

## **Litter accumulation from *Mucuna bracteata* cover crop and its effects on some soil chemical properties in rubber plantations**

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### **Abstract**

*Young rubber plants do not provide sufficient protection to the soil, mainly due to the poor canopy cover. *Mucuna bracteata* (MB) has been introduced recently as a potential cover crop for young rubber plantations. This study aimed to assess the litter accumulation from MB and its impact on soil properties under rubber. In this study sampling was done from different age groups of rubber (1 to 8 years) in two different rubber growing soil series, namely Boralu and Homagama series. Soil samples were collected under three different ground cover conditions, under MB (UM), naturals (NA) and weed free circle (WF) at two soil depths; D1 (0-15 cm) and D2 (15-30 cm). The Experimental design was a fully nested ANOVA with three replicates. Soil organic C, total sol N, available P and K were measured using standard methods. Litter accumulation of MB was significantly high in five years old plantation. Mean soil organic carbon was significantly different between two soil series and at different locations in a rubber plantation. Higher soil N contents (0.22-0.37%) were observed in four, five and six year's old rubber plantations. Soil K content was significantly different between age of rubber plantation and at different locations in a rubber plantation. Highest soil K content (43.47mg/kg) was observed in four years old plantation and lowest value (22.92mg/kg) was observed in the one year old plantation. Available P differed significantly between different locations in a rubber plantation. Peek litter production was under four to five years old plantations and took another one to two years to achieve highest nutrient contents. Results suggest that MB improves soil fertility in 1-8 years old rubber plantations.*

**Key words:** *Mucuna bracteata*, nutrients, organic carbon, rubber, soil fertility

### **Introduction**

In Sri Lanka, rubber is grown as a rain fed plantation crop and plays an important role in its economy. Main rubber growing areas in the country are

low country wet zone and mid country wet zone. These areas are sloppy lands receiving more than 2500 mm annual rainfall with high intensity rain storms lead to soil erosion. In addition

continuous cultivation is also known to deplete soil nutrients and thereby lead to soil degradation (Samarappuli and Yogaratnam, 1995 & 1996). Therefore, establishing and managing of ground cover becomes an important aspect in rubber plantations.

Cover crops may fulfill several purposes in tree crop plantations, which have long been recognized. The leguminous ground cover protect the soil from erosion, enrich it with organic matter, improves soil structure leading to better aeration, increases infiltration and retention of moisture (Samarappuli, 1992). Cover crops also minimize leaching losses of nutrients and competition from noxious weeds (Samarappuli *et al.*, 2004), and should not compete with rubber plants for nutrients and moisture. Legumes are preferred ground covers because they fix nitrogen, which can subsequently be used by the immature rubber plants.

Traditional leguminous cover crop used in rubber plantations of Sri Lanka was *Pueraria phaseoloides* which does not perform successfully against weed growth (Samarappuli *et al.*, 2004). This situation leads to inefficient management of soil and moisture under rubber. Therefore, investigation of new leguminous species with superior characteristics became essential (Samarappuli *et al.*, 2003). *Mucuna bracteata* is a leguminous creeper, grown as a cover crop in rubber plantations and native to Kerala, South India. It has a very vigorous growth pattern, high drought tolerance, high

biomass production, efficient control against weed growth, non palatable to livestock and tolerant to pest and diseases (Mathews, 1998, Samarappuli *et al.*, 2004).

Due to continuous cultivation in rubber plantations organic matter can be reduced. Higher green matter and litter production of *Mucuna* can increase organic matter content in rubber growing soils leading to better soil fertility. *Mucuna* produces a thick litter layer with a thickness of three times higher than *Pueraria* (Samarappuli *et al.*, 2004). The management of nutrient cycling is the function of the biomass production and the decomposition rate (Lehman *et al.*, 2000).

Therefore, the objective of this study was to study the litter accumulation of *Mucuna bracteata* and its contribution to the chemical properties in two selected soil series which are known as *Boralu* and *Homagama*.

### Materials and Methods

This study aimed to assess the litter accumulation from *Mucuna bracteata* and its impact on some soil chemical properties under rubber. In this study sampling of litter and soil were done from different age groups of rubber (1 to 8 years) in two different rubber growing soil series, namely *Boralu* and *Homagama* with textural class of sandy clay loam and sandy loam, respectively (Senarath and Dassanayaka, 1999; Samarappuli, 2000).

Litter collection was done using 1m<sup>2</sup> frame traps and three measurements

were taken in each field. The mean value of the three measurements was used to estimate the litter accumulation, which was extrapolated to get the per hectare value. The same sample was used for chemical analysis of N, P, K, Mg and Ca. N and P were analyzed by colorimetric determination after using Se/H<sub>2</sub>SO<sub>4</sub> digestion procedure and K was determined by flame photometer in the SKALAR Auto Analyzer. Mg and Ca was determined by the single beam atomic absorption spectrophotometer model GBC 903.

Soil samples were collected from three different places or ground cover conditions, namely, under MB (UM), nearby field covered with naturals (NA) and weed free circle around the rubber plant (WF) at two soil depths; D1 (0-15 cm) and D2 (15-30 cm). Soil organic C, total soil N, available P and K were measured using standard methods. Organic C (Nelson, and Sommers, 1996), total N by Se/H<sub>2</sub>SO<sub>4</sub> digestion

(Faithfull, 2002), exchangeable K by Ammonium Acetate extraction (Helmke and Sparks, 1996) and available P by Bray II method (Bray and Kurtz, 1996) were used. Soil N content in the digested samples were determined calorimetrically using a Technicon II auto analyzer (Mulvaney, 1996), Potassium and Mg contents in the extraction were determine using single beam atomic absorption spectrophotometer model GBC 903 and available P were determined using spectrophotometer at 630nm wave length.

The Experimental design was a fully nested ANOVA with three replicates.

## Results and Discussion

### *Litter accumulation of Mucuna*

Dry weight of litter accumulation at different years of rubber plantation for *Homagama* and *Boralu* soil series are shown in Table 1.

**Table 1.** Mean dry weight of litter accumulation with age of rubber for *Boralu* and *Homagama* soil series

Age of rubber	<i>Mucuna</i> litter DW mt/ha	
	<i>Boralu</i> series	<i>Homagama</i> series
1	1.07 <sup>b</sup>	3.01 <sup>b</sup>
2	9.82 <sup>a</sup>	8.55 <sup>a</sup>
3	9.25 <sup>a</sup>	7.54 <sup>a</sup>
4	9.94 <sup>a</sup>	8.48 <sup>a</sup>
5	10.51 <sup>a</sup>	8.67 <sup>a</sup>
6	9.95 <sup>a</sup>	8.35 <sup>a</sup>
8	6.47 <sup>b</sup>	6.56 <sup>b</sup>

Means with the same letters along the column are not significantly different

The dry weight of *Mucuna* litter was not significantly different between the two soil series, but it was significantly different among different ages of rubber plantation. In both soil series, dry weight of *Mucuna* litter at one and eight years after replanting were significantly different from two to six years after replanting ( $p < 0.05$ , using nested ANOVA). Highest litter accumulation was observed in five years old rubber plantation in *Boralu* series soils. Six to eight years after replanting, litter accumulation of *Mucuna* showed a reduction (Table 1). This may be as a result of the increase in shade with the age of the rubber as *Mucuna* receives low sun light due to increase of rubber tree canopy. Due to this growth reduction, litter accumulation can also be reduced. Mathews (1998) and Samarappuli (2007) also reported that under shade *Mucuna* cover crop could grow, but growth was comparatively less.

Chiu *et al.* (2001) found dry litter production by *Mucuna* were 19.6 mt/ha in the open and 8.7 mt/ha under shade of rubber. Samarappuli *et al.* (2004) reported 6.75 mt/ha of litter accumulation under *Mucuna*. Total dry matter production of *Mucuna* litter in the present study was around 9-10 mt/ha which was in agreement with those reported by Mathews (1998) and Samarappuli *et al.* (2004). It is

important to compare litter production of *Mucuna* with other commonly used leguminous cover crop, *Pueraria*. The reported litter production values of *Pueraria* was 1- 2 mt/ha (Mathews, 1998) and 2 mt/ha (Samarappuli, 2004). There was much higher litter production for *Mucuna* than *Pueraria*. Therefore, *Mucuna* can provide thicker mulch cover and higher soil carbon and nutrient contents than *Pueraria*.

#### **Nutrient content of *Mucuna* leaf and litter**

The importance of the cover crop for the nutrient recycling of the cropping system depends on the amount of litter added and the rates of nutrient are recycling. The magnitude of the nutrient recycling is a function of biomass production, the nutrient contents and the decomposition rate (Lehmann *et al.*, 2000).

Nutrient availability of leaf and litter of *Mucuna* are shown in Table 2. These are much higher than the 2.26% of N, 0.1% of P, 0.25% of K and 0.15% of Mg reported by Chiu *et al.*, (2001) for *Mucuna* under oil palm. These differences may be due to the differences in the sampling period and nutrient status of soil. Legumes generally have high foliar N contents typically ranging from 20 to 45 mg/g. They are also rich in other nutrients like P, K and Ca (Szott, 1987).

**Table 2.** Available major and secondary nutrients in leaf and litter of *Mucuna* cover crop

Nutrients	(% ) Dry matter	
	Leaf	Litter
N	4.29	3.18
P	0.35	0.27
P	0.83	0.28
M	0.17	0.16
Ca	0.29	0.58

**Chemical properties of soil**

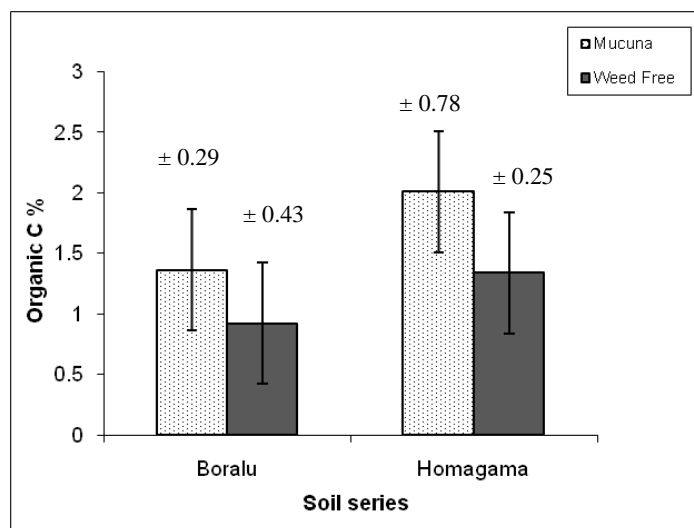
Organic matter is an important parameter which improves soil chemical, physical and biological properties. Higher organic matter layer on soil surface would prevent the direct impact of rain drops, thus preventing the breakdown of soil structure.

A mulch layer on soil surface also act as a barrier against the kinetic energy exerted by rain drops (Samarappuli, 1995). Changes of soil organic C under *Mucuna* and weed free circle for both soil series are shown in Figure 1. Organic C in top soil (0 -15 cm depth) was significantly different between the two soil series *ie*, *Boralu* and

*Homagama* and between the two locations *ie.*, under *Mucuna* and weed free circle around the rubber plants ( $p < 0.05$ , using nested ANOVA). The highest C was observed in *Homagama* series soils under *Mucuna*. Samarappuli (2004) observed 1.1% organic carbon content under *Pueraria* and it was lower than that under *Mucunaa* (2.8%), which indicated higher build- up of organic C under *Mucuna*. In general, soil organic C differed significantly between location ( $p < 0.05$ , using nested ANOVA) and also with top soil and sub soil (Table 3). Top soil showed higher organic C than sub soil.

**Table 3.** Mean soil organic C in different soil depth at different locations

Location	Organic C %	
	0- 15 cm	15- 30 cm
<i>Mucuna</i>	1.72	1.34
Weed Free	1.23	0.98 ±0.25
Naturals	1.52	1.12



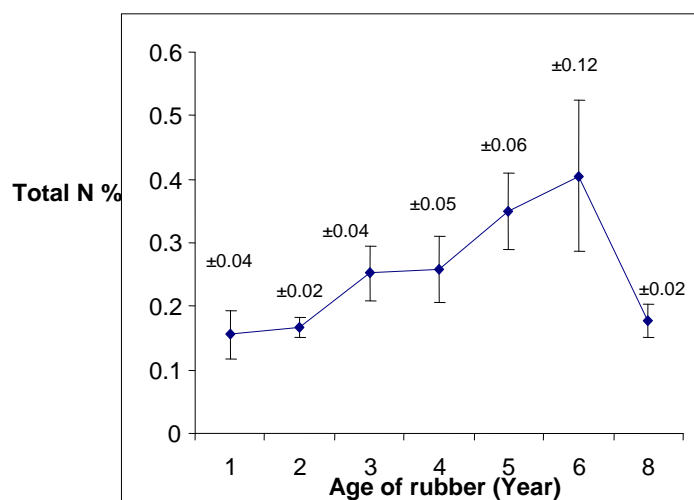
**Fig. 1.** Changes of mean Soil organic C in *Mucuna* and weed free circle in both soil series (Horizontal bars shows  $\pm$  standard deviation)

The changes in soil total N at different depths and in different locations in rubber plantation are shown in Table 4. Soil N contents under rubber in different ages are presented in Figure 2. It showed a significant difference in N contents with different ages and locations ( $p < 0.05$ , using nested ANOVA). Higher N contents were observed in five and six year's old

plantations and lowest value was observed in the one year old plantation. Soil total N under *Mucuna* has increased with the age of rubber plantation in both *Boralu* and *Homagama* series soils. Samarappuli *et al.*, (2004) reported that soil N under *Mucuna* was 0.2% and higher than that of under *Pueraria*.

**Table 4.** Mean soil nitrogen in different soil depth at different locations

Location	Soil Nitrogen %	
	0- 15 cm	15- 30 cm
<i>Mucuna</i>	0.25	0.29
Weed Free	0.14	0.11
Naturals	0.12	0.09



**Fig. 2.** Soil N under *Mucuna* with different age of rubber plantation

Soil K content was not significantly different between the two soil series but it showed a significant differences with age of the rubber plantation and location ( $p < 0.05$ , using nested ANOVA). Soil K under *Mucuna* has increased with the age of rubber plantation and highest K content was observed in three years old plantations and lowest value was observed in the eight year old plantations (Table 5). Samarappuli *et al.* (2004) reported soil K under *Mucuna*

was 64 ppm and under *Pueraria* it was 43 ppm.

Soil P data was not significant between the soil series and age of rubber plantation but showed a significant difference with location ( $p < 0.05$ , using nested ANOVA, (Table 6)). It shows that under *Mucuna*, higher P was observed than natural conditions. Samarappuli *et al.*, (2004) reported soil P under *Mucuna* was 33ppm and under *Pueraria* it was 13ppm.

**Table 5.** Changes of mean soil K with different ages of rubber plantation

Treatments	Soil K mg/kg (Age of plantation)						
	1	2	3	4	5	6	8
Under <i>Mucuna</i>	36.17 <sup>a</sup>	27.04 <sup>a</sup>	57.30 <sup>a</sup>	33.89 <sup>a</sup>	30.00 <sup>a</sup>	19.91 <sup>a</sup>	22.34 <sup>a</sup>
Naturals	36.04 <sup>b</sup>	37.27 <sup>a</sup>	50.57 <sup>b</sup>	25.69 <sup>b</sup>	21.81 <sup>a</sup>	22.97 <sup>b</sup>	23.12 <sup>a</sup>

(Means with the same letters along the column are not significantly different)

**Table 6.** Mean available Soil P under *Mucuna* and naturals

Treatments	Available soil P mg/kg
Under <i>Mucuna</i>	10.92 <sup>a</sup>
Naturals	6.81 <sup>b</sup>

(Means with the same letters along the column are not significantly different)

Possible explanation for the better nutrient content under *Mucuna* could be that it has a deep root system, which allows uptake of nutrients from more deeper layers of soil. Further, weed growth was significantly less while the competition for nutrient was also less.

### Conclusions

The maximum litter production of *Mucuna* was observed in the five years old rubber plantation (10.51mt/ha) in *Boralu* series soils. Soil nutrient contents were higher under *Mucuna* than natural condition (without *Mucuna*) and weed free circle around rubber plants in a rubber plantation. Possible explanation for the better nutrient content under *Mucuna* could be that it has a deep root system, which allows uptake of nutrients from more deeper layers of soil. Further, weed growth was significantly less while the competition for nutrient was also less. Another advantage of *Mucuna* is the increase in soil cation exchange capacity due to increase in soil organic C. This probably contributed to an improved fertility condition of soils under *Mucuna*.

Therefore, it can be concluded that *Mucuna* improves soil fertility in rubber plantations, mainly due to its high contribution of litter to the soil.

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