S.L.J Tea Sci. 70(1), 18-28, 2005, Printed in Sri Lanka

Potential of Selected Green Matter Sources for Mulching and Green Manuring in Tea Plantations

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ABSTRACT

A study was carried out to investigate the potential of various green materials as alternative sources of green manure or mulch to improve the soil fertility in Low country tea plantations. Green materials of *Flemingia congesta, Cassia spectabilis, Euphatorium innulifolium,* and *Lantana camara* were tested against unthatched control in three replications. Tender shoots/leaves of each species were spreaded on randomly chosen squares in each replicate at 3 kg m^{-2}. The rate of breakdown of materials in terms of percentage ground exposure was assessed. Weed density, weed fresh and dry weights were also measured at 4-6 week intervals. Soil organic C and pH were also analyzed.

About 50% of the ground exposed in plots mulched with *E. innulifolium, L. camara, C. spectabilis* and *F. congesta* at 4, 6, 7.5 and 18 weeks after mulching (WAM), respectively. The total breakdown of green matter of *E. innulifolium, L. camara, C. spectabilis* was recorded at 20 WAM and the ground exposed only 88% in *F. congesta* treated plots even at 24 WAM.

Weed density significantly ($p<0.05$) reduced in all mulched treatments compared to that of untreated control at 8 WAM. It was significantly greater in *E. innulifolium* and *L. camara* treatments compared to that of *F. congesta* and the control treatment at13 WAM. Weed dry weight was significantly greater in *E. innulifolium* treated plots even at 4 WAM when compared to the other treatments. Further, it was significantly lower in *F. congesta* and *C. spectabilis* treatments compared to that of *E. innulifolium* and untreated control, 8 WAM. The, lowest weed density and dry weights were recorded with *F. congesta* mulch until 18 WAM.

The soil organic C content increased in all the treatments until 24 WAM and *E. innulifolium* treatment and showed the highest C content. Low C contents recorded in both unthached control and *C. spectabilis* treatments were comparable. Carbon content was significantly ($p<0.05$) greater in *F. congesta* and *L. camara* treatments at 24 WAM onwards compared to that of the unthatched control. Soil pH was significantly greater in *E. innulifolium* and *C. spectabilis* when compared to *F. congesta* and the control treatments, until 24 WAM. However, pH was increased in *F. congesta* treatment at 28 WAM.

Green materials of *E. innulifolium* and *L. camara* have a very good potential for making compost or to use as green manure at their tender phase of growth. Shoots of *F. congesta* could be recommended as a good source of mulch for tea. Shoots of *C. spectabilis* could also be used as a source of green manure or mulch for tea cultivations.

Key words: mulching, green manure, tea, weed density

INTRODUCTION

Mulching is a recommended practice for newly planted tea fields as young tea remains exposed to the vagaries of weather until the tea canopy is formed to provide adequate soil cover. The objective of having a ground cover is not only to conserve the soil and moisture, but also to manage weed growth. Furthermore, the fertility in tea soil has become poor particularly in the low country due to heavy erosion and fast breakdown of organic matter in soil. Consequently, the productivity in tea fields is in a poor state. Being a perennial crop, ground covering and soil improvement in tea fields is therefore essential to be practiced as a continuous process.

Traditionally, Mana (*Cymbopogon confertiflorus*) or Gautemala grass (*Tripsacum laxum*) is used for mulching (thatching) to cover new clearings of tea. About 30-40 t ha^{-1} of grass biomass is required to mulch one hectare of tea land and it is necessary to re thatch at least 3 times annually. Practically it is not possible for all the estates to supply such large amount of biomass to their tea fields due to lack of lands for the maintenance of 'thatch banks' and high cost of mulching. Likewise, improvement of soil fertility by way of application of organic fertilizer such as cow dung or farmyard manure is also not possible. The loppings of shade trees are also not sufficient to provide the ground with a proper cover right throughout the year. Therefore, an investigation on the feasibility of using some green materials as alternate sources of ground cover and green manure, is timely important.

The suitability of any material as a source of mulch or a green manure would depend upon its durability on soil and the ability to improve soil fertility. An understanding of the rate of breakdown of any material is a useful guide for farmer's decision making in the selection of materials. Prematilake (1996) and Prematilake *et al.* (1998) reported that *Flemingia congesta* has a very good potential as an alternative source of mulch which lasts longer on soil. Species like *Euphatorium innulifolium* which is known as "Curringhan" is commonly found in the Up country and Uva region and *Cassia spectablis*, a tree species and *Lantana camara* (Gandapana) are found in the Mid and Low country of Sri Lanka. These species are freely grown on fences, road sides, waste lands and under forest plantations without having any proper use. *L. camara* is also spreading fast in agricultural lands as an invasive species (Mo, 1999). The objective of the present study is to further confirm the potential of *F. congesta* as a source of mulch and investigate the feasibility of using other green matters as sources of mulches and green manure for tea.

MATERIALS AND METHODS

This study was conducted at the Low Country Station, Ratnapura, at an elevation of about 30 m amsl. The soil belongs to the major soil group Red Yellow Podsolic (Ultisol). An open area in a tea field was selected for the experiment and 1 m^2 was demarcated for each treatment with three replications following weeding and soil leveling. Green materials of *F. congesta, C. spectabilis, E. innulifolium* and *L. camara* all at their tender phase of growth i e before flowering were tested against an unthatched control. The experiment consisted of a Randomized Complete Block Design (RCBD).

Tender shoots of each species, which consisted of leaves, petioles and rachis, were used for mulching. Each material was evenly spread on randomly chosen squares in each replicate at 3 kg m^{-2} in order to cover the ground properly. The dry matter content of *F. congesta, C. spectabilis, E. innulifolium* and *L. camara* were 28%, 22%, 19% and 21%, respectively. About 3-4 kg of fresh biomass was required to cover an area of 1 m^2.

The rate of breakdown of materials was assessed in terms of percentage ground exposure at monthly interval commencing from 6 WAM. To make more precise assessments, a wire mesh with a total area of 0.5 m^2 with 16 small squares, was used. The mesh was placed four times on each thatched area in order to assess the percentage exposure of the entire 1 m^2 area.

The density, fresh and dry weight of weeds were measured at 4-6 week intervals commencing from 4 WAM from each treatment including the unthatched control. Soil organic C was analysed using the Walkley and Black method (Grewelling and Peech, 1960; Peech *et al.*, 1947; Walkley, 1947). After 12 WAM, soil pH was also measured at same intervals.

RESULTS AND DISCUSSION

Rate of ground exposure and breakdown of green materials

The rate of ground exposure in concurrence with the degradation of mulching materials is depicted in Fig. 1. The difference in the rate of break-down between each material was significant at 6 WAM. Thereafter, the differences became lesser indicating no significance in *E. innulifolium, C. spectabilis* and *L. camara* treatments. The differences in the rate of decaying between *F. congesta* and other materials were highly significant throughout. It was assumed that 50% ground exposure reflects the loss of half of each mulching material on the basis that each square was evenly mulched, and therefore the time taken to decompose 50% was considered half-life of each material. Accordingly the half-life of *E. innulifolium, L. camara, C. spectabilis and F. congesta* were 4, 6, 7.5 and 18 weeks, respectively. The same duration was previously recorded for *F. congesta* (Prematilake, 1996; Prematilake *et al.*, 1998). Eventually, *E. innulifolium, L. camara* and *C. spectabilis* had been totally decomposed at 20 WAM. Whereas, it was only 88% in *F. congesta* treatment even at 24 WAM.

The loss of green materials in soil is mainly due to microbial decomposition as well as by the removal of soil fauna such as insects and arthropods (Budelman, 1988 b). Prematilake (1997) also observed that termites, some arthropods and snails, which fed on mulch are involved in the process of breaking the material under Low country conditions. Other than microbial activity, some parts were removed by small birds and squirrels, as they carried them away from the plots. The factors that affect the decomposition of material by soil microbs and other fauna are the soil moisture level or rainfall, soil and ambient temperature, some morphological characteristics of leaves and lignin content of leaves etc.

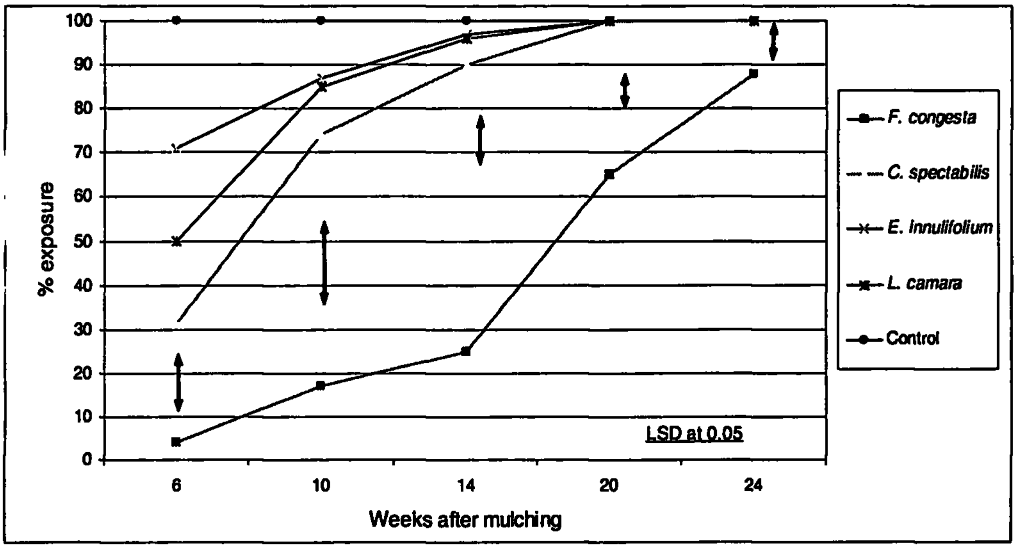

Fig.1: Percentage ground exposure following breakdown of different mulching materials

The fast breakdown of green matters of *E. innulifolium, L. camara* and *C. spectabilis* could be attributed to their lower C:N ratio (Table 1). In contrast, great durability in *F. congesta* could be attributed to its high C:N ratio. The laboratory analyses have recorded a very low C:N ratio (11.2) in *E. innulifolium* leaves and high N% as indicated in Table 1 (Prematilake *et al.*, 2002). High N content together with low C:N ratio might be responsible for fast breakdown of the material in soil. The same mulch under Up-country conditions lost almost 90% of its green matter within 10-12 weeks after thatching (Premtilake and Gamage, 2003). The fast decomposition of the material together with the maintenance of high organic C level in soil itself, indicates that green materials of *E. innulifolium* is more suitable for production of compost or to use as a green manure.

Some reports showed that some Up-country farmers occasionally use *E. innulifolium* for making compost. In Java too, it is used as a source of green matter for making compost (Kehl and Rajiah, 1954). Prematilake *et al.* (2002) showed that about 15-22 mt ha^{-1} of biomass can be yielded from a single lopping from a field with a dense cover of *E. innulifolium,* before flowering.

Breakdown of *F. congesta* mulch was very slow and this could be attributed to its high C:N ratio of 21:1 as reported by Budelman (1988 b). Further, Budelman, (1988 a) indicated that the presence of high lignin content in leaves explains the persistency of *F. congesta.* Perera (1993) reported that comparatively lower digestibility in *F. congesta* leaves was associated with high lignin content of 30%.

Table 1: C:N Ratio and K content in some green matters

	N%	C:N Ratio	K%
Cassia spectabilis (Legume) (Wickramasinghe, 1985)	3.85	10.08	1.08
Tithonia diversifolia (Non-legume) (Wild Sunflower) (Wickramasinghe, 1985)	4.76	7.23	2.70
Cymbopogon confertiflorus (Non-legume) (Mana grass) (Wickramasinghe, 1985)	1.40	28.80	1.40
Flemingia congesta (Legume) (Budelman, 1988 b) and GTZ-UMWMP Pers Commun)	3.30	21.00	2.40
Euphatorium innulifolium (Non-legume) (Prematilake *et al.*, 2002)	3.15	11.20	2.00

Prematilake *et al* (1998) reported that *F. congesta* leaves are less susceptible forlow country termites than *Gliricidia sepium* leaves. Thus, the same reason may be attributed to its tolerance to termites. As Budelman (1988 a) reported large leaflets of *F. congesta* were firmly attached to the petiole when drying started. The leaflets have a strong tendency to curl during drying thereby the litter has less contact with the soil where microbial and other fauna activities occur.

Prematilake *et al* (1998) reported that the maximum half-life periods (i.e. time taken to occur 50% ground exposure following thatching) of 6.0, 11 and 20 weeks for *G. sepium, C. confertiflorus* and *F. congesta,* respectively. Also maximum periods of 11, 27 and 28 weeks were recorded for break down of 95% of the same green materials. Same trend in respect of *F. congesta* in the present study was observed with 50% and 88% decomposition at 18 and 24 WAM, respectively.

C. spectabilis is reported to be a material with a lower C:N ratio of 10.08 (Wickramasinghe, 1985). Such a lower C:N ratio might have attributed to the fast breakdown of its green matter compared to *F. congesta*. Further, the succulent nature of leaves had closer contacts with soil underneath, where microbial activities take place, particularly when soil is wet. However, a comparatively slow rate of breakdown of *C. spectabilis* than that the *L. camara* and *E. innulifolium* may be due to waxy layer on its leaf surface and fibrous nature of the leaf structure. The system of veins of the leaf was visible, indicating partial decomposition, while green materials of *L. camara* and *E. innulifolium* had been totally disappeared. *E. innulifolium* leaves were rapidly separated from petiols and formed a more compact structure pasting many leaves each other, under wet conditions. Adherence of these leaves to wet soil might give rise to microbial and other fauna activities on the mulch. Termite attack was also observed (*Coptotermes ceylonicus)* on the mulch.

In *L. camara* mulch, leaflets rapidly separated from the rachis, folded and appeared to be curled. Thus, the litter had a lesser contact with soil compared to *E. innulifolium* mulch. Further, breaking of leaflets, into small pieces under dry weather allowed them to blow away with winds and also to wash away by rain water.

Weed growth

Weed density was significantly ($p<0.05$) reduced in all treatments at 8 WAM compared with unthatched control (Fig. 2). However, there was no significant difference in weed count within mulched treatments. Weed density was significantly ($p<0.05$) increased with *E. innulifolium* and *L. camara* mulches when compared with *F. congesta* mulch and unthatched control at 13 WAT. However, weed density was not affected significantly at 18 WAT onwards. The lowest density was recorded with *F. congesta* mulch until 18 WAT. It was found that the weed density was comparable in all treatments after 18 WAT.

Weed dry weight was significantly ($p<0.05$) increased in plots thatched with *E. innulifolium* even at 4 WAT when compared with other treatments (Fig.3). There was significantly lower weed dry weight in *F. congesta* and *C. spectabilis* treatments at 8 WAT. Although non-significant, weed dry weight was relatively greater in *C. spectabilis* and *E. innulifolium* and *L. camara* treatments at 13 and 18 WAT. Similar to the weed density, the weed dry weight was also comparable in all the treatments thereafter.

The results indicated that weed growth was suppressed by the mulching materials as long as it was able to persist on soil by providing a proper ground cover. However, the weeds emerged from the ground with gradual exposure of the ground with the breakdown of the mulch. Furthermore, high soil organic matter content and moisture following mulch breakdown created conducive conditions for weed growth even at very early stage of mulching.

The poor weed growth in *F. conjesta* treatment could be attributed to its persistency on soil, with the provision of 50% ground cover, over a period of about 18 weeks. Prematilake *et al.* (1998) also reported a significantly lower weed growth for a period of 14 WAT with *F. conjesta* when compared with untreated control. Budelman (1988 a) introduced this period with a poor weed growth as '*Effective Life Span* (ELS) of a given mulch and reported an ELS of 12.5 weeks with *F. conjesta* at 3 t DM ha^{-1}. The ELS of Mana (*C. confertiflorus)* in the same study was 9 weeks and it indicates the potential of *F. conjesta* as an alternative source of mulch.

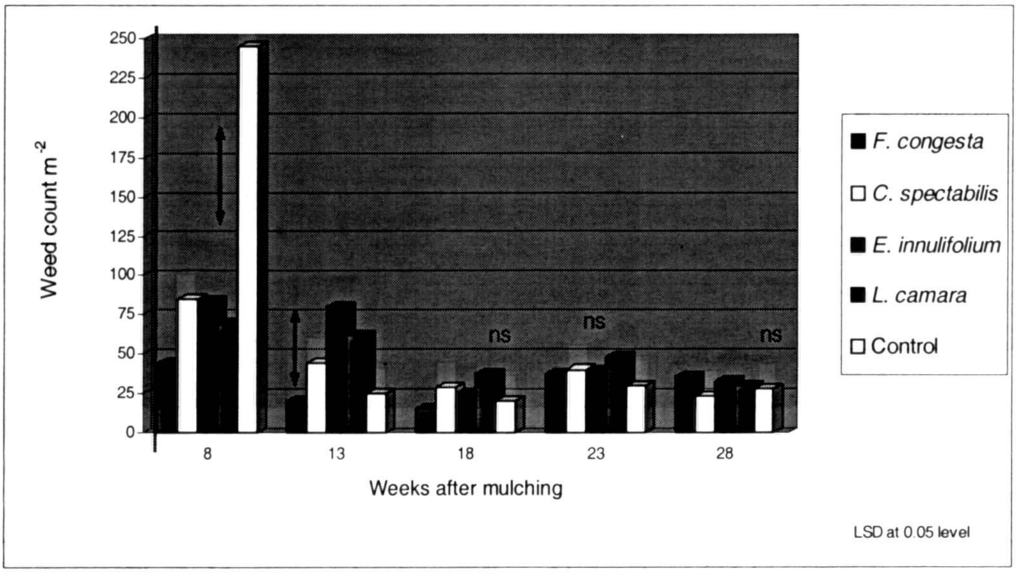

Fig. 2: Mean weed density as affected by various mulch treatments

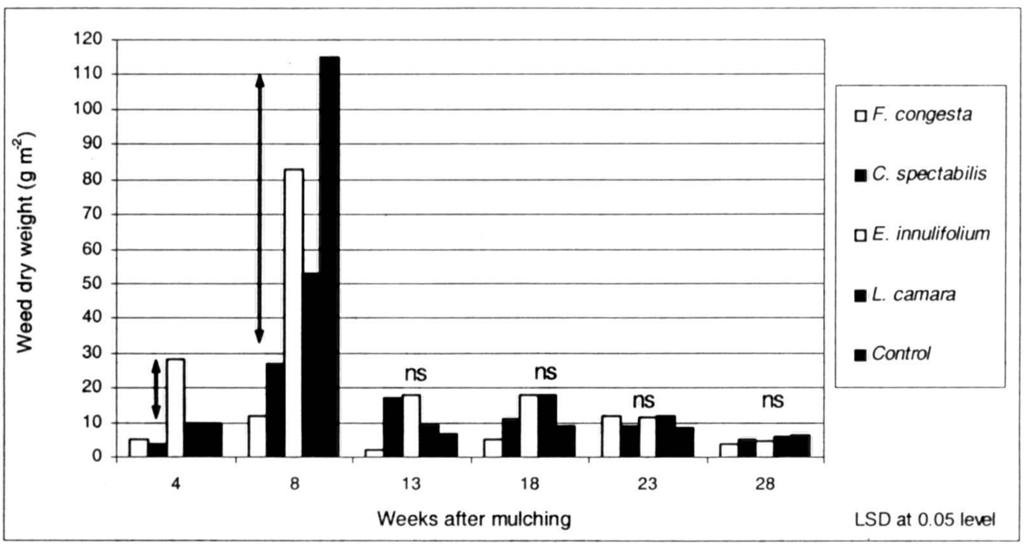

Fig. 3: Mean weed dry weight as affected by various mulch treatments

The early ground exposure of *C. spectabilis E. innulifolium* and *L. camara* treated plots coupled with soil enrichment with high organic matter and moisture, resulted in heavy weed infestation. Prematilake *et al.* (1998) reported 5-6weeks of ELS for *Gliricidia sepium,* also had very low C:N ratio of 9.3:1 (Wickramasinghe, 1985). Anon (1999) reported poor germination and seedling growth of Passali kodi (*Anredera cordifolia)* bulbils when dipped in an aqueous extract of *E. innulifolium* and *L. camara* leaves but germination was not poor with *F. congesta* and *C. spectabilis* leaf extracts. However, a fast germination and growth were observed, when the same fresh bulbils were potted followed by mulched with *E. innulifolium leaves.* De Silva (2000) also reported that the aqueous extracts of *L. camara* has both positive and negative allelopathic effects on germination and growth of rice seedlings. Although, there could be some impact of allelopathic compounds found in the green materials on weed growth, such effects might have been masked by the smothering effect of mulches.

Soil Organic Carbon and Soil pH

There was an increasing trend in soil C content until 24 WAM in all the treatments. The highest soil organic C content was recorded in *E. innulifolium* mulch with a significantly greater C% than that of other mulches at all phases except for *F. congesta* 28 WAM (Fig 4). Plots treated with *C. spectabilis* recorded a significantly low C% than that of *L. camara* and *E. innulifolium.*

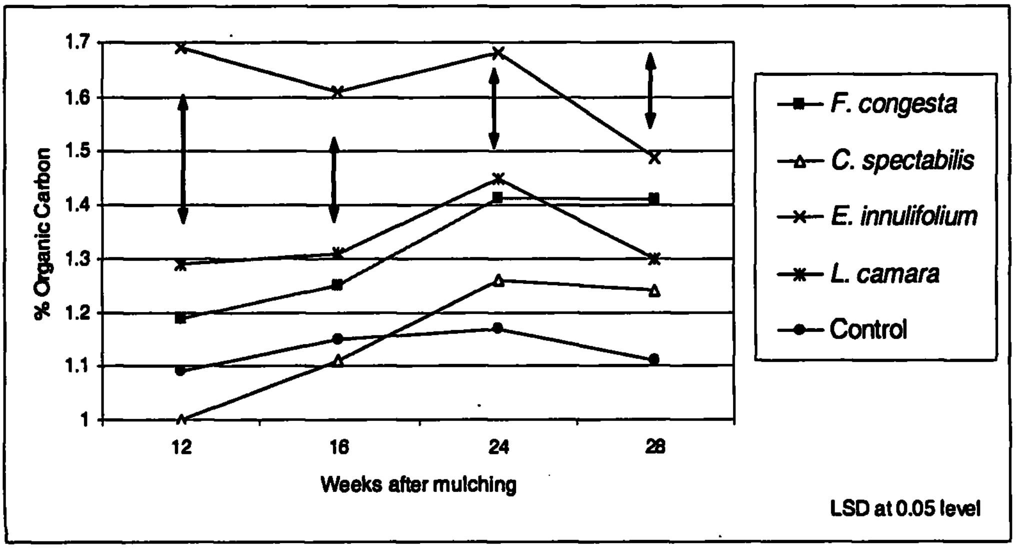

Fig. 4: Soil organic Carbon content as affected by different mulching treatments

As shown in Fig. 5, significantly higher soil pH was recorded in plots thatched with *E. innulifolium* and *C. spectabilis* at 12, 16, 24 WAM, when compared with *F. congesta* and unthatched control treatments. The pH was significantly greater with *L. camara* treatment than that of *F. congesta* treatment until 24 WAM. Wijeratne *et al* (1999) and Heenkenda and Gunaratne (2000) reported an increase of soil pH with refuse tea and Gliricidia mulch, respectively. As the breakdown of *F. congesta* mulch was faster at the latter phase, there was a rapid increase in pH at 28 WAM. The high soil pH may also could be attributed to the occurrence of many weeds in *E. innulifolium*, *C. spectabilis* and *L. camara* treated plots.

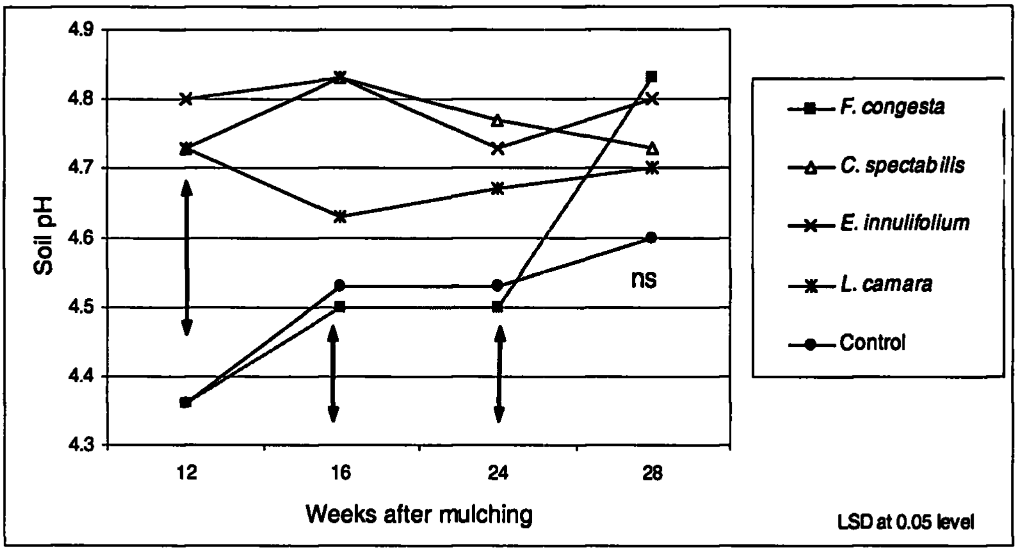

Fig. 5: Soil pH level as affected by different mulching treatments

The durability of any green matter on soil is the prime factor that governs the rate of ground exposure followed by the occurrence of weeds, *i.e.* the faster the decomposition of materials, the quicker the ground exposure and emergence of weeds. Therefore, more emphasis has to be given on the durability and nutritive value of any material in its selection for the purpose of mulching or green manuring. Furthermore, coppicing ability of a given plant species also an important factor because a higher weight of biomass is required to thatch tea lands or supply green manure. *I. innulifolium,* being a plant having a high nitrogen content high coppicing ability (Prematilake *et al.*, 2002), it has a big potential to use as a green manure crop. Similarly, *C. spectabilis* as a large tree species can also produce a large quantity of biomass periodically and could be used for green manuring in tea fields. Since *L. camara* as an 'invasive' type species, its fast spreading in agricultural lands could be avoided by regular lopping of its tender shoots and by using them as a green manure. The mulch of *F. congesta* has shown a great persistency on soil and has a great potential for using as a ground cover. Harnessing such species for increasing the crop productivity would therefore be a great benefit to the cultivators.

CONCLUSIONS

The green materials of *Euphatorium innulifolium* are found to be more suitable for making compost or green manuring rather than using as a mulch. The superiority of green materials of *Flemingia congesta* as a good source of mulch is further confirmed. Tender shoots of *Cassia spectabilis* and *Lantana camara* can also be used as green manure. Although, direct impact of mulches on tea growth was not investigated, it could be possible to recommend these materials for compost making or as good sources of mulches or green manure for tea fields, because no serious agronomical or other pest and disease hazards were reported due to use of those materials. However, more emphasis has to be drawn to select only the tender shoots of *E. innulifilium* and *L. camara*, because mature shoots at bearing stage could result in a massive production of seeds, thereby spread of these species on tea lands as weeds.

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