STUDY ON INTERCROPPING & BEST FARMING PRACTICES IN SMALL HOLDER RUBBER PLANTATIONS

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APOLLO TYRE FOUNDATION

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Final Report

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EXECUTIVE SUMMARY

Intercropping is an economically efficient method of cultivation where a crop is growing among plants of a different kind in the same plot, usually in the space between rows, for high yield by making use of available resources. Economic crisis was the reason behind rubber intercropping and it became common in all rubber growing countries. The rubber-based smallholder farmers were forced to do various ways to attain economic stability. At a mature stage, rubber intercropping becomes somewhat challenging rather than immature stage, due to canopy formation and very few plants will survive.

The project was aimed to study the best practices existing in intercropping and integrated farming systems among rubber crops in Kerala. And also to find out the soil quality of rubber monocrop fields. This data will aid in preparation of suitable intercrops and planting and maintenance protocols.

Available secondary data was explored in detail and made conclusions with regard to the advantages and disadvantages of intercropping; best suitable crops for rubber; and best practices in Kerala. Besides, soil quality was assessed between rubber monocrop field and intercrop field in order to find out impact on soil and *vice versa*.

Since there are many plants that can be used for the intercropping with rubber, one should choose the suitable crop based on some criteria like temperature, humidity, soil pH, soil nutrient, soil water content, economical and ecological value of that crop, its benefits on rubber yield, disadvantages etc. In this aspect banana, cassava, coffee, black pepper, vanilla and cinnamon are more suitable for the intercrop farming system in Kerala. Banana cassava are crops suitable in the immature stage of rubber and coffee, cinnamon and pepper are the crops suitable for entire life cycle of rubber and also vanilla is suitable only during the mature phase of rubber. Current study shows that banana the most suitable intercrop in rubber plantation. It acts as a nurse crop for rubber during the immature stages (initial 2 years), as the stem girth and height of the rubber significantly increased with the population density of plantain. It is also noticed that banana cultivation supports soil and water conservation naturally.

Pineapple intercropping has disadvantages than advantages. It will increase the soil pH (4.3 +/- 0.3), temperature after intercropping and it also reduce the microbial life in the soil. It will also transform the soil texture sandy nature so that water and nutrient holding capacity of the soil will get declined and this leads to nutrient leaching. The heavy application of weedicides, pesticides etc. leads to toxic pollution of soil, water & food.

With regards to the soil quality impacts of the intercropping banana and yam, showed improvements in the level of nitrogen, phosphorous, organic carbon and moderately maintained microbial population. It can be concluded that even though statistically significant variations have not been observed, mean values are improved in intercropping fields than monocropping fields. Intercropping increases the soil organic matter and maintains soil moisture and is also better for soil and water conservation (A single rubber tree extracts 16,500 liters of water /year). Intercropping is essential for monocrop rubber plantations to provide more ecological and economic benefits.

The soil quality of the experimental plot at Vazhoor, Kottayam District on analysis showed that it is suitable for both rubber and pineapple crops with little nutrient modifications. Soil is highly acidic hence controlled liming is necessary. Total Nitrogen and available Potassium and Organic carbon are sufficiently present. Even though Phosphorous requirement is least among the macronutrients for both the crops, available Phosphorous is far below than that of the desirable limits. Hence addition of VAM ((Vesicular Arbuscular Mycorrhiza)) recommended.

INTRODUCTION

Rubber is a perennial plant grown as an important cash crop which generates income as well as having a fundamental influence on the way of life for many rural people in India. Large areas of primary forests have been converted into rubber plantation using a mono-cropping system practiced by smallholder farmers. The last decades brought along a tremendous expansion of rubber plantations at the expense of natural forests and traditional food based agricultural farms as well as respective socio-economic transformations.

One of the measures suggested to reduce environmental and economic risks is rubber intercropping.Intercropping is an economically efficient method of cultivation where a crop is growing among plants of a different kind in the same plot, usually in the space between rows, for high yield by making use of available resources. Integrated farming is an intercropping system of cultivation in which the plants growing in a given piece of land will be mutually benefited. It is interdependent and interrelated. All plants are benefited by utilizing accessible supplies.

Rubber intercropping was started due to the economic crisis. The rubber-based smallholder farmers were forced to do various ways to attain economic stability.
This led to the adaptation of different kinds of cultivation techniques and finally they came up with an intercropping system as a way to increase the farm's productivity and income.

They tried different crops to cultivate with rubber and found some plants with more ecological and economical value with respect to the climatic condition of the given plot or land.Intercropping and integrated farming is now common in all rubber growing countries across the world. Research has been done on already begun practices and only improvements have been suggested.

Often practicing countries include; India (particularly in Kerala, Tripura and Karnataka), Sri Lanka, China, Africa (particularly in sub Saharan Africa), Thailand, Indonesia, Malaysia, Brazil etc. The intercropping in rubber is somewhat challenging. Because rubber will form canopy in its mature stages. So not all plants can thrive in shades. There are many plants suitable for intercropping at the immature stage of rubber. But only a few shade tolerant plants can survive in the mature stage of rubber. Process of finding best shade tolerant crops for a particular land involves experiments and studies.

Intercrops serve a double function in that it gives farmers additional income and increases land and labor productivity as well as cover crops which can reduce soil erosion. Intercropping during the early growing stage of rubber provides one means of

addressing the gaps in income suffered by smallholders after replanting or new planting of rubber. Both food and horticultural/medicinal crops can be intercropped during the immature rubber period and had no negative effect on rubber growth. Integrated farming (apiculture, use of shade tolerant crops such as cocoa, yam, coffee, cardamom and edible mushroom) can be introduced at maturity phase of rubber plantation.

Rubber farming either monocropping or mixed planting (at least during immature stages) faces serious challenges especially due to the practices of heavy use of pesticides, herbicides and chemical fertilizers. Promising models for integrated farming using biopesticides and biofertilizers together with 50% use of chemical fertilizers have been adopted by several farmers in many countries including India, but popular practices remain as chemical farm practices. The present project is an attempt to identify best practices among the intercropping as well as integrated farming in smallholder rubber plantations.

BACKGROUND OF THE PROJECT

Apollo Tyre Foundation (ATF) has keen interest in promoting and maintaining biodiversity and sustainable livelihood among communities. Besides, being a rubber based industry ATF has high priority to address the environmental, social and economic challenges faced by natural rubber production systems. The present project was conducted in this background.

Tropical Institute Ecological Sciences (TIES) is a not for profit environmental research organization and stands for MAN and NATURE through education and practice: a synergy of science, tradition and environment. TIES has rich experience in working as a technical collaborator for CSR activities to do responsible green business. TIES provides technical assistance in Biodiversity assessment, Waste management, Wildlife conservation & Biodiversity enhancement, Fresh water body restoration, Natural resource management, Community capacity building, Sustainable development & green lifestyle.

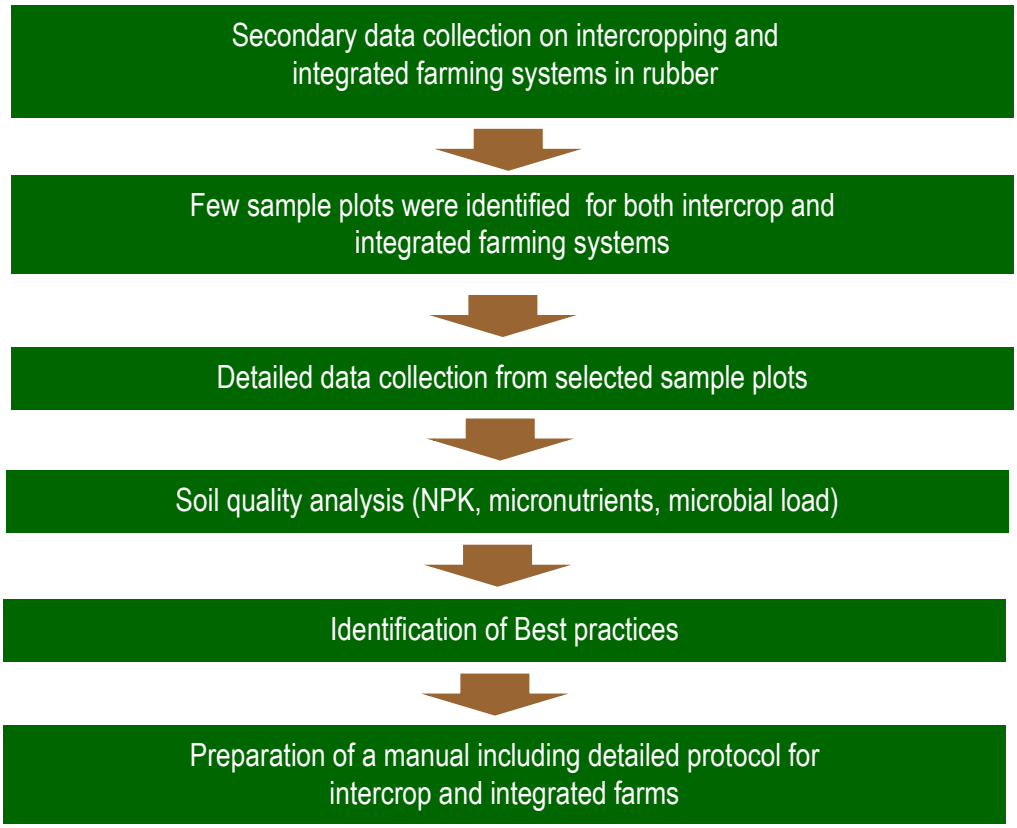
TIES' research team has completed this study within a short span of 3 month time period.

OBJECTIVES

- To study the best practices existing in intercropping and integrated farming systems among rubber crop in, Kerala
- To conduct a sample study on soil quality of monocrop rubber fields and intercropping systems in order to find out soil quality improvement suggestions
- To prepare suitable intercrops and planting and maintenance protocols
- To identify best integrated farming practices among rubber crop

METHODOLOGY

The study was conducted mainly through the secondary data collection from various resources. Based on the data received, a few sample plots were identified and primary data collection, regarding farming practices were collected. Also, soil quality analysis for monocrop farms, intercrop farms and integrated farms was conducted. Summary of the methods done is given as a Flow chart below:



Secondary Data Collection

Data on intercropping and integrated farming systems in rubber were collected from all sources including research reports, studies and interviews. About 80 research papers related to rubber intercropping in different scenarios were studied and comprehensive information was collected. Interviews with farmers and the local practitioners of intercropping supported the data collection and a fundamental study was developed. Discussion with experts in the field gave a scientific insight to the matter.

Identification of Sample Plots

Sample plots suitable for both intercropping and integrated farming were identified. Plots in Vazhoor and Velloor in Kottayam district were identified for detailed data collection.

Detailed data collection and soil quality analysis

Soil samples were collected from 6 spots from each site. Samples collected randomly from crops Pineapple, Cassava, Banana, Yam, Coffee and Turmeric were tested using different parameters. Collected the samples were shade dried, ground and sieved (2mm).

S. No.	Replication	Pineapple	Cassava	Banana	Yam	Coffee	Turmeric
1	R1	Velloor	Velloor	Velloor	Vazhoor	Vazhoor	Vazhoor
2	R2	Velloor	Vazhoor	Vazhoor	Vazhoor	Vazhoor	Vazhoor
3	Control	Velloor	Velloor	Velloor	Vazhoor	Vazhoor	Vazhoor
4	Control	-	Vazhoor	Vazhoor	-	-	-

Table 1. Inter crop status of selected study fields (N = 73)

Parameters Tested

Microbial population count for bacteria, fungi and actinomycetes(serial dilution method), pH (pH meter), Organic carbon (Walkey and Black method), available phosphorus (Bray and Kurtz method), available potassium (Flame photometric method), available nitrogen (Organic carbon nitrogen ratio).

Plate 1. Sample collection of soil from the selected plots

Plate 2 Testing soil quality at TIES Testing laboratory (KSPCB)

Statistical Analysis

The treatment were compared (Mean) by calculating ANOVA one way at 5% level of significance (significant at $P < 0.05$) and the ranking of treatments denoted by letters using the SPSS 20.0 statistical package.

Identification of best practices

Crop suitability for intercropping, intercropping period and results of soil quality analysis were used to identify best practices of intercropping. Advantages and disadvantages of intercropping were another vital factor taken into consideration for this purpose. It has been evaluated in both ecological and economic aspects.

Preparation of protocol for intercrops and integrated farming

In the practice of rubber intercropping, local and global scenarios were analyzed. For that, major crops cultivated as intercrop in India, Srilanka, Philippines, China, Malaysia, Thailand, Indonesia were studied and a possible package of practice in Kerala was formulated. This is truly based on available secondary data and not on any field trials.

RESULT AND DISCUSSION

According to the information gained from the reports and interviews with farmers, the progression of this practice has been evaluated. Even though the cultivation of rubber is practiced by many countries, there are a few countries that often practice farming in an economical aspect.

Rubber intercropping was started due to the economic crisis. The rubber-based smallholder farmers were forced to do various ways to attain economic stability. This has led to the adaptation of different kinds of cultivation techniques and finally they came up with an intercropping system as a way to increase the farm's productivity and income. They tried different crops to cultivate with rubber and found some plants with more ecological and economical value with respect to the climatic condition of the given plot or land.

There are many plant species used for intercropping practice. Among these, there are some popular and successful crops used in different countries based on their convenience. However, studies are still going on to find a better crop which is good in ecological aspects too. In addition to this, experiments are conducted to find out the crops better for integrated farming and having shade tolerance as some plants cannot grow in the mature stage of the rubber due to canopy formation.

Comparative study on soil quality of various types of intercropping farms

As a part of soil analysis, the following parameters were studied: Nitrogen, Phosphorus, Potassium, Organic Carbon content and pH.

Here analyzing the available amount of the above parameters in the case of all intercrops worked with rubber and rubber alone.

Available Nitrogen content (%) in the soil samples

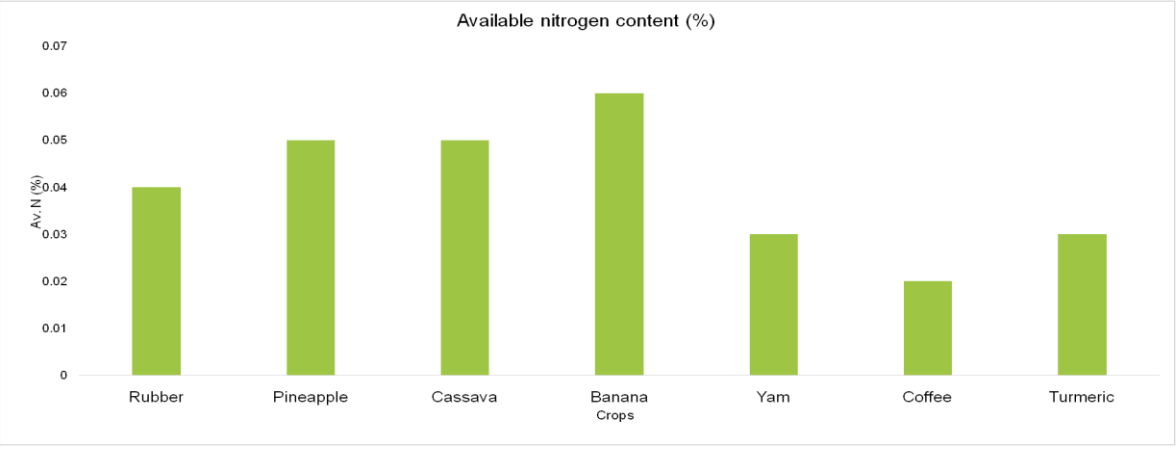


Fig.1. Available Nitrogen in the soil samples tested

The graph shows available Nitrogen content after intercropping with various plants. The percentage of Nitrogen content is more in the Banana field (0.06%) followed by Pineapple and Cassava (0.05%) and less in the Coffee field (0.02%).

Available phosphorus content (ppm) in the soil samples

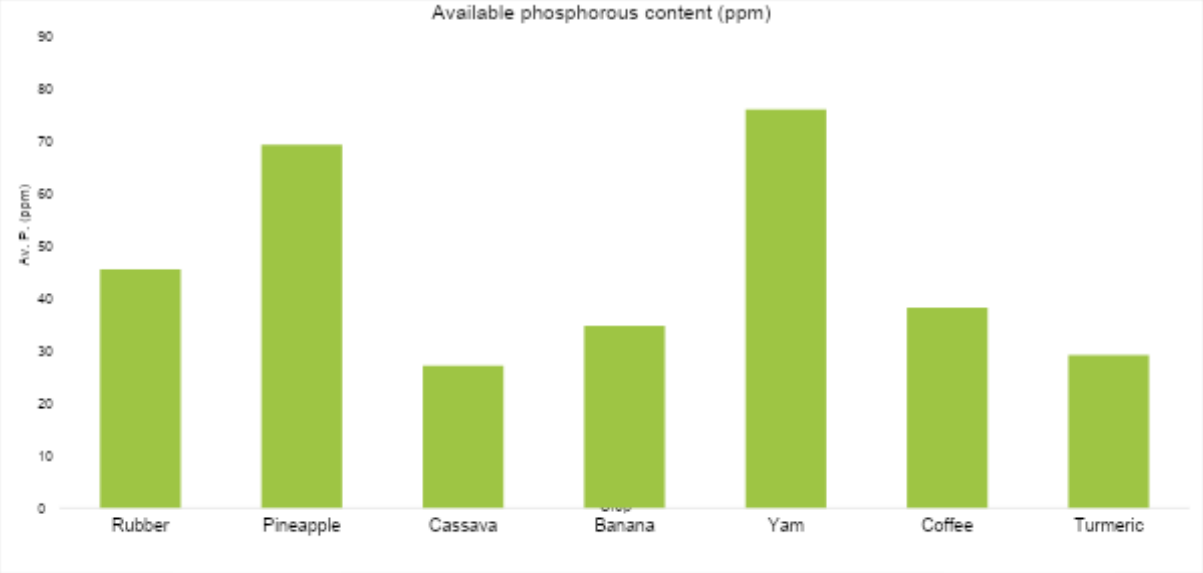


Fig.2. Available Phosphorous in the soil samples tested

The graph represents the available Phosphorus content and here yam is the plant showing the highest amount (75 ppm) followed by pineapple (approx. 70 ppm). At the same time Cassava field has the least amount (25 ppm).

Available Potassium content (ppm) in the soil samples

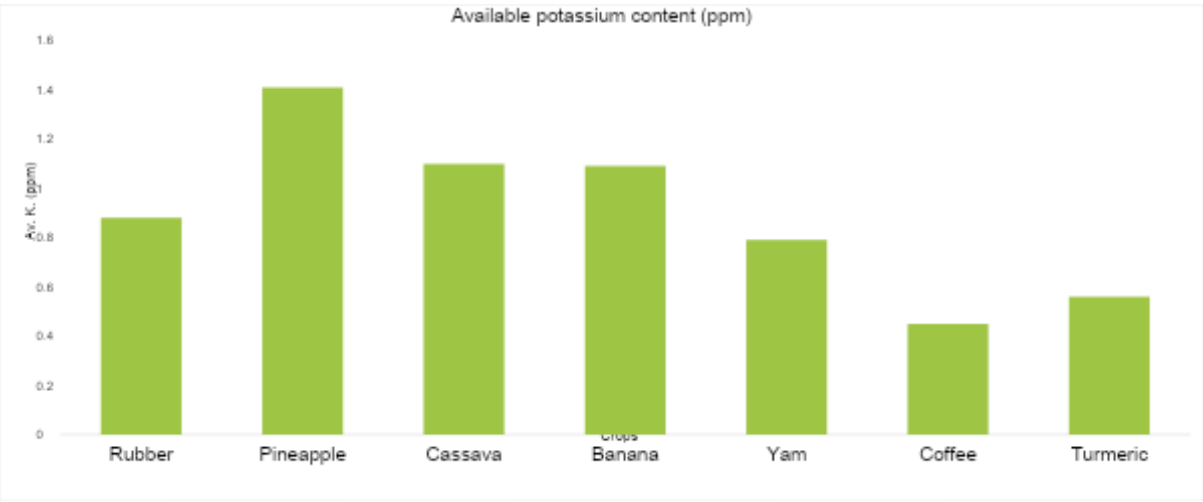


Fig.3. Available Potassium in the soil samples tested

The available Potassium content is comparatively higher in pineapple field (1.4 ppm) and less in Coffee field (0.4 ppm).. Cassava and Banana fields have equal amounts of Potassium content (approx 1.3 ppm).

Available Organic Carbon content (ppm) in the soil samples

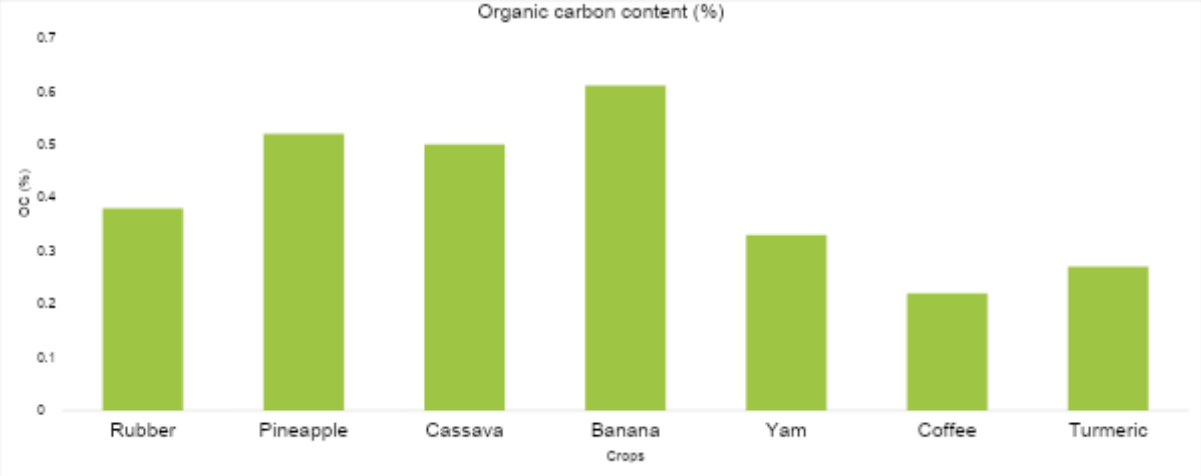


Fig.4. Available organic carbon in the soil samples tested

As in the case of Nitrogen content, organic Carbon content is also higher in the Banana field (0.6 ppm). It is followed by Pineapple field (0.51 ppm) and then (0.5 ppm). Here also Coffee field has the least content quantity (0.2 ppm).

Available Microbial population count in the soil samples

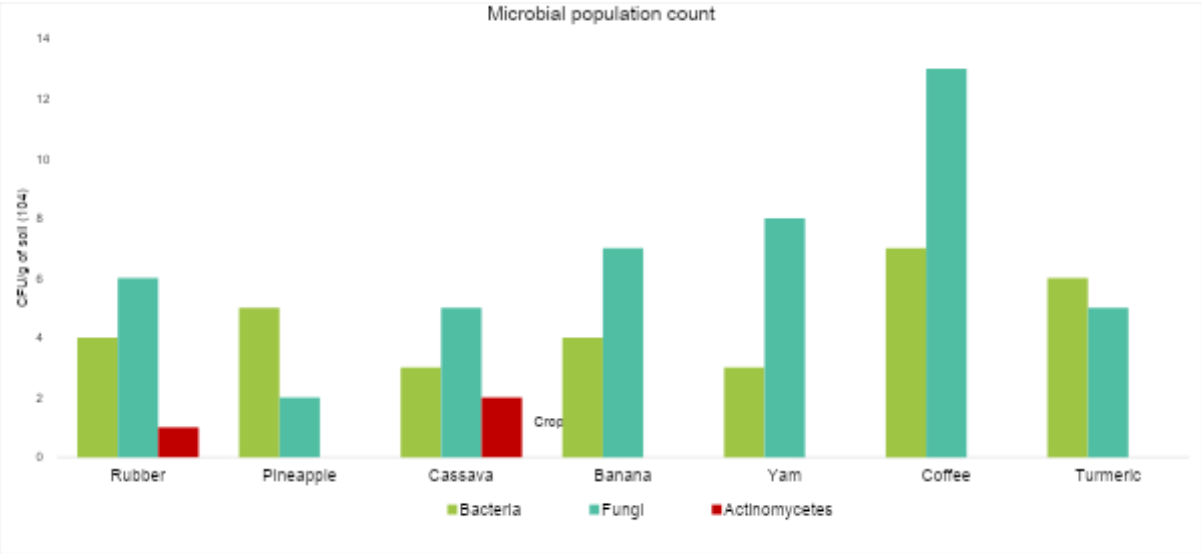


Fig.5. Available organic carbon in the soil samples tested

From the graph it is clear that only sole Rubber field and Cassava field possess 3 kinds of microbes; Bacteria, Fungi and Actinomycetes. Fungi and Bacteria is prominently found in the Coffee field (13 CFU/g and 7 CFU/g respectively) followed by turmeric (Bacteria – 6 CFU/g and Fungi - 5 CFU/g. Other fields also have preferable amount, however, Pineapple field contains only less than 2 CFU/g Fungi and Yam field comprises only 3 CFU/g Bacteria).

Soil nutrient content from pineapple intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
P + R 1	0.05 a	47.45 a	2.28 a	4.36 a	0.51 a	8.0 a	2.0 a	0 b
P + R 2	0.05 a	91.39 a	0.54 b	4.39 a	0.52 a	2.0 b	0.0 b	0 b
P + R Control	0.05 a	51.19 a	2.89 a	4.66 a	0.42 a	2.0 b	3.0 a	1.0 a

Table 2. Soil quality of Pineapple intercrop fields

P – Pineapple; R - Rubber.
Values followed by the same letter were not significantly different at P≤0.05

The table shows the soil nutrient content from pineapple intercropping sites. Sample 1 is represented as P+R 1, Sample 2 is represented as P+R 2 and P+R represents control. Amount of nutrients measured was of varied values. A common trend is not found with pineapple intercropping sites. However, P,K,, pH and OC is reported high in sample 2. All other parameters show varied values.

Soil nutrient content from cassava intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
C + R 1	0.04 a	25.19 a	1.1 a	4.4 b	0.48 a	2.0 a	3.0 b	2.0 a
C + R 2	0.05 a	29.26 a	1.1 a	5.1 a	0.52 a	3.0 a	7.0 a	0.0 b
C + R Control	0.04 a	23.64 a	0.32 b	4.4 b	0.48 a	1.0 a	2.0 b	2.0 a

Table 3. Soil quality of Cassava intercrop fields

C – Cassava; R - Rubber.
Values followed by the same letter were not significantly different at P≤0.05

From the table, Sample 2 clearly shows a higher nutrient contents than sample 1 and control. Only the content of actinomycetes is zero and thus represents the least when compared to sample 1 and control.

Soil nutrient content from banana intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
B + R 1	0.04 a	49.5 a	0.78 a	4.4 b	0.48 a	5.0 a	9.0 a	0.0 a
B + R 2	0.07 a	20.2 b	1.4 a	5.2 a	0.74 a	2.0 a	5.0 a	0.0 a
B + R Control	0.05 a	34.3 ab	1.1 a	5.2 a	0.55 a	4.0 a	5.0 a	0.0 a

Table 4. Soil quality of Banana intercrop fields

B – Banana; R - Rubber.

Values followed by the same letter were not significantly different at P≤0.05

In the banana intercropping, sample 1 shows highest amount of P and Fungi where sample 2 shows highest amount of Nitrogen and Organic Carbon.

Soil nutrient content from yam intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
Y + R 1	0.02 b	87.98 a	0.94 a	5.4 ab	0.25 b	3.8 a	8.5 a	0.0 a
Y + R 2	0.04 a	64.35 a	0.64 a	6.1 a	0.4 a	1.5 a	6.5 a	0.0 a
Y + R Control	0.02 b	57.75 a	0.38 a	4.9 b	0.24 b	4.8 a	10.5 a	0.17 a

Table 5. Soil quality of Yam intercrop fields

Y – Yam; R - Rubber.

Values followed by the same letter were not significantly different at P≤0.05

Here also the samples show varied values. Sample 1 has more Phosphorus and Potassium values. Overall, nitrogen content is low in all sites with Yam intercropping.

Soil nutrient content from coffee intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
Co + R 1	0.03 a	35.64 a	0.47 a	5.0 b	0.3 a	8.5 a	8.0 ab	0.0 a
Co + R 2	0.01 a	41.02 a	0.43 a	6.0 a	0.14 a	4.5 a	18.5 a	0.0 a
Co + R Control	0.03 a	57.69 a	0.38 a	5.5 ab	0.32 a	4.0 a	7.0 b	0.0 a

Table 6. Soil quality of Coffee intercrop fields

Co – Coffee; R - Rubber.

Values followed by the same letter were not significantly different at P≤0.05

In coffee intercropping sites, nitrogen and phosphorous content is comparatively low and the highest value of Nitrogen is shown by sample 1 and control (0.03 a).

Soil nutrient content from turmeric intercropping sites

Treatments	N	P	K	pH	OC	Bacteria	Fungi	Actino-mycetes
T + R 1	0.04 a	39.21 a	0.56 a	5.0 b	0.42 a	7.5 a	11.0 a	0.0 a
T + R 2	0.01 a	19.23 a	0.56 a	6.6 a	0.11 b	5.0 a	9.5 a	0.0 a
T + R Control	0.02 ab	49.36 a	0.22 b	5.5 b	0.27 ab	6.5 a	8.2 a	0.0 a

Table 7. Soil quality of Turmeric intercrop fields

T – Turmeric; R - Rubber

Values followed by the same letter were not significantly different at P≤0.05

Phosphorus level is lower in turmeric intercropping sites and all other parameters have varied values.Potassium level is equal in sample 1 and 2.

The graphs portrayed represent the amount of nutrient contents in the fields where co-growth of different plants with rubber was done. In most cases, the Pineapple field has a comparatively higher amount of nutrients in the soil. The Banana and Cassava fields, except in the case of Phosphorus, have a relatively high amount of soil nutrients availability. At the same time, Coffee and Turmeric fields have a little amount of nutrients. Except in the case of Phosphorus, the Yam field also has a small quantity of nutrient availability.

Soil quality of experimental plot of Vazhoor

Sl. No.	Parameter	Sample value*	Desirable Nutrient Range for Rubber	Desirable Nutrient Range for Pineapple
1	pH	4.42 ± 0.18	6.5-8.0	4.5-5.6
2	Total Nitrogen (N) (%)	0.74 ± 0.05	0.5 – 1.0%	-
3	Av. Phosphorous (P) (mg/kg)	3.6 ± 0.04	10-25 mg/kg	20-25 mg/kg
4	Av. Potassium (K) (mg/kg)	88 ± 2.1	50-125 mg/kg	80-100 mg/kg
5	Organic carbon (OC) (%)	7.4 ± 0.5	0.75 – 1.5 %	-

Table 8. Soil quality of Vazhoor

*Values are mean ± standard deviation

- As per the result given in, Table No. 8 the soil is found highly acidic during the testing period. Highly acidic soil is not much good for both rubber crop as well as pineapple. Hence remedial measures should be implemented such as, adding lime to the soil, which will compensate Calcium and Magnesium deficiencies also.
- Total Nitrogen and available Potassium are within the required range for Rubber as well as Pineapple. However, available Phosphorous is extremely low than the desirable range for both the crops. Even though uptake of macro-nutrients is in decreasing order as given, K>N>Ca>Mg>S>P, the level of available Phosphorous is far below than that of the desirable range. Remedial measures such as, addition of VAM (Vesicular Arbuscular Mycorrhiza) is recommended.
- The land was planted with Rubber crops till recent time, but the soil is enriched with remains of the cover crop, hence high level Organic carbon recorded. This provides an optimum condition for better growth attributes for any crop under an organically managed nutrient paradigm.

Identification of Best Practices

Advantages and disadvantages of intercropping practices were analyzed and based on the inferences, the challenges and benefits were taken into consideration while identifying the best suitable crops.

Intercropping is a profitable and beneficial farming strategy to the farmers, national economy and the environment.

The benefits comprise both ecological and economic aspects.

Ecological Aspects:

Intercropping is found to be a Sustainable farming practice – the more diversity the more stability. It follows Optimum utilization of resources and improved land-use efficiency. It Increases soil organic matter and maintains soil moisture.
Increase in vegetative cover and biodiversity is also observed.
Reduced use of fertilizers and pesticides in intercropping contributes to climate change mitigation strategy.It is better for soil and water conservation (A single rubber tree extracts 16500 liters of water /year).

Economic Aspects:

Obtaining higher crop yield than sole crop yield is the primary economic benefit. Intercrop yield provides supportive livelihood. Net less expenditure and more productivity is another vital aspect. Additional income and no expenditure for rubber crop till 4-5 years (as in the case of Pineapple- lease based farming) is highly beneficial.

Disadvantages of Intercropping?

Irrigation and fertilization differ for the different crops in the field. It requires more attention and expert management. Careful cultivar selection and planning is needed.Planning the interspacing is important.Selection of the crop for a location is truly a scientific process.

By analyzing the advantages and disadvantages, and the soil nutrient experiments, three of the crops were identified as appropriate for intercropping with better yield and lesser environmental hazards. *ie,* Banana, Pineapple and Coffee are the selected suitable intercrops.

Package of Practice

1. Banana

- Banana can be planted in two ways; BBR OR BBBR.
  i.e., two or three rows of banana in between two rows of rubber.
- Within a row the spacing varies from 2.4 m to 3.6 m depending on the variety of banana.
- Planting holes- 60x60x60cm. Filled with organic manure and soil.
- Clumps should be maintained with three plants at a time.
- Season Rain fed crop: April-May Irrigated crop: August-September Adjust planting season depending upon local conditions.
- Manuring: Apply compost, cattle manure or green leaves @ 10 kg/plant at the time of planting. Apply N:P2 O5:K2 O at the following dose (g/plant/year). Nendran (irrigated): 190:115:300 Other varieties depending upon soil fertility level)
- Irrigation 1. During summer months, irrigate once every three days. 2. Ensure good drainage and prevent water logging. 3. About 6-10 irrigations per crop may be given depending upon soil conditions.

2. Coffee

- Coffee is an economically important crop plant that thrives well in soils of pH 6.5. Two major varieties are used;
  Coffea arabica: Well suited to cooler climates. This species fetches a premium price due to itssuperior quality.
  Coffea canephora: Thrives well at low altitudes with warm and humid conditions. Extensivelyused in instant coffee.
- One to two rows of coffee can be planted in between the rubber rows and spaced 2.5m between and within rows, with a single stem pruning.
- The initial shade required by the coffee during the immature phase of rubber could be provided economically by combining this system with a rubber/banana intercrop.

Crops suitable for different growth stages of rubber			
Only during the immature phase of rubber	***Intercropping throughout the life cycle of rubber***		***Only during the mature phase of rubber***
- Banana - Pineapple - Passion fruit - Sugarcane (only for dry areas) - Annual/seasonal crops	***With no change in planting density of rubber***	***With reduced planting density of rubber***	- Cardamom - Vanila - Rattan - Anthurium
	- Coffee - Cocoa	- Tea - Cinnamon - Pepper	

Adapted from : rubber Based Farming Systems. Advisory No. 2013/10. Rubbber Research Institute of Srilanka.

CONCLUSION

Intercropping is essential for monocrop rubber plantations to provide more ecological and economic benefits. Since there are many plants that can be used for the intercropping with rubber, one should choose the suitable crop based on some criteria like temperature, humidity, soil pH, soil nutrient, soil water content, economic and ecological value of that crop, its benefits on rubber yield, disadvantages etc. In this aspect banana, cassava, coffee, black pepper, vanilla and cinnamon are more suitable for the intercrop farming system in Kerala. Intercropping increases the soil organic matter and maintains soil moisture and is also better for soil and water conservation (A single rubber tree extracts 16500 litres of water /year).

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