

GREEN MANURING OF RICE FIELDS IN THE CENTRAL REGION OF SRI LANKA

NIRMALA GUNAPALA and S. L. AMARASIRI¹

Central Agricultural Research Institute, Gannoruwa

ABSTRACT

The increasing cost of fuel-based chemical fertilizers and the mounting concern on the long-term productivity of soils emphasize the importance of renewable resources as manures in agriculture. As a preliminary step in promoting the development of a feasible practice of adding green manures to rice fields, this investigation was conducted in the central region of Sri Lanka to determine the suitable types of plants available as green manures in the region, their present use and their manurial value. Direct information obtained from farmers indicated green manuring of rice fields at present to be almost an insignificant practice. Twenty seven species of plants were identified that are being used by farmers as green manures. Rapid decomposition, manurial value and pest-control properties possessed in plants were criteria for this selection. Results indicate the possibilities for identifying a wide range of plants from plant species in the natural environment of rice fields that could serve as manures and as natural pesticides.

KEY WORDS: C/N ratio, Natural pesticides, Organic fertilizers; Renewable resources

INTRODUCTION

It is well accepted that increased food production in the future should arise through intensification of agricultural productivity. Increased supply of plant nutrients will be important to realize the full potential of high yielding rice varieties grown in an intensive cropping system. Chemical fertilizers, one of the most important inputs in rice production will continue to play a significant role in increasing productivity. These fertilizers, however, are chemical products that consume a considerable amount of energy in their production.

In view of the universal shortage and high cost of energy sources, conservation of energy through efficient management of renewable resources as far as is practicable would seem to be an imperative at the present time. Organic materials such as crop residues, animal wastes and green manures

¹Present address: Research Division, Department of Agriculture, P. O. Box 5, Peradeniya.

are considered as important resources for building soil fertility. Organic recycling converts those materials into valuable inputs for agricultural productivity. On account of the low organic matter content in tropical soils and the rapidity with which it is biodegraded in arable soils, continued addition of organic matter to these soils seasonally is necessary if fertility is to be maintained. Addition of organic matter to soils causes an overall improvement of soil conditions relating to soil productivity. Organic matter supplies humus to the soil, thereby supplementing essential plant nutrients, including micronutrients, whose deficiency can be expected with intensive cropping and increased productivity.

Green manuring of rice fields, or in other words the practice of incorporating undecomposed plant material into the soil with the object of increasing soil fertility, is an age-old manuring method known to farmers in almost all parts of Sri Lanka. Before sowing, leaves and tender branches of selected plants may be brought to the field and added, and ploughed in. Or, a green manure crop, usually an annual legume crop may be grown in the field itself and ploughed into the soil prior to sowing. The former method is sometimes referred to as "green leaf manuring" and the latter as "green manuring".

Many years before the advent of chemical fertilizers in the country, agriculturists showed considerable interest in promoting the increased use of green manures in rice cultivation. As observed by Molegoda (1921), the use of green leaves and twigs of certain common trees and plants, such as Kekuna (*Canarium zeylanicum*[†]), Dadap (*Erythrina lithosperma*), Keppetiya (*Croton laccifer*), Karanda (*Pongamia pinnata*), Wild sunflower (*Tithonia diversifolia*) among others as manure for rice was a common practice in the central region. The use of sufficient quantities of these materials was observed to cause an appreciable increase in rice yields (Molegoda, 1921). Many experiments showed encouraging results from the incorporation of a crop of sunn hemp (*Crotalaria juncea*) grown in the rice fields itself (Molegoda, 1918). The Department of Agriculture took efforts to promote the use of *in situ* green manures such as sunn hemp, pila (*Tephrosia purpurea*) and dhaincha (*Sesbania aculeata*) by providing information, instruction and necessary seeds to farmers (Department of Agriculture, 1922).

[†]According to current usage, *Aleuritus moluccana*.

GREEN MANURING OF RICE FIELDS

Since the introduction of chemical fertilizers in the early 1950s and the increased adoption of their use by farmers, the practice of green manuring has gradually become less important. Today, it is an insignificant practice in rice cultivation.

The present emphasis on the increased use of organic manures in agriculture, however, stresses the importance of studies aimed at developing feasible practices for the green manuring of rice fields. As a preliminary step towards such a goal, it would be of considerable use to determine the availability of green manures in a given region, taking into consideration the types of suitable plants available, their present use, their manurial value and efficiency in maintaining soil productivity under intensive cropping.

This paper reports the findings of an investigation carried out to study the current practices of green manuring by farmers in the central region, including the types of plants selected by farmers and the plant nutrient contents of some important plant species.

MATERIALS AND METHODS

This study was confined mainly to the rice fields in the central region of the country, which consists of four districts, Kandy, Kegalle, Matale and Nuwara Eliya. From each district about 25 locations that are well-distributed throughout the rice growing area in the district were pre-selected. At the beginning of the cultivation season, each location was visited and 1 to 3 farmers who have been involved in rice cultivation in the location for at least 30 years were interviewed to obtain the following information: 1) current practices of green manuring at the location, 2) the extent of the practice, 3) types of plants used, 4) amounts added to the field, 5) benefits observed, 6) special characteristics if any in these plants, and 7) their availability in the area.

Using plant samples consisting of leaves, flowers and fruits, all plants used by farmers as green manures were botanically identified. From each identified plant species, samples of tender branches were collected for chemical analysis. Attempts were made to collect a maximum of about 10 such samples from each species. However, in a few species reported, the total number of samples collected is less than 10. In each species, sampling was

limited to one sample per plant. Plants for sampling were selected from different locations distributed throughout the region so as to get the best possible distribution of each species within the region. Each sample was separated into leaves and tender stems, dried at 60°C and analyzed for N, P, K and organic C contents using conventional analytical methods.

RESULTS AND DISCUSSION

The rice lands in the four districts, Kandy, Kegalle, Matale and Nuwara Eliya in the central region are mostly found within the mid-and up - country wet and intermediate zones. Rice fields are generally located in narrow inland valleys and terraces in the landscape that are invariably surrounded by highlands consisting of home gardens, plantation crops and shrub jungle.

The practice of green manuring

According to observations of this study, it is a fairly common practice amongst farmers in the region to add some amount of green leaves and tender branches, very often from certain selected plants to rice fields as manure at land preparation. These are normally cut from plants in the immediate surroundings of rice fields, and are carried manually in bundles to the field. These plants are mostly large and small trees, shrubs, herbs and sometimes creepers that are common in the surroundings of the rice field. About 85 to 90% of the farmers in this region resort to this practice. Green manuring is more commonly observed at the beginning of maha season rather than of yala season. Although it seems a common practice, the extent of land area to which manure is added is very limited. Majority of farmers confine this addition to the rice nursery bed area only. In certain locations very few farmers, however, were found to add green manures to an area beyond this limit. Generally, the quantity of green manure added to a holding seems to be around 0.2 to 1.0 t/ha. Although this seems to be a very low rate of addition, since the addition is mostly confined to the nursery bed area which is about 8 to 10% of the holding, it seems evident that the rice nurseries are benefitted by a fairly high rate of green manure.

In the region studied, rice cultivation is mainly rainfed. At the beginning of a season, with the first rains farmers begin land preparation and try to establish the crop as early as possible. Often, after the first

GREEN MANURING OF RICE FIELDS

ploughing, and in certain locations after a second ploughing, green manures are cut and brought, and are spread on the surface of the nursery bed area. Very often after spreading, it is trampled into the mud. Within 10 to 15 days when leaves have fallen off, undecomposed hard twigs and stems are pulled out and thrown away. Final ploughing is then carried out incorporating the partially decomposed green material. Preparation for sowing the nursery follows. A period longer than 15 days is not normally available for the added material to decompose.

The practice of growing an annual legume crop *in situ* as green manure and ploughing in was not found to exist at any location in this region.

There are many reasons why the above described practice of adding green manures is not extensively carried out today. Unlike in olden days, at present, more and more jungle areas have been cleared for the mounting needs of man. It is found increasingly hard to obtain sufficient quantities of green manure for this purpose. Moreover, on account of the difficult economic situations faced specially by small and marginal farmers, rice cultivation cannot be considered as the only means of livelihood. As time permits, most farmers resort to other income earning avenues. As such, there is a general reluctance to undertake a time and labour consuming practice as green manuring.

Types of plants used

In this study 27 species of plants were identified that are being added to rice fields by farmers. Table 1 presents the botanical names as well as local names of these plants. Table 2 gives a more informative picture of each of these species. Of the plants listed in Table 1, following species are reported as green manures used by farmers more than 60 years ago in this region: Karanda, Kekuna, Dadap, Keppetiya, Wild sunflower, Pila, Suriya or Gansuriya, Totilla and Kaduru (Molegoda, 1918 and 1921).

Benefits of green manuring

It is obvious that farmers intend to achieve more than one benefit through this practice. Through long experience farmers seem to have identified the specific types of plants in the surroundings that would give the specific benefit or benefits desired when added to the soil. It is interesting to note

that supplying of plant nutrients to the rice crops is often not the major benefit intended in this practice. In all locations studied farmers are well adopted to using chemical fertilizers in rice cultivation. The practice of adding tender parts of certain plants to the soil at land preparation is directed more towards getting the hardened soil loosened, facilitating easy and quick land preparation and puddling. Addition of green plant material with low C/N ratio would increase the microbial activity in the soil leading to a rapid decomposition of hard stubble and weed residues. As is seen in Table 2, certain types of plants have been specifically mentioned by farmers as those that would undergo rapid decomposition in the soil. Rice seedlings in a nursery added with such green manures are said to grow well, to be healthy and sturdy. They are easy to uproot and resistant to damage during uprooting compared to seedlings that have received only chemical fertilizers. When green manures are added many farmers do not use chemical fertilizers to the nursery bed.

A further interesting observation in this study was that certain species of plants are specially selected to be added to rice nurseries because of the pest-control properties shown by them. When these decompose in the soil, rice seedlings are observed to be protected from many common pest attacks. As seen in Table 2, more than 75% of the plant species reported have been mentioned by farmers as having these properties. Of these, plant species such as *Wickstroemia canescens*, *Cerbera manghas*, *Curcuma zedoaria*, *Barringtonia racemosa*, *Pagianta dichotoma* and *Microglossa ceylanica* are added to rice nurseries because of the pest-control potential observed in them.

Due to many problems arising through continued and frequent, injudicious use of synthetic pesticides, plants with pest-control properties are now gaining more and more scientific attention. Grainge and Ahmed (1988) reported information on about 2,400 plant species found throughout the world that possess pest-control properties. Many species of plants shown in Table 2 as having pesticidal properties are included among these 2,400 species reported. Further, the two species *Pongamia pinnata* and *Datura metel* are listed under plants having broad-spectrum pest-control properties (Grainge and Ahmed, 1988).

GREEN MANURING OF RICE FIELDS

Chemical composition of leaves and tender stems

The N, P, K and organic C content as well as the C/N ratio of leaves and tender stems of all species studied showed a considerable variation (Table 3). From each species, samples for analysis were collected from different locations in the region. The nutrient composition of each sample could vary with the age of the plant at sampling time, soil and other environmental conditions under which it grows. Although a statistically valid comparison of these results cannot be obtained, they can still provide a basic understanding about the nutrient composition of these species.

As observed in Table 3, the N content of leaves seems to be invariably higher than that of tender stems. The leaves of some non-leguminous plants such as *Tithonia diversifolia*, *Datura metel* and *Mikania cordata* showed over 4.34% N which is quite comparable to that of leguminous plants reported (Table 3). About 80% of the plant species had more P in leaves than in tender stems.

In contrast to above observations, about 78% of the species showed more K in tender stems than in leaves. Of these, again, *Tithonia diversifolia*, *Mikania cordata* and *Datura metel* showed over 4.60% K in tender stems (Table 3).

The mean C/N ratio of leaves of all plant species was lower than that of tender stems. In leaves it ranged from 7.5 to 21.7 whereas in tender stems, it ranged from 13.3 to 61.3. This may explain the tendency in stems of added green manure to remain longer in soil as compared to leaves that decompose within few days.

The potential of some plant species as manure

Except for a few, for most plant species that were identified in this study, published information on their potential value as manures is very scarce.

Gliricidia sepium is a common quick growing legume tree normally grown as 'live fences' in village areas. Sticks and branches are used as fuel wood and for staking. Leaves and tender green parts are used as fodder and green manure. *Tithonia diversifolia* too is a common large shrub that grows wild in jungles, hedges and along roadsides. It grows rapidly producing a considerable mass of green matter. Farmers have been using these species as green manures for many years.

A field study reported by Nagarajah and Amarasiri (1977) in two different agro-climatic regions in Sri Lanka showed that application of chemical fertilizer to rice could be reduced appreciably if applied in combination with either of the above two plant species as green manure. Each of the species at the rate of 9t/ ha (fresh weight) with 45-50% of the recommended level of NPK chemical fertilizer gave a slightly higher grain yield than that obtained by the recommended level of NPK chemical fertilizer (Nagarajah and Amarasiri, 1977). Grain yield data obtained for different combinations of *Tithonia diversifolia* and NPK chemical fertilizer suggested that depending on the amount of this green manure added, one could make adjustments for the amount of chemical fertilizer to be supplemented (Nagarajah and Nizar, 1982).

The study of decomposition and nutrient release patterns of different green manures in flooded rice soils would also be important in assessing their potential as well as their effective utilization. Such an approach was taken by Joachim and Kandiah in 1929. A series of laboratory experiments conducted by them have shown that to obtain best results, green manures should be incorporated into the soil about 1—2 weeks before transplanting of rice. The maximum availability of N in the form of NH_4^+ -N was observed in 4 weeks after incorporation. This would coincide well with the active vegetative growth of rice plants (Joachim and Kandiah, 1929).

Observations of this study indicate the possibilities of finding a large assortment of plant types from many common plant species that could serve as good organic manures for rice fields. Seasonal addition of tender parts of such plants to the field will promote the maintenance of the fertility in the soil. Plants with high nutrient contents as well as plants with pest-control properties would ideally support to reduce the use of costly synthetic products that are also hazardous to the environment. However, more intensive studies are needed to test the potentials of these indigenous renewable resources as manures for rice fields. Once the potential plants are identified, an approach could be taken to cultivate suitable plants in highlands adjacent to rice fields. This would greatly reduce the burden of cutting and transporting of green manure from distances. Further, having such plant covers in sloping highlands closer to rice fields as found in the central region, would also help to reduce the problems of soil loss due to erosion.

GREEN MANURING OF RICE FIELDS .

ACKNOWLEDGEMENTS

The assistance given by Dr. A. H. M. Jayasuriya, Head, National Herbarium, Peradeniya in the botanical identification of plants, and Mrs. S. de Silva in the analysis of plant samples is gratefully acknowledged.

REFERENCES

- Department of Agriculture, Ceylon. 1922. Food Production Circular No. 21. Green manures for paddy. *Tropical Agriculturist* 59:87.
- Grainge, M. and S. Ahmed. 1988. Handbook of Plants with Pest-control Properties. John Wiley and Sons, New York.
- Joachim, A. W. R. and S. Kandiah. 1929. Laboratory and field studies on green manuring under paddy land (anaerobic) conditions. *Tropical Agriculturist* 72:253-271.
- Molegoda, W. 1918. Green manuring of paddy fields in Kandy district. *Tropical Agriculturist* 51:349.
- Molegoda, W. 1921. Green manures and paddy cultivation. *Tropical Agriculturist* 56:3-4.
- Nagarajah, S. and S. L. Amarasiri. 1977. Use of organic materials as fertilizer for lowland rice in Sri Lanka. *In* Soil organic matter studies. Vol. I. pp. 97-104. International Atomic Energy Agency, Austria.
- Nagarajah, S. and B. M. Nizar. 1982. Wild sunflower as a green manure for rice in the mid-country wet zone. *Tropical Agriculturist* 138:69-80.

Table 1. Plant species used as green manures in the central region of Sri Lanka

<i>Plant species</i>	<i>Plant family</i>	<i>Local name (in Sinhala)</i>
1. <i>Aleurites moluccana</i>	Euphorbiaceae	Kekuna
2. <i>Melia dubia</i>	Meliaceae	Lunumidella
3. <i>Gliricidia sepium</i>	Fabaceae (Leguminosae)	Wetahira, Sewana
4. <i>Michelia champaca</i>	Mangoliaceae	Sapu, Gini Sapu
5. <i>Thespesia populnea</i>	Malvaceae	Gansooriya, Sooriya
6. <i>Pagiantha dichotoma</i>	Apocynaceae	Dee - Kaduru
7. <i>Cerbera manghas</i>	Apocynaceae	Mudu - Kaduru, Goda - Kaduru
8. <i>Barringtonia recemosa</i>	Lecythidaceae	Midella
9. <i>Samanea saman</i>	Mimosaceae (Leguminosae)	Mara
10. <i>Pongamia pinnata</i>	Fabaceae (Leguminosae)	Karanda, Mangulkaranda
11. <i>Erythrina</i> sp.	Fabaceae (Leguminosae)	Erabadu
12. <i>Oroxylum indicum</i>	Bigoniaceae	Totilla
13. <i>Premna tomentosa</i>	Verbenaceae	Seru
14. <i>Alstonia macrophylla</i>	Apocynaceae	Hawarinuga
15. <i>Manihot glaziovii</i>	Euphorbiaceae	'India rubber'
16. <i>Manihot</i> sp.	Euphorbiaceae	Alimannokka
17. <i>Jatropha curcas</i>	Euphorbiaceae	Wetaedaru
18. <i>Tithonia diversifolia</i>	Asteraceae (Compositae)	Naththasooriya, Tiiththa
19. <i>Croton laccifer</i>	Euphorbiaceae (Leguminosae)	Keppetiya
20. <i>Tephrosia purpurea</i>	Fabaceae (Leguminosae)	Pila
21. <i>Microglossa ceylanica</i>	Asteraceae (Compositae)	Pupala
22. <i>Wickstroemia canescens</i>	Thymelaeaceae	Nahadunu, Maha patta
23. <i>Eupatorium odoratum</i>	Asteraceae (Compositae)	Podisignomaran
24. <i>Curcuma zedoaria</i>	Zingiberaceae	Harankaha
25. <i>Mikania cordata</i>	Asteraceae (Compositae)	Watu - palu, Gahala - wel
26. <i>Datura metel</i>	Solanaceae	Aththana
27. <i>Pavatta inidca</i>	Rubiaceae	Pavatta

Table 2. ¹Description of plant species given in Table 1

		Species number given in Table 1																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
TYPE OF PLANT	tree	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*									*
	shrub																		*	*	*	*	*	*			*	
	climber																									*		
	herb																							*				
PLANT HABITAT (in relation to the rice field)	jungle	*	*		*	*	*	*	*	*			*	*	*				*	*	*	*	*	*		*		
	wild in surrounding	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	
	home gardens	*	*	*	*	*						*															*	
	live fences			*		*	*	*				*	*					*	*								*	
WHY CHOSEN TO BE ADDED TO RICE FIELDS	traditional practice and manurial value	*	*	*		*				*	*	*	*						*	*								
	easily obtainable and rapid decomposition			*								*				*	*	*	*	*			*		*	*	*	
	disposal of jungle & garden clearings (loppings)	*	*	*	*	*	*	*	*	*		*		*	*		*		*	*					*			
	material collected during clearings of surroundings of rice fields	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*			*		*	*	*
	pesticidal properties		*				*	*				*							*	*		*	*		*		*	
IMPORTANT USES	timber	*	*		*	*				*				*	*													
	fodder			*																								
	medicinal					*	*				*							*		*	*	*	*		*		*	
	other	*		*							*	*						*		*								
	none																*		*					*		*	*	

¹Totally based on information obtained directly from farmers

Table 3. Nutrient composition of leaves and tender stems of plant species used as green manures

Plant species	No. of samples	Average N%	Range N%	Average P%	Range P%	Average K%	Range K%	Average Org. C%	Range Org. C%	Average C/N	Range C/N
1. <i>Aleurites moluccana</i>	10 L	2.74	1.53-3.68	0.19	0.13-0.29	1.70	1.24-2.50	42.7	39.5-45.8	16.5	11.6-28.0
	S	1.09	0.73-1.46	0.20	0.05-0.37	2.01	1.32-3.50	42.8	37.5-46.9	41.9	28.6-64.3
2. <i>Melia dubia</i>	10 L	3.90	2.22-5.22	0.20	0.06-0.33	1.97	1.00-3.00	43.6	38.1-46.9	11.7	8.3-18.2
	S	1.25	0.84-1.88	0.17	0.03-0.33	1.91	0.92-3.00	46.5	42.9-51.5	40.0	24.8-56.6
3. <i>Gliricida sepium</i>	10 L	4.61	4.01-5.51	0.19	0.03-0.27	2.17	1.45-2.95	45.4	35.3-51.3	9.9	7.8-12.9
	S	1.84	1.53-2.23	0.17	0.09-0.23	2.81	1.95-3.70	45.6	39.3-49.8	25.1	20.0-32.5
4. <i>Michelia champaca</i>	10 L	2.58	2.18-3.20	0.14	0.09-0.20	1.07	0.48-1.84	47.0	43.7-48.7	18.5	14.4-21.7
	S	1.01	0.10-1.46	0.15	0.07-0.31	1.57	0.52-2.25	48.2	43.4-51.6	45.2	31.7-61.9
5. <i>Thespesia populnea</i>	10 L	3.39	2.85-4.26	0.30	0.15-0.79	2.30	1.43-3.30	42.4	37.3-48.2	12.8	8.8-15.4
	S	1.85	1.20-3.23	0.31	0.15-0.59	2.49	1.33-4.00	42.1	36.6-46.5	24.9	11.3-35.0
6. <i>Pagiantha dichotoma</i>	8 L	2.15	1.69-2.91	0.15	0.07-0.26	1.92	1.20-2.70	45.3	39.0-50.6	21.7	14.9-26.8
	S	1.44	1.08-1.71	0.17	0.21-0.31	2.60	1.70-3.70	44.3	37.3-48.2	41.2	26.9-41.5
7. <i>Cerbera manghas</i>	6 L	2.31	1.77-2.66	0.16	0.12-0.18	1.92	0.95-3.10	46.5	40.1-50.9	20.4	18.5-26.4
	S	1.05	0.48-1.46	0.16	0.10-0.19	2.26	1.25-3.40	46.1	43.9-48.0	50.3	30.1-97.4
8. <i>Barringtonia racemosa</i>	7 L	2.31	2.14-2.85	0.14	0.05-0.26	1.44	0.93-1.75	47.5	45.1-49.3	20.9	17.0-35.1
	S	1.12	0.63-1.78	0.13	0.03-0.23	1.99	1.03-3.18	45.2	39.9-48.6	44.3	22.4-77.2
9. <i>Samanea saman</i>	3 L	5.21	4.27-6.07	0.18	0.13-0.21	1.25	1.15-1.40	51.2	49.7-52.4	10.0	8.5-11.4
	S	2.35	1.90-2.82	0.10	0.06-0.14	1.77	1.60-2.05	46.6	41.7-49.8	20.1	17.7-21.9

Plant species	No. of samples	Average N%	Range N%	Average P%	Range P%	Average K%	Range K%	Average Org. C%	Range Org. C%	Average C/N	Range C/N
10. <i>Pongamia pinnata</i>	10 L	4.56	4.08-4.88	0.23	0.10-0.35	1.84	1.24-2.76	46.3	42.9-50.4	10.2	9.3-11.4
	S	2.30	1.69-2.93	0.21	0.13-0.30	2.07	1.30-3.08	44.8	38.4-48.5	19.9	13.1-26.1
11. <i>Erythrina</i> sp.	10 L	5.21	4.26-6.07	0.32	0.24-0.45	1.83	0.92-2.88	44.1	36.6-52.9	8.7	6.6-10.9
	S	1.85	1.39-2.75	0.21	0.03-0.45	2.20	0.92-3.80	43.7	33.7-50.2	25.0	12.3-33.2
12. <i>Oroxylum indicum</i>	10 L	2.91	2.12-3.51	0.26	0.18-0.39	1.24	0.48-1.85	47.8	42.2-52.9	16.9	13.8-19.9
	S	0.78	0.51-1.14	0.18	0.11-0.31	1.74	0.52-3.20	45.7	40.9-50.9	61.3	39.8-82.4
13. <i>Premna tomentosa</i>	5 L	3.04	2.23-3.51	0.22	0.11-0.35	1.38	0.65-1.90	51.4	47.6-54.8	17.5	13.6-24.6
	S	1.12	0.91-1.46	0.11	0.23-0.18	1.49	0.78-2.05	50.2	46.6-53.1	46.4	33.6-58.3
14. <i>Alstonia macrophylla</i>	10 L	2.54	1.96-3.61	0.13	0.04-0.24	1.69	0.78-2.80	49.4	46.5-51.9	20.2	12.9-25.7
	S	1.09	0.79-1.74	0.12	0.03-0.22	1.54	0.72-2.72	46.9	44.7-49.3	45.2	25.8-61.2
15. <i>Manihot glaziovii</i>	10 L	4.34	3.16-5.19	0.34	0.23-0.43	1.68	1.35-2.50	45.6	40.9-47.8	10.8	8.5-14.5
	S	1.46	0.89-2.37	0.21	0.07-0.40	1.98	1.19-2.50	43.2	35.5-47.7	32.9	17.8-52.3
16. <i>Manihot</i> sp.	10 L	4.51	2.85-5.72	0.33	0.18-0.47	1.47	0.94-1.84	45.7	36.3-50.2	10.6	7.5-16.5
	S	1.40	0.73-1.87	0.17	0.05-0.27	1.84	0.42-3.63	45.1	40.7-48.7	35.2	23.0-66.7
17. <i>Jatropha curcas</i>	10 L	3.23	2.69-3.70	0.23	0.04-0.31	2.06	0.80-2.75	42.2	40.2-45.1	13.2	11.5-15.2
	S	1.16	0.89-1.64	0.20	0.11-0.31	3.46	2.30-5.25	41.0	30.8-45.1	37.2	22.5-48.3
18. <i>Tithonia diversifolia</i>	10 L	4.67	3.68-5.37	0.38	0.30-0.45	3.32	2.15-4.20	40.1	32.5-48.2	8.7	7.3-12.2
	S	2.33	1.16-3.70	0.27	0.11-0.42	4.66	2.15-7.40	39.7	36.0-50.4	20.5	9.8-39.1
19. <i>Croton laccifer</i>	10 L	3.54	2.95-4.33	0.22	0.15-0.35	1.61	1.25-1.85	42.0	34.5-46.3	12.2	8.0-14.9
	S	1.49	0.98-2.08	0.11	0.07-0.15	1.67	1.19-2.25	45.6	43.3-47.7	32.2	26.9-47.7

Table 3. (continued)

Plant species	No. of samples	Average N%	Range N%	Average P%	Range P%	Average K%	Range K%	Average Org. C%	Range Org. C%	Average C/N	Range C/N
20. <i>Tephrosia purpurea</i>	9 L	4.28	2.37-5.22	0.22	0.04-0.36	1.19	0.70-1.70	47.5	41.7-52.2	11.5	8.9-17.6
	S	1.69	1.13-2.09	0.18	0.05-0.28	1.01	0.70-1.70	47.9	41.9-51.2	30.1	23.6-41.4
21. <i>Microglossa ceylanica</i>	8 L	3.99	2.72-5.19	0.23	0.17-0.30	2.67	1.70-3.40	44.7	38.5-49.4	11.5	9.5-14.8
	S	1.59	0.70-3.23	0.15	0.15-0.19	2.19	0.95-3.20	45.2	41.7-47.9	33.8	14.1-60.4
22. <i>Wickstroemia canescens</i>	6 L	3.01	2.21-3.64	0.24	0.20-0.26	1.63	1.30-1.80	44.7	40.9-49.1	15.2	12.7-19.3
	S	1.46	1.14-1.80	0.15	0.11-0.23	1.63	1.15-2.20	44.3	36.7-49.3	31.1	25.4-35.8
23. <i>Eupatorium odoratum</i>	10 L	3.34	2.72-3.80	0.25	0.13-0.34	1.79	1.40-2.13	45.7	39.7-49.3	13.8	11.6-18.1
	S	1.26	0.88-1.93	0.15	0.05-0.23	2.62	1.33-5.40	45.6	37.5-48.0	38.2	22.2-52.7
24. <i>Curcuma zedoaria</i>	6 L	2.02	1.93-2.12	0.26	0.15-0.33	4.17	3.40-5.40	43.5	42.3-45.6	21.6	20.5-23.6
	S	1.74	1.17-3.60	0.15	0.12-0.34	2.80	1.70-5.90	40.5	38.5-43.3	27.1	10.7-36.1
25. <i>Mikania cordata</i>	10 L	4.36	3.29-4.94	0.32	0.23-0.39	3.35	2.22-4.25	39.7	33.4-43.4	9.2	7.8-12.7
	S	1.85	1.27-2.33	0.24	0.18-0.38	4.84	3.20-7.50	40.9	37.1-43.8	23.0	16.6-34.5
26. <i>Datura metel</i>	10 L	5.25	4.24-6.45	0.33	0.24-0.46	4.30	3.45-5.10	38.7	34.5-42.3	7.5	5.8-9.8
	S	2.64	1.55-3.83	0.29	0.20-0.42	5.57	3.64-7.25	37.8	30.6-45.4	16.5	8.8-28.8
27. <i>Pavetta indica</i>	10 L	5.01	4.33-5.95	0.13	0.19-0.50	2.90	1.80-3.45	41.9	34.7-45.7	8.4	6.9-10.2
	S	3.15	2.21-3.90	0.38	0.28-0.49	3.80	3.00-4.50	40.3	37.0-43.0	13.3	9.8-19.1

L = Leaves; S = Stems