Nature safe fertilizers **for rubber plantations**

Rubber Research Institute of Sri Lanka

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Preface

At a time when the country is searching for a sustainable alternative to chemical fertilizer as per the government policy document, “Vistas of Prosperity and Splendor”, this booklet aims to provide a technical guide to rubber growers with many valuable information in doing so. Chemical fertilizer has raised productivity but its consequent negative repercussions challenging the overall sustainability. Practice of applying only chemical fertilizers resulted in soil degradation which has brought a vicious cycle of applying more and more agrochemicals to sustain the yields. Organic fertilizers and some other environmental friendly technologies developed recently to provide the nutrient requirement of plants have a potential to reduce the use of chemical fertilizers. The booklet highlights the important parameters and uses of different types of organic fertilizers such as crop residues, green manures, animal manures, compound organic fertilizers, liquid organic fertilizers and biofertilizer together with the uses of soil amendments and new fertilizer application techniques. Further, it includes details of organic fertilizer preparation techniques at farm level, their recommended dozes and application procedures for rubber. Based on the scientific evidence, the booklet introduces four environmentally sound nutrient supplying packages enabling rubber growers to select the most appropriate package for them. May rubber growers build up a healthy soil for the next generation!

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Nature Safe fertilizers for Rubber Plantations

There has been a long history of the use of nature-safe manure such as crop residues, plant materials, animal wastes, and some byproducts of agro-industries in improving and maintaining soil fertility. After the green revolution in the 1960s, chemical/inorganic fertilizers continued to play a prominent role in providing nutrients for crops which brought a manifold increase in agricultural production. However, continuous use of chemical fertilizers alone, negatively affected soil fertility, particularly when applied without a sense of environmental balance. On the above ground, the time has come to step into integrated farming systematically given sustainable soil fertility management in rubber growing soils.

The guidelines and the recommendations given in this booklet are mainly based on long-term systematic research conducted at the Soils and Plant Nutrition Department, Rubber Research Institute of Sri Lanka (RRISL). This booklet introduces an integrated approach to assuring ecosystem sustainability whilst avoiding negative effects on crop growth and yield.

Application of nature-safe fertilizers to rubber along with the Integrated Plant Nutrient Management System (IPNMS) is proposed herewith and in doing so, this manual intends to guide the growers through the knowledge of options available, how the available materials are to be used, and how new techniques can be applied to reap the optimum benefits.

Benefits of applying organic fertilizer at a glance

- Provides all the essential nutrients but in minute quantities in a slow manner
- Improves nutrient holding capacity of the soil with enhanced fertilizer use efficiency
- Improves aeration & water holding capacity of the soil
- Enhances phosphorus and potassium availability by increasing biological activity in the soil
- Acts as a mulch minimizing weed growth in the manuring circle
- Provides food for soil biota and increases their activities such as nitrogen fixation, secretion of plant growth promoting hormones, and different enzymes accelerating the decomposition and solubilization processes.
- Improves symbiotic relationships with beneficial organisms such as mycorrhizae increasing the adsorption of plant nutrients

Ultimately organic fertilizer improves the soil quality ensuring better plant growth and yield

Types of available organic fertilizer

A. Crop residues

These are the remnants of crops left after harvesting or processing of agricultural products. Applying organic materials to the soil, the C: N ratio should be considered. Materials decompose faster, they have a low C: N ratio. If it decomposes slowly, it has a high C: N ratio. Materials with a high C: N ratio may create short-term N deficiency, and this condition could be overcome by mixing with high N materials; legumes, and animal manure.

Type of organic manure	Nutrient availability	Remarks
Paddy straw Vegetative part left after harvesting	N:0.6%-0.7%, P:0.07%-0.1%, K:1.4%-1.9%, Mg:0.2%-0.3%, C:30%-40%, Si:4%-6.5%	• Good source of potassium (K)
Coir dust A major by-product in the coconut fiber industry	Poor in nutritional value	• Low fertile soil combined with coir dust, poultry manure and refused tea shows similar growth of rubber plants in nurseries with topsoil[2]
Paddy husk A by-product of rice milling	Contains silicon (Si), a beneficial element	• Burned paddy husk can be used as partial fulfillment of chemical fertilizer to achieve the required growth of rubber plants in nurseries[3]

Fig. 1. Field application of paddy straw

The application procedure is given in section D2

Utilize crop wastes for improvement of crops

B. Green manure

Green manuring is a practice of incorporation of fresh plant material into the soil, legumes are effective green manures and produce large quantities of biomass within a short period of time. It contains high N, helps to suppress weed growth

Type of Green manure	Planting material requirement	Nutrient availability	Biomass production/ Remarks
Crotolaria	5 kg seeds/ha	Lopping contains N:2.3%, P: 0.5%, K:1.5%	• Can be grown in inter-row areas of rubber • Green biomass production is about 8-12 Mt/ha
Tephrosia	5 kg seeds/ha	Lopping contains N:2.5%, P: 0.5%, K: 0.52%, Mg:0.31%	• Can be grown in inter-row areas of rubber • Green biomass production is about 3-4 Mt/ha
Gliricidia	Minimum 500 sticks as a single row within two rubber rows/ha (8’x26’)	Foliage contains N:4% K:2%	• Can be grown in inter-row areas with correct spacing as single or double rows and along the fence
Guatemala (Not a legume)	39,000 stem cuttings/ha	Foliage contains N:0.73%, P:0.07%, K:1.69%, Mg: 0.22%	• Above-ground plant parts can be used as a mulch • Green biomass production is about 85-110 Mt/ha • Only to be grown outside the rubber land as it may interfere with the existing crop

Type of Green manure	Planting material requirement	Nutrient availability	Biomass production/ Remarks
Mucuna	Rooted cuttings of *Mucuna* planted in polybags, at the stage of 5/6 leaves should be established in the field	Foliage contains N:4.29%, P:0.35%, K:0.83%, Mg:0.17%	• Should be established immediately after land clearing • Leguminous creepers are the most useful ground covers • They preserve soil fertility and prevent soil erosion • Soaking seeds in hot water or sulphuric acid is necessary to induce germination • Dressing of 200 kg of Eppawala Rock Phosphate (ERP)/ha at the beginning and 100 kg of ERP/ha during the first year is recommended for better establishment & growth of cover crop[4] • Green matter and litter production of *Mucuna* is 3 times higher than *Pueraria*
Pueraria	6 kg seeds/ha	Foliage contains N:1.87%, P:0.36%, K:0.62%, Mg:0.31%	
Desmodium	4 kg seeds/ha	Foliage contains N:1.5%, P:0.31%, K:0.52%y, Mg:0.25%	

The nutrient requirements of the rubber plant cannot be totally overcome by the recommended quantity of fertilizer application. Hence, the establishment of the cover crop is very important under rubber[5,6,7]. Field establishment of bush legumes in inter-row areas and field application of lopping as green manure are shown in Figures 2 (a & b)

(a) **(b)**

Fig. 2 a. Field establishment of bush legumes and **b.** Field application of loppings as green manure

Growing legumes is the cheapest way to add nitrogen to the soil

C. Animal manure

Animal manure is often a mixture of dung and urine along with bedding materials. Goat manure, Cattle manure, Poultry manure, Swine manure and Farmyard manure are some of them
Nutrients in animal dung are in readily available form for plants

Type of animal manure	Nutrient availability	Remarks
Cow dung	N:1.2-1.9%, P: 0.2-0.5%, K:0.5-1.1%, Mg:0.5-0.6%	• Enhanced plant growth was observed in nursery & immature rubber plants[8,9]
Poultry litter	**Broiler litter** N:2.0-2.3%, P:0.6-1.0%, K:1.7-2.0%, Mg:0.5-0.6% **Layer litter** N:1.8-2.4%, P:0.6-1.2%, K:1.6-2.0%, Mg:0.4 - 0.7%	
Farmyard manure A mixture of dung and urine of the farm animals along with litter and left over materials of fodder	N:1.2-1.8%, P:0.4-0.6%, K:1.1-1.9%, Mg:0.5-1.0%	

Animal waste is also a good nutrient supplement for the plants

D. Compound Organic Fertilizers

Composting is an environmentally friendly process
It converts fresh wastes into valuable black hummus-like substances
Its nutrient contents depend on the type of raw materials utilized

Type	**Nutrient availability**	**Remarks**
Compost	Contains N:1%, P:0.22%, K:0.84%	• Nutrient contents vary with the raw material used Preparation • Use of both high nitrogen and high carbon sources in a correct ratio is important for the preparation of quality compost in the desired time period • Optimum level of moisture in the materials is 50-60% and the moisture levels below or above the optimum level slow down the composting process • Compost & some other organic fertilizers have been evaluated and with the ability to proven to enhance plant growth parameters in immature rubber plants[9]
Vermicompost		• Organic manure produced by earthworms • Consists physically and chemically broken organic matter, live earthworms, their cocoons and other organisms • Rich in macro and micronutrients, enzymes, antibiotics, growth hormones and immobilized microflora • Cost-effective and efficient way of recycling organic wastes • Enhanced growth was observed by adding these to the nursery plants of rubber[10]. There is a possibility of using kitchen garbage as a suitable media to multiply the earthworm, *Eudrilus spp*. and they can be used for the preparation of compost at the home garden level without any expense[10]

In addition to the solid form of composts, liquid fertilizers can also be prepared in a similar process. Quality parameters of solid compost and liquid organic fertilizers decided by the Sri Lanka Standard Institute are given in Table 1a and 1b, respectively. Also, nutrient values of some materials that could be used for compost preparation are given in Table 2.

Compound organic fertilizers are more efficient in releasing nutrients

Table 1a. *Specification for compost, Sri Lanka Standard 1635:2019*

Parameter	Value/Range
Moisture	< 25%
Sand	< 20%
pH	6.5 - 8.5
Organic Carbon	20%
N	1%
P_2O_5	0.5%
K_2O	1%
MgO	0.5%
CaO	0.7%
C to N ratio	10 – 25

Table 1b. *Specification for liquid Organic Fertilizers, Sri Lanka Standard 1702:2021*

Parameter	Value/Range
pH	6.0-8.5
EC (ds/m)	20
N	1%
K_2O	0.5%
P_2O_5	0.5%
N+ K_2O+ P_2O_5	2%
Organic carbon	5%

Table 2. *Average nutrient contents of other commonly available organic materials used in compound organic fertilizer preparation*

Manure	Nutrient contents (%)		
	N	P_2O_5	K_2O
Sewage sludge$^+$	2.0-3.5	1.0-5.0	0.2-0.5
Wild sunflower$^+$	3.0-3.5	0.2-0.4	2.5-3.0
Refused tea$^+$	3.0-3.4	0.2-0.3	1.2-1.4
Banana trash$^+$	0.61	0.21	1.0
Groundnut husk*	1.6-1.8	0.3-0.5	1.1-1.7

* Fresh, $^+$ Dry

The quality of the raw materials used will greatly affect the preparing compound organic fertilizer

D1: Preparation of Compound Organic Fertilizer

Compost

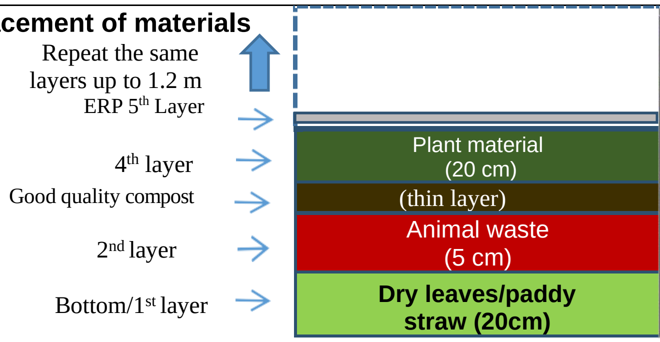
Materials needed: Preparation of 10 Mt of compost needs 20 Mt of raw materials; 2 Mt of partially burned paddy husk + 8 Mt of sawdust + 3 Mt of green leaves + 2 Mt of paddy straw or refuse tea + 3 Mt of cow dung +2 Mt of other animal manure +1Mt of ERP and 20 kg of good quality compost as inoculum

Factors affecting the quality; Particle size and moisture content of the materials used are to be around 5 cm & 50-60%, respectively. A mixture of materials containing high N as well as high C is required to maintain an acceptable C:N ratio of the final product

I. Heap method

Heap is about 2 m wide, 1.2 m high, and 3-5 m in length

Placement of materials



- Dry leaves or paddy straw is placed at the bottom as the 1st layer
- Any animal waste is placed over the 1st layer as the 2nd layer
- Good quality compost is then spread to enhance the composting process as a very thin 3rd layer
- Plant material is spread over the composting layer as the 4th layer
- ERP is then spread to increase the phosphorus content of the final product as a very thin 5th layer
- After the 5th layer, the same combination is repeated up to a height of 1.2 m
- Covering the pile with black polythene or poly sack bags throughout the process is necessary
- Holes are allowed for easy entry and circulation of air

Pile turning/mixing

- First turning is done at the end of one month; the pile is spread into a side, mix well and make a pile again
- Second turning is done at the end of the second month same as the first turning
- Third and the final turning is done at the end of the third month same as the first turning
- Prepared compost is air dried and sieved through a 4 mm sieve and is ready for field application

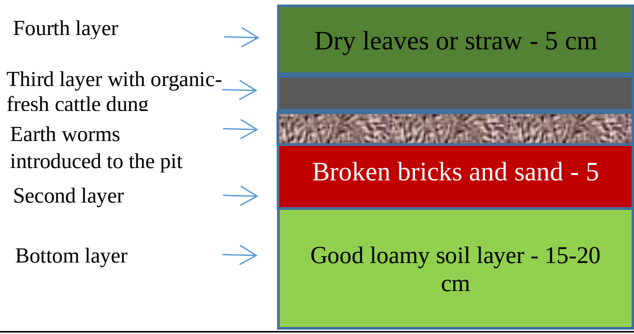
There are two other compost preparation methods; "*Kotu kramaya*" and "Pit method" where organic wastes are placed in a cage prepared with sticks or a hole prepared on the ground, respectively. These methods produce low quality compost and also take more time due to the variation in the quality of materials used and also difficulty to mix the materials.

Vermicompost

Materials needed: Crop residues, Grass cuttings or clippings, Kitchen garbage

Factors affecting the quality: Temperature, pH, Proper C:N ratio of feed, Moisture content

Placement of materials



- Moisture content of 55 to 65% is maintained throughout the period (wetness can be checked when a dry stick is inserted)
- After four weeks a thin layer (5 cm) of moist/green organic waste should be placed on top of the fourth layer
- Application of green organic waste can be repeated every 3-4 days till the compost pit is nearly the height of 50 cm
- Mixing of wastes in upper layers is needed periodically without disturbing the vermibed
- Moisture content is brought down by stopping the addition of water for 3-4 days to ensure drying of compost and migration of worms into the vermibed
- The mature compost, a fine loose granular mass is removed out from the pit, sieved, dried and ready for field application

RRISL recommends applying organic fertilizer for rubber. If there are enough organic fertilizers, it is possible to apply total nutrient requirements by organic fertilizers or organic fertilizer along with mineral fertilizers of natural origin to promote organic farming. Only in the case of poultry manure, planting hole application has to be done at least 3-4 weeks prior to planting and in all latter applications, it is recommended to leave poultry manure at the field for 2-3 weeks before applying to the plants. If paddy straw is freely available, it can be used to replace 50% of the recommended quantity of any organic manure.

D2: Organic fertilizer recommendation and application procedure for rubber

Except for the planting hole application, one of the following organic fertilizers should be applied in 2 applications per year for immature rubber. Organic fertilizer to mature rubber should be applied in early January avoiding dry spells in February. That provides sufficient time required to mineralize organic fertilizer and release nutrients to fulfill the optimum period of demand for mature rubber. From the first year onwards, recommended quantity of organic fertilizers should be incorporated into the topsoil layer around the manuring circle with light forking. Remember, that organic fertilizers should not be applied near the base of the rubber plants. Amounts to be applied are given in Tables 3 & 4.

Table 3. Guideline for organic fertilizer application in rubber plantations along with inorganic fertilizers for P and Mg

Growth stage	Quantity (kg/plant/year) Use only one of these materials		
	Green manure	**Compost/cow dung/poultry litter**	**Poultry manure* (Poultry dropping only)**
Planting hole	-	3	2
1st year	3	3	2
2nd year	4	4	3
3rd year	6	6	4
4th year	6	6	4
5th year up to tapping	7	7	5
Mature	5	5	4

* Planting hole application of poultry manure should be done at least 3-4 weeks prior to planting. In other instances, 2-3 weeks lag time is required before field application

Table 4. Guideline for organic fertilizer application for the total nutrient requirement in rubber plantations

Growth stage	Quantity (kg/plant/year) Use only one of these materials		
	Green manure	**Compost/cow dung/poultry litter**	**Poultry manure * (Poultry dropping only)**
Planting hole	-	3	2
1st year	4	4	3
2nd year	6	6	4
3rd year	8	8	6
4th year	8	8	6
5th year up to tapping	10	10	8
Mature	6	6	5

* Planting hole application of poultry manure should be done at least 3-4 weeks prior to planting. In other instances, 2-3 weeks lag time is required before field application

Organic fertilizers enhance soil microbial population & use the efficiency of inorganic fertilizers

E. Liquid Organic Fertilizer

Produced by the decomposition of organic materials
Contains a high amount of carbon
Can be used even with drip irrigation systems
Enhance plant growth and improve soil fertility

Types of liquid organic fertilizers	Remarks
Extracted Forms; Humic acid and Fulvic acid • Natural polymeric organic compounds • Extracted from bog soils or seaweeds • Instead of traditional compost, this can be used as a long lasting soil conditioner • Decay very slowly compared to traditional organic residues and remain in the soil for a long time • Work as plant growth stimulants The general form of liquid organic fertilizers (“*Shaka Sara*”) • Consists of essential plant nutrients, organic acids, plant growth hormones and beneficial microorganisms	• Improve cation exchange capacity, microbial activity, moisture retention, nutrient uptake & transport and availability of micronutrients • Direct action on the plant is hormonal in nature • Research evidence is available on the success of using liquid organic on immature rubber[11,12]
Please refer to Table 5 for recommendations	

The general form of liquid organic fertilizer (Commercially available or homemade) recommendation and application procedure for rubber

Liquid organic fertilizer is recommended to apply as a spray around the base of the rubber plant (within the manuring circle) in 3 applications per year. The application rate per plant depends on the age of the plant and also the type of fertilizer used. Commonly applied quantities are given in Table 5. Quality parameters of liquid organic fertilizers decided by the Sri Lanka Standard Institute are given in Table 1b.

Table 5. Guideline for liquid organic fertilizer or liquid organic fertilizer enriched with biofertilizer application in rubber plantations

Growth stage	Frequency	Quantity (ml/tree/year)
1st year	3 applications per year	300
2nd year		600
3rd year		900
4th year		900
5th year up to tapping		1200
Mature	One application per year	1000

Liquid organic fertilizers are easy to handle

E 1: Preparation of Homemade liquid organic fertilizer

Material needed: *Gliricidia*/Wild sunflower or any green plant material, Cow dung or any animal dung, Partially burnt paddy husk, Eppawala Rock Phosphate (ERP) and any biofertilizer or yeast or previously prepared liquid organic fertilizer	
Factors affecting the quality: The ideal green material and animal dung ratio of the feed is 2:1	
The process used: Simple fermentation with organic materials as the carbon source	

Place the different materials in a barrel (20 L) in four equal size layers as shown in the diagram below

Fourth layer →	**250 g of ERP and previously prepared liquid organic fertilizer/biofertilizer/yeast (100g) were added as an inoculum with water**
Third layer →	**Green material**
Second layer →	**3:1 Ratio of any animal dung dissolved in water and partially burnt paddy husk**
First layer →	**Chopped or cut green material**

Fig. 3. Manual mixing is important to complete decomposition of materials in the bin

- Stir well and place the barrel in a shady area and the opening cover with a linen cloth
- Mix well daily
- At the end of 3 weeks, digestion (liquidized nature) is observed
- Filter the content and dilute the filtrate into 1:5 to 1:10 ratio (depending on the material used and their nutrient ratios)
- Then the mixture is ready for field application

It is not difficult to prepare liquid organic fertilizer

F. Biofertilizer

Includes living or dormant microorganisms helpful in enhancing soil fertility and plant growth

(a) (b) (c)

Basic steps of biofertilizer preparation

Fig. 4 a. Collection of root samples at field **b.** Isolation of microbes under laboratory conditions **c.** Observation of bacteria and fungi in the cultures with a microscopic view of the formation of biofertilizer

Benefits of Biofertilizer
• Decompose organic materials and release available forms of nutrients • Increase the availability of nutrients • Converts unavailable phosphorus and potassium into the available form • Increase root surface by induced root growth promotion • Enhance other beneficial symbiosis associated with plants • Improve soil fertility parameters & reduce leaching loss of some nutrients in rubber-growing soils [13,14] • Enhance plant growth with reduced levels of chemical fertilizers [14, 15,16]
This is applied in liquid form with the recommended dilution of the manufacturer to improve soil fertility

Fig.5. Field application of Biofertilizer

Biofertilizers are less bulky, low cost and environmentally friendly

G. Soil Amendments

There are many different types of soil amendments, and each has its own functionalities. They focus on some specific aspects of improving soil quality and finally promote healthy growth of plants. Biochar is one of the best such materials available.

Fig.6. Field application of biochar at early stages of growth

Characteristics of Biochar	Benefits
• Approximately 70% is carbon, In addition, it consists of nitrogen, hydrogen and oxygen among other elements • More stable carbon source compared to compost, crop residues and other organic mulching materials • Highly porous, high charge density, very light, and has a large surface area • Chemical composition depends on the raw material used for preparation and the method used for heating.	• Field application increases nutrient availability, microbial community, enzyme activities, moisture availability and sometimes high pH associated with biochar have helped to improve soil fertility and crop growth • Further, biochar enhances soil parameters such as porosity, water holding capacity, bulk density of rubber growing soils and finally the growth of *Hevea* plants[17, 18]
Please refer to Table 6 for the recommendation	

Biochar recommendation and application procedure for rubber

During the 1st and 2nd years after planting, biochar should be incorporated into the soil in the manuring circle with light forking. During the 3rd year and the commencement of tapping, biochar has to be applied in two trenches of about 60 cm x 20 cm x 15 cm (length x wide x depth) on either side of the plant perpendicular to the contour line. All applications should be done in one application per year and refer to Table 6 for the recommendation.

Table 6. *Guideline for biochar application in rubber plantations (Provisional recommendation)*

Age of the Plant (Year after planting)	Quantity (kg/plant/year)
1st	0.5
2nd onwards up to tapping	1.0

G 1: Preparation of Biochar

Material needed: Any organic material available	
Made by: Burning of any organic residue or waste without much air or oxygen by the process of pyrolysis	
Factors affecting the quality: Materials used and pyrolysis settings such as heating time, the temperature used and oxygen level of burning	
Methods used: Retort, TLUD (Top-Lit Updraft Gasifier), Open Burn and Flame Cap Kiln	

Traditional biochar preparation

During burning soil is applied on the surface to limit aeration

Basic steps in biochar preparation

- Dried logs are chopped to about 3 - 6 cm thick and 40 cm long pieces
- Pack tightly into a 50 cm diameter × 100 cm height metal container having six 1-cm diameter holes at the bottom.
- The container is closed with the lid
- Keep it in a place where the temperature goes up to about 600°C (Place on a fire pit made outside)
- It is possible to place smaller containers inside the furnace of the smokehouse
- When the syngas (mixture of hydrogen & Carbon monoxide) production from the material inside is ceased under the required temperature at about 3½ hours, then remove from the furnace
- Produced biochar is quenched with water to prevent rapid oxidation and self-ignition.
- Once dried and sieved, it is ready for field application

Fig. 7. Biochar preparation in a Barrel

Be careful about fire hazards in biochar preparation

G 2: Use Rubber wood & *Gliricidia* for biochar preparation

Potential of producing biochar from rubber wood and *Gliricidia* sticks

From rubber wood

Total weight of an uprooted mature rubber tree	**600 kg**
Total firewood weight per tree (30% of the total weight)	**180 kg**
Biochar production from firewood/tree [180x(20/100)] (Conversion rate of biomass into biochar 20%)	**36 kg**
Biochar production from firewood/ha (assuming 300 trees/ha)	**10,800 kg**
Average biochar requirement/plant/year	**1 kg**
Average biochar requirement/ha/year (1x500 trees)	**500 kg**
Therefore, the firewood content of rubber trees in one hectare of uprooted land could have the possibility to produce biochar for about 20 ha	

From *Gliricidia* sticks

The periphery of 1 ha of rubber land	**400 m**
Total trees planted at 1m distance	**400**
Total stick weight/plant/year	**10 kg**
Total dry matter production from plants along the fence/ha/year (10x400)	**4, 000 kg**
Total biochar production/ha/year (4, 000x12/100) (Conversion rate of biomass carbon into biochar 12%)	**480 kg**
Average biochar requirement/plant/year	**1 kg**
Average biochar requirement/ha/year (1x500)	**500 kg**
Therefore, planting *Gliricidia* along the fence around one hectare of rubber land (1 m distance) would be sufficient to meet the biochar requirement for 1 ha Further, it produces a huge amount of green manure that could be utilized as a good source of nutrients	

Being low cost, paddy husk also can effectively be used in biochar preparation

Any organic material can be converted into biochar

H. New Techniques of Fertilizer Application

These techniques are developed to release nutrients slowly in order to match with the nutrient requirement of rubber plants over an extended period of time

Type of new technique	Benefits	Remarks
Reusable Fertilizer Porous Tube (RFPT) /Reusable Fertilizer Porous Bag (RFPB) Developed using low grade rubber and polythene respectively Filled with fertilizer and other filling materials	• Needs only one fertilizer application per year • Reduce labour cost by 75% compared to split fertilizer application • Reduce fertilizer cost by 50% • Minimize fertilizer wastage and environmental pollution • Maximize fertilizer use efficiency • Can cut down the cost of weed control compared to conventional fertilizer application	• Possibility of using a single application of RFPT/RFPB (Fig. 4a/4b) as a substitute for the conventional split application of recommended fertilizers for immature rubber plants[19] • A single application of ECB (Fig. 4c) gave similar growth parameters compared to conventional inorganic fertilizer application[20, 21]
Encapsulated Coir Brick (ECB) Developed using coir dust as a coating material to encapsulate fertilizers		

Application

Incorporate into the soil, 5 cm below the ground level once a year.

Fig. 4a Field application of RFPT b. Field application of RFPB c. Field application of ECB

Slow release fertilizer application techniques enhance fertilizer use efficiency

Different fertilizer packages for your choice

The four packages mentioned below are based on long-term research and their findings on different organic fertilizers, soil amendments, biofertilizer and their different combinations with inorganic fertilizers conducted by the Soils & Plant Nutrition Department of the Rubber Research Institute of Sri Lanka.

Package 1

Suitability:

Small scale rubber growers (land extent less than 2 ha), who could devote sufficient time for the field activities with abundant organic materials in the surrounding areas. Further, this is the package available for the growers who cannot afford to purchase any fertilizer from outside

Activities & Guidelines

No.	Activity	Guideline
1	Cover crop & other soil conservation practices	Advisory circular, "Soil Conservation"
2	Compost or other organic manure preparation and application	Refer Table 7

Package 2

Suitability:

Small scale rubber growers (land extent less than 2 ha), who could devote sufficient time to field activities and have some amount of organic materials in the surrounding areas

Activities & Guidelines

No.	Activity	Guideline
1	Cover crop & other soil conservation practices	Advisory Circular, "Soil Conservation"
2	Compost or other organic manure preparation and application	Refer Table 8
3	Locally available inorganic fertilizer application	Refer Table 12 & 13

Package 3

Suitability:

Medium scale and estate sector growers, who could afford the cost of inorganic fertilizer Other than inorganics, encourage growers to apply conventional organics/biochar/biofertilizer to enhance soil fertility and fertilizer use efficiency

Activities and Guidelines

No.	Activity	Guideline
1	Cover crop and other soil conservation practices	Advisory Circular, "Soil Conservation"
2	Inorganic fertilizer application, 75% of the recommended quantity is sufficient	Advisory Circular, "Fertilizer to rubber"
3	Compost or organic manure/ Biochar/biofertilizer/	Refer Table 9/Table 10/Table 11

Package 4

Suitability:

Medium scale and estate sector growers, who could afford the cost of inorganic fertilizer and are willing to apply new fertilizer application techniques

Activities and Guidelines

No.	Activity	Guideline
1	Cover crop and other soil conservation practices	Advisory Circular, "Soil Conservation"
2	Inorganic fertilizer application	Establish one of the new fertilizer application techniques; Encapsulated Coir Brick (ECB)/ Reusable Fertilizer Porous Tube (RFPT)/ Reusable Fertilizer Porous Bag (RFPB) Required only 50% of the recommended fertilizer quantity for immature rubber

Table 7. *Guideline for organic fertilizer application for the total nutrient requirement in rubber Plantations*

Growth stage	**Quantity (kg/plant/year)** Use only one of these materials		
	Green manure	**Compost/cow dung/poultry litter**	**Poultry manure * (Poultry dropping only)**
Planting hole	-	3	2
1st year	4	4	3
2nd year	6	6	4
3rd year	8	8	6
4th year	8	8	6
5th year up to tapping	10	10	8
Mature	6	6	5

* Planting hole application of poultry manure should be done at least 3-4 weeks prior to planting. In other instances, 2-3 weeks lag time is required before field application

Table 8. *Guideline for organic fertilizer application in rubber plantations along with mineral fertilizers for phosphorus and magnesium*

Growth stage	**Quantity (kg/plant/year)** Use only one of these materials		
	Green manure	**Compost/cow dung/poultry litter**	**Poultry manure* (Poultry dropping only)**
Planting hole	-	3	2
1st year	3	3	2
2nd year	4	4	3
3rd year	6	6	4
4th year	6	6	4
5th year up to tapping	7	7	5
Mature	5	5	4

* Planting hole application of poultry manure should be done at least 3-4 weeks prior to planting. In other instances, 2-3 weeks lag time is required before field application

Table 9. *Guideline for organic fertilizer application in rubber plantations along with recommended inorganic fertilizers*

Growth stage	Quantity (kg/plant/year) Use only one of these materials		
	Green manure	**Compost/cow dung/poultry litter**	**Poultry manure* (Poultry dropping only)**
Planting hole	-	3	2
1st year	2	2	1
2nd year	3	3	2
3rd year	4	4	3
4th year	4	4	3
5th year up to tapping	5	5	4
Mature	3	3	2

* Planting hole application of poultry manure should be done at least 3-4 weeks prior to planting. In other instances, 2-3 weeks lag time is required before field application

Table 10. *Guideline for biochar application in rubber plantations (Provisional recommendation)*

Growth stage	Quantity (kg/plant/year)
1st year	0.5
2nd year onwards up to tapping	1

Table 11. *Guideline for liquid organic fertilizer or liquid organic fertilizer enriched with biofertilizer application in rubber plantations*

Growth stage	Frequency	Quantity (ml/tree/year)
1st year	3 applications per year	300
2nd year		600
3rd year		900
4th year		900
5th year up to tapping		1200
Mature	1 application per year	1000

Table 12. *Composition of inorganic fertilizer (without nitrogen and potassium) to be applied to meet the nutrient requirement of immature rubber*

Growth stage	Frequency	Quantity (g/tree/year)	
		Parambe and all other rubber growing areas	
		ERP	Dolomite
1st year	2 applications per year	150	50/75*
2nd year		300	75/150*
3rd year		400	100/200*
4th year		400	100/200*
5th year up to tapping		600	150/250*

*Lower Mg dose is for Parambe series soils and higher dose for all other rubber growing soils.

Table 13. *Composition of inorganic fertilizer (without nitrogen and potassium) to be applied to meet the nutrient requirement of mature rubber*

Growth stage	**Frequency**	**Quantity (g/tree/year)**	
		Parambe and all other rubber growing areas	
Mature	one application per year	ERP	Kieserite
Virgin bark		100	75/150*
Renewed bark		-	50/100*

*Lower Mg dose is for Parambe series soils and higher dose for all other rubber growing soils. All inorganic fertilizers to mature rubber are to be applied before June in the wet zone (traditional) and September to November in dry zone rubber growing areas.

Summary

Traditional organic manures provide a mixture of major and minor nutrients. Biochar enhances soil fertility parameters; cation exchange capacity, water holding capacity and microbial population etc. and biofertilizer enhance nutrient availability, other beneficial symbiosis associated with plants. Under the organic agriculture concept, locally available mining products such as ERP and Dolomite are accepted to provide plant nutrients; P and Mg respectively. Fertilizers are also used in slow-release fertilizer techniques; Encapsulated Coir Brick (ECB), Reusable Fertilizer Porous Tube/Bag (RFPT/RFPB) enhance fertilizer use efficiency and reduce labour costs associated with split applications.

Sustainable soil fertility management is everyone's responsibility

Special points for concern in the application of organic fertilizers in rubber lands

- *Strict compliance to disease management and pest control strategies are required when applying organic fertilizers to the soils infected with White Root Disease & with incidences of Cockchafer Grub attack*

- *Further, in lands with white root disease history, it is not advisable to establish Mucuna as a cover crop. In such areas, RRISL recommends to grow Pueraria, Desmodium or other cover crops.*

Pertinent Literature

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