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Leguminous ground cover *Mucuna bracteata* in mature rubber plantations: Effect on soil pH and organic carbon

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Acidification of agricultural soils is a global concern, and despite increasing awareness about its causes and impact on crop productivity, the cultivated area under acid soils is steadily increasing. Nitrogen addition in excess of assimilation and storage by biota and organic matter and incomplete return of alkalinity of organic anions to the soil cause acidity (Barak *et al*., 1997). Another major factor leading to soil acidification is the imbalance in the uptake of cations over anions by nitrogen fixing leguminous crops (Bolan *et al*., 1991). In areas of Australia where clover has been grown continuously for more than 30 years, the soil pH has decreased by about one unit (Williams, 1980).

In many traditional rubber growing areas, rubber has been repeatedly cultivated for more than a century and there are reports that many plantations are becoming more acidic (Jacob *et al.,* 2012). Rubber plantations are mainly established on sloping and undulating lands in these regions and leguminous ground covers are established along with rubber due to their well-documented multiple advantages. *Pueraria phaseoloides* and *Mucuna bracteata* are the popular cover crops in India (Philip *et al*., 2005). *Pueraria* is shade sensitive and after the luxuriant growth in the initial years, dies off when shade intensifies in the plantation whereas, *Mucuna* is comparatively shade tolerant and once established, will continue to survive throughout the plantation cycle in most cases. The long term effect of *Mucuna* on soil acidification in rubber plantations was not studied so far and the present study was taken up with this objective. The effect of retaining *Mucuna* on soil organic carbon status and other chemical properties was also studied.

The study was conducted at three locations, one each in North Central, Central and South Kerala. In each location, soil samples were collected from adjacent 18-20 year old plantations with and without *Mucuna bracteata* as ground cover. Each plantation was divided into eight blocks and composite soil samples (0-30 cm) were collected from each block for chemical analyses during August 2012 before post-monsoon fertilizer application. Extent of above ground dry matter production by *Mucuna* was also quantified.

Soil samples were dried in the shade, sieved through 2 mm sieve and analyzed for soil pH (1:2.5 soil water ratio), organic carbon by Walkley and Black's method as described by Jackson (1973), available phosphorus by chloromolybdic stannous chloride reduction method using Bray II extractant (Bray and Kurtz, 1945), available potassium using flame photometer (Morgan, 1941) and available calcium and magnesium by ammonium acetate extraction (Vogel, 1969) followed by subsequent determination by atomic absorption spectrophotometer (Avanta-GBC Scientific equipment Company Ltd. Australia). Exchangeable Al content and total exchangeable acidity were determined from two locations, North Central Kerala and Central Kerala as described by McLean (1965). The data sets were compared by t-test.

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Table 1. Effect of *Mucuna bracteata* ground cover in rubber plantations on soil pH

Location	Without *Mucuna*	With *Mucuna*
North Central Kerala	5.74	4.88**
Central Kerala	5.17	4.89**
South Kerala	5.23	4.97**

** significant at p<0.01 level

Soil pH was significantly lower in rubber plantations with *Mucuna* as ground cover compared to the adjacent plantations without *Mucuna* (Table 1). Soil acidification due to the imbalance in the uptake of cations over anions by nitrogen fixing leguminous crops is well documented (Williams, 1980) and this might be the reason for the lower soil pH under *Mucuna*. Nitrogen fixation by *Mucuna* in mature rubber plantations is expected to be less due to the shaded situation, compared to the young rubber plantations. A short period of 30-45 days with less shade is available due to the leaf shedding of rubber trees during annual wintering. Hence, though less in quantity, nitrogen fixation might take place in mature rubber plantations also. Furthermore, the recycling of litter might also lead to reduction in soil pH. Content of excess cations or litter alkalinity influence the effect of residues on soil pH, and residues with lower content of litter alkalinity has the higher acidifying effect (Noble *et al*., 1996; Marschner and Noble, 2000; Xu *et al*., 2006). A comparison of litter alkalinities of various ground covers in rubber plantations showed that *Mucuna* litter had the lowest alkalinity compared to *Pueraria* and natural flora and thus the highest acidifying effect (Jessy *et al*., 2013).

The magnitude of the difference in soil pH between adjacent fields with and without *Mucuna* varied between the locations. *Mucuna* is comparatively shade tolerant and when established in young plantations, continue to survive in the mature rubber plantations also. But the extent of growth varies between locations depending on the light availability within the plantations, which again is influenced by the extent of tree loss in the plantations due to various factors. The change in pH over time will be influenced by soil type and initial soil pH (Butterly *et al*., 2013), and in the present study also, the extent of reduction in pH

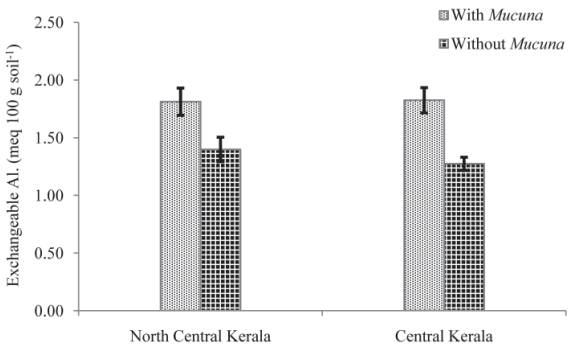

Fig. 1. Effect of leguminous ground cover *Mucuna* in rubber plantations on soil exchangeable Al content

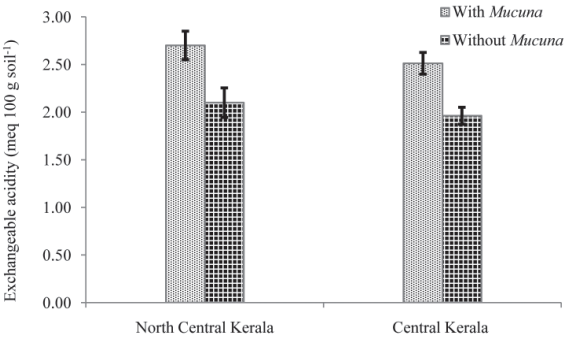

Fig. 2. Effect of leguminous ground cover *Mucuna* in rubber plantations on total exchangeable acidity of soil

was higher in the soil with higher pH. Though the optimum range of pH for *Hevea* is reported to be 4-6.5, it can tolerate pH of 3.8 to 7.0 (Krishnakumar and Potty, 1992) and in all the fields studied, soil pH was within this range. Soil exchangeable Al and total exchangeable acidity was also significantly higher under *Mucuna* (Fig. 1 and 2). Contrary to this observation, Jessy *et al*. (2013) observed that in young rubber plantations, though soil pH was significantly lower under *Mucuna bracteata* compared to *Pueraria* and natural cover, there was no corresponding increase in exchangeable Al and total exchangeable acidity under *Mucuna*. This might be due to the complex formation of Al by the decomposition products of *Mucuna* litter which is substantially higher than that of *Pueraria* (Philip *et al*., 2005) in young rubber plantations.

Soil organic carbon status varied between locations and was significantly higher under *Mucuna* in all the locations (Fig. 3). Though less vigorous in growth compared to the young

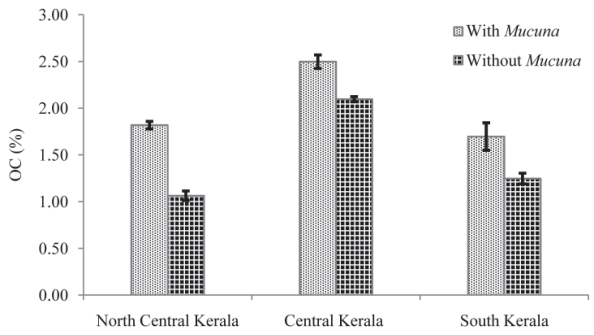

Fig. 3. Effect of leguminous ground cover *Mucuna* in rubber plantations on soil organic carbon status

plantations, *Mucuna* covers most of the inter-row area in mature rubber plantation also and reduces run off and erosion. Apart from this, the recycling of litter will also contribute to the higher organic carbon status under *Mucuna*. The above ground dry matter accumulation by *Mucuna* in the mature rubber plantations studied was 2.12, 1.80 and 2.12 t ha^{-1} in North Central Kerala, Central Kerala and South Kerala respectively. Cattle grazing is common in many mature rubber plantations, and hence the growth of natural flora will be restricted in such plantations. *Mucuna* is unpalatable to cattle and at all the locations studied, the plantations without *Mucuna* were grazed by cattle and there was virtually no undergrowth, and this might be the reason for the higher soil organic carbon status observed under *Mucuna* in comparison to the adjacent fields without *Mucuna.* Retaining an undergrowth of weeds in rubber plantation also will improve soil organic carbon status as reported by Abraham and Joseph (2012).

Regular manuring with urea, rock phosphate and muriate of potash was practiced in all the fields and there was no significant difference between the fields with and without *Mucuna* in the status of these nutrients. Soil available P status showed wide variation within the same field itself and between locations, but there was no significant difference between fields with and without *Mucuna*. Soil potassium status varied between locations, 39.2 mg kg^{-1} in central Kerala to 168.9 mg kg^{-1} in North Central Kerala, but there was no significant difference in fields with and without *Mucuna* in all the locations. In the case of Ca and Mg also, status varied between locations, but there was no significant difference between the two situations.

The results showed that retaining *Mucuna* in mature rubber plantations increased soil organic carbon status and reduced soil pH to varying degrees and hence acidity of rubber growing soils should be compared in relation to the ground cover management also.

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