata*. In *M. bracteata* the high biomass yield, the thickness of canopy and the resultant coverage of the crop was high and this might have caused comparatively more death of leaves at the lower portions due to the shading effect as observed by Singh (1983).

**4.5 Nutrient status of the soil**

Soil samples taken at a depth of 0 to 15 cm and 15 to 30 cm from the plots covercropped with *P. phaseoloides*,

Table 4. Leaf litter addition from cover crops

| | Leaf litter (Kg $ha^{-1}$) | |
|---|---|---|
| | *Pueraria phaseoloides* | *Mucuna bracteata* |
| Sample I | 1115.840 | 2691.64 |
| Sample II | 1383.88 | 1604.92 |
| Sample III | 1117.44 | 2675.72 |
| Mean | 1205.72 | 2324.09 |

M. bracteata, intercrop (banana) and natural cover were chemically analysed and the data are tabulated in Table 5. The pH of the soil at 0-15 cm under the four situations ranged from 5.3 (intercrop) to 5.5 (Mucuna). It was observed that the content of organic carbon (2.23), available P (1.17 mg/100 g) and available K (10.0 mg/100 g) in the soil at a depth of 0 to 15 cm was higher in plots planted with M. bracteata than plots planted with P. phaseoloides, intercrop and those with natural cover. The availability of Mg was found to be highest in plots intercropped with banana. Plots cover-cropped with M. bracteata recorded lowest magnesium status of the soil and this can be attributed to a possible higher uptake and utilization due to high biomass production.

The data on the nutrient status of soil at 15 to 30 cm depth revealed that the pH, organic carbon and nutrient contents were considerably reduced at lower depth. This is in agreement with Babu (1983) who observed a similar trend while working out the nutrient enrichment through P. phaseoloides. A comparable trend in the nutrient content as for 0 to 15 cm depth was maintained and the availability of nutrients was found to be highest in the plots cover-cropped with M. bracteata except for magnesium as already reported. The difference in the content of organic carbon, phosphorus and

Table 5. Nutrient status of the soil as influenced by different cropping systems

| Ground cover | 0-15 cm depth | | | | | 15-30 cm depth | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pH | Available Nutrients | | | | pH | Available Nutrients | | | |
| | | Organic Carbon | $P_2O_5$ (mg/ 100 g) | K (mg/ 100 g) | Mg (mg/ 100 g) | | Organic Carbon | $P_2O_5$ (mg/ 100 g) | K (mg/ 100 g) | Mg (mg/ 100 g) |
| *Pueraria phaseoloides* | 5.42 | 2.13 | 0.6 | 6.97 | 4.49 | 5.17 | 1.65 | 0.30 | 3.60 | 3.42 |
| *Mucuna bracteata* | 5.5 | 2.23 | 1.17 | 10.0 | 2.88 | 5.45 | 2.20 | 0.72 | 7.09 | 2.84 |
| Intercrop | 5.3 | 2.14 | 0.5 | 7.62 | 6.5 | 5.2 | 1.71 | 0.10 | 6.60 | 5.50 |
| Natural cover | 5.48 | 1.97 | 0.23 | 7.02 | 3.5 | 5.37 | 1.58 | 0.10 | 5.60 | 2.73 |
| CD at 0.05 | | N.S | N.S | N.S | N.S | | 0.41 | 0.45 | N.S | 0.88 |

magnesium at 15 to 30 cm depth as influenced by different cropping system was found to be significant.

The improvement in the chemical nature of the soil through the addition of nitrogen to the top soil, as reported by Prilletwitz (1930) holds true in this study also and a high carbon content was observed in *M. bracteata* cover-cropped plots. A marked difference between *Pueraria* and intercrop with regard to organic carbon content could not be visualised perhaps due to the higher addition of organic matter in banana intercropped plots. The increase in the P content in covercropped plots can be attributed to the accumulation of organic matter which enhances the activity of microörganisms in the soil resulting in the increased production of organic anions. These anions tend to release phosphoric acid locked up in the highly insoluble Fe and Al phosphates. According to Kothandaraman *et al*. (1989) the counts of bacteria, fungi and actinomycetes were higher in soils under *M. bracteata*. The population of *Beijerinckia* sp. the non-symbiotic nitrogen fixing bacteria and phosphate solubilising microorganism were also found to be higher. The maximum availability of phosphorus under *Mucuna* covercropped plots can be attributed to the above reason.

## 4.6 Soil moisture

The soil moisture level was recorded during April and May and the data are presented in Table 6. The data indicated that there was much variation in the soil moisture level between the two ground cover systems. It is also evident that any sort of cropping whether cover-cropping or inter-cropping helps to conserve the moisture. The area under natural cover recorded the lowest moisture content in both the months (15.18 per cent and 7.27 per cent during April and May respectively). *P. phaseoloides* was found to be most efficient with regard to moisture conservation, since the soil under its cover recorded the highest moisture content in both the months (20.89 per cent and 13.71 per cent). Before taking soil samples during May a few rains were received and the difference in the moisture content in cover-cropped and inter-cropped plots were not much pronounced whereas the soil under natural cover showed substantial reduction in moisture content in May.

In contrast to the present findings, Kothandaraman *et al*. (1989) found that there is not much variation in the soil moisture level between the two cover-crops i.e., *M. bracteata* and *P. phaseoloides*. In the light of the findings of the present study it is to be presumed that *M. bracteata* remains green during summer and draws more moisture due to the thick coverage of canopy resulting in loss of moisture through transpiration.

The observation made by Pushpadas *et al*. (1976) that the moisture percentage in the slashed plots of *Mucuna* was maintained at higher levels and also for longer duration when compared to unslashed plots which emphasise the transpiration loss from the foliage of *Mucuna* and further confirm the present findings.

**4.7 Girth of rubber**

It was found that the girth of the rubber plants planted with cover crop or intercrop is comparatively higher than those rubber plants under natural cover (Table 7 ). Rubber trees with *Mucuna* as cover crop recorded the maximum girth (23 cm) followed by *Pueraria* (22 cm). This is in conformation with the findings of Pushparajah and Chellapah (1969) that compared with grass cover leguminous cover resulted in better growth of immature rubber.

Table 6. Moisture content of soil as influenced by different cropping systems

| Ground cover | April moisture percentage | | May moisture percentage | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| *Pueraria phaseoloides* | 15.98-24.80 | 20.89 | 13.57-15.92 | 13.71 |
| *Mucuna bracteata* | 15.31-18.32 | 16.91 | 11.55-12.94 | 12.11 |
| Intercrop | 15.65-18.46 | 17.25 | 9.83-12.07 | 11.09 |
| Natural cover | 13.11-17.88 | 15.18 | 6.36-8.82 | 7.27 |

Table 7. Girth of rubber as influenced by different cropping systems

| Ground cover | Girth of rubber trees (cm) | |
|---|---|---|
| | Range | Mean |
| *Pueraria phaseoloides* | 20-24 | 22 |
| *Mucuna bracteata* | 20-26 | 23 |
| Intercrop | 17-23 | 20 |
| Natural cover | 16-20 | 18 |

# Summary

# SUMMARY

The study was conducted in Ottapalam taluk (Palakkad district, Kerala State) to make a comparative evaluation of two covercrops (Pueraria phaseoloides and Mucuna bracteata) with respect to yield of biomass, leaf litter addition, nutrient composition, soil enrichment through added nutrient, moisture regime of the soil and its impact on growth of rubber. The salient findings of the study are summarised below.

Mucuna bracteata recorded higher biomass on per hectare basis than Pueraria phaseoloides. The status of nutrients N, P and K were higher in Mucuna bracteata than Pueraria phaseoloides and the difference was much evident in the case of N content. Calcium and magnesium were found to be high in Pueraria phaseoloides. The leaf litter from the cover crop was quantified and found that the Mucuna bracteata produced higher leaf litter (2324.09 kg $ha^{-1}$) compared to Pueraria (1205.72 kg $ha^{-1}$). Content of organic carbon, available P and available K in the soil at two depths (0-15 cm and 15-30 cm) was higher in plots cover-cropped with M. bracteata than other three plots cover-cropped with P. phaseoloides, inter-cropped and those with natural cover. The availability of magnesium was found to be highest in plots

inter-cropped with banana. M. bracteata recorded lowest magnesium status of the soil and this can be attributed to the higher uptake due to high biomass production.

Any sort of cropping whether cover-cropping or inter-cropping helps to improve the nutrient status of soil and conserve the moisture. The area under natural cover recorded the lowest moisture content during both the months. P.phaseoloides was found to be the most efficient with regard to moisture conservation and recorded the highest moisture content during April and May.

Cover-cropping or inter-cropping was found to augment the growth of rubber and maximum girth increment was observed for Mucuna bracteata covercropped plots.

The study also revealed that in general Mucuna bracteata was much superior to Pueraria phaseoloides with regard to biomass production, and addition of major nutrients to the soil. The low moisture content in Mucuna cover-cropped plots demands further investigations to arrive at definite conclusions regarding the competition for soil moisture between rubber and the cover crop.

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* Originals not seen