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Potential of Various Green Matters as Mulches and Their Impact on Weed Suppression in Tea Lands

K.G. Prematilaka, R.J. Froud-Williams[1] and P.B. Ekanayake[2]

Agronomy Division
Tea Research Institute
Ratnapura, Sri Lanka

ABSTRACT. A study was carried out to investigate the suitability of alternative thatching materials on tea fields and their potential for weed suppression at the Low Country Station of Tea Research Institute, Ratnapura (elevation 60 m amsl), Sri Lanka. Three successive thatching of Cymbopogon confertiflorus, Gliricidia sepium and Flemingia congesta were evaluated against an unthatched control. Each material was spread thoroughly at the rate of 1 kg dry matter m^{-2}. Rate of ground exposure with the decomposition of each material over time was recorded and the weed growth in plots was assessed.

Gliricidia sepium, C. confertiflorus and F. congesta mulches had maximum half-life periods of 6, 16, and 20 weeks, respectively (i.e. time taken for 50% ground exposure) during three successive thatchings. The maximum time period taken for 95% of ground exposure in plots thatched with G. sepium was 11 weeks (second thatching), C. confertiflorus was 27 weeks (third thatching) and F. congesta was 28 weeks (third thatching). Weed density was significantly reduced by the F. congesta mulch three months after first thatching. During the first thatching, overall weed dry weight was the lowest in F. congesta treatment which was a two to three-fold reduction when compared to that of the unthatched control and G. sepium mulch. Over three thatching rounds, the density and dry weight of weeds in plots mulched with G. sepium were similar to that of the unthatched control, but significantly higher than that of F. congesta and C. confertiflorus. The effective life span (ELS) of G. sepium, C. confertiflorus and F. congesta were about 5–6, 9 and 14 weeks, respectively.

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1 Department of Agricultural Botany, School of Plant Sciences, University of Reading, United Kingdom.

2 Mid Country Advisory and Extension Centre, Tea Research Institute, Hantane, Kandy, Sri Lanka.

INTRODUCTION

Tea [*Camellia sinensis* (L.) O. Kuntz.] which was originated from a forest environment prefer the conditions of ground litter cover. In plantations, tea itself contributes a proportion of its vegetation to this litter. However, thatching is a recommended practice particularly for newly planted tea fields since young tea remains exposed to the vagaries of weather until such time a canopy is formed to provide adequate soil cover. With such ground exposure, soil is prone to erosion, higher moisture loss, poor fertility and heavy weed infestation (Wijeratne *et al.*, 1994). Thus, the loppings of either mana (*Cymbopogon confertiflorus*) or gautemala (*Tripsacum laxum*) grass are used as thatching materials and their beneficial effects are well documented (Sandanam and Rajasingham, 1982).

About 30–40 t ha^{-1} of fresh grasses are required for a single thatching of tea fields and it is necessary to re-thatch at least 3 times annually. In order to meet such a demand, maintenance of a 'thatch bank' is advocated. However, this is not possible in all tea estates due to the lack of land availability. The high cost of thatching with grasses is also a major obstacle. Thus, the feasibility of alternative plant species for use as thatching materials needs to be investigated.

The efficacy of any thatching material depends on its durability when thatched on the ground. Moreover, the understanding of the rate of decomposition is useful in a decision-making on suitable thatching material and frequency of thatching within a given period. Hence, a study was initiated under field conditions to evaluate the suitability of *Flemingia congesta* and *Gliricidia sepium* based on their rate decomposition and potential for weed suppression when compared to commonly used *Cymbopogon confertiflorus.*

MATERIALS AND METHODS

The study was conducted at St. Joachim estate, Tea Research Institute, Ratnapura, Sri Lanka, during the period of July 1994 to May 1995. The experimental site was located at an elevation about 60 m amsl, and soil was Red Yellow Podsol (Ultisol) with sandy loam. A bare land adjacent to a tea new clearing was selected for the study. An area of 1 m^2 was demarcated for each treatment after weeding and soil levelling. Each area was fenced by fixing wooden frames of 10 cm in height.

Loppings of mature *Cymbopogon confertiflorus* and tender shoots of *Flemingia congesta* and *Gliricidia sepium* which consisted of leaves, petioles and rachis, were used as thatching materials. Each green material was spread thoroughly on randomly chosen squares on three successive occasions as indicated in Table 1. An unthatched plot was used as the control. The experiments were carried out in a randomized complete block design (RCBD) with four replicates.

Table 1. The date and rate of mulch applied.

Materials	Thatching 1 26 July 1994		Thatching 2 01 December 1994		Thatching 3 05 May 1995	
	Fr. Wt. $kg\ m^{-2}$	Dry Wt. $kg\ m^{-2}$	Fr. Wt. $kg\ m^{-2}$	Dry Wt. $kg\ m^{-2}$	Fr. Wt. $kg\ m^{-2}$	Dry Wt. $kg\ m^{-2}$
Cymbopogon confertiflorus	3.75	1.0	3.95	1.0	3.35	1.0
Flemingia congesta	3.49	1.0	3.57	1.0	3.17	1.0
Gliricidia sepium	4.54	1.0	3.40	1.0	4.10	1.0

Fr. Wt. - fresh weight   Dry Wt. - dry weight

Fresh *C. confertiflorus* grass at the rate of 3.75 kg m^{-2} was used as the standard rate equivalent to the recommended rate of thatching on tea fields. The rates of *F. congesta* and *G. sepium* was adjusted to supply the same amount of dry matter as that of *C. confertiflorus i.e.* 1 kg m^{-2}. The second and third thatchings were applied after about 85% of the previous mulch has decomposed.

Assessments and identification of weeds emerged through the mulch in each demarcated area were done before imposition of treatments and after imposition at 4–6 weeks interval, depending on weed density. After a weed count, the above ground biomass was oven–dried to determine the dry weight. Further, visual observations were made on the rate of decomposition of each thatching material in terms of % ground exposure at weekly intervals. A wire mesh with a total area of 50×50 cm^2 having 16 small squares (each of 12.5×12.5 cm^2 area) was used to estimate the % ground exposure. The mesh was placed four times on each thatched area, in order to assess the entire one m^2 area. The % ground exposure within each of the sub quadrats was recorded and total % exposure was determined accordingly. By the end of the experiment, soil organic carbon content at the depth of 0–15 cm was analysed using the Walkley–Black Method (Walkley, 1947; Peech *et al.*, 1947; Grewelling and Peech, 1960).

Statistical analyses

Data on % ground cover were transformed to arc–sine values to achieve a normal distribution and homogeneity of variance prior to ANOVA. Data for weed density and weed dry weight were also log–transformed and analysed using GLM procedure with the inclusion of the initial weed counts as a co–variate. Mean values were separated using LSD at $p=0.05$.

RESULTS AND DISCUSSION

Rate of ground exposure with decomposition of materials

The rate of ground exposure is summarised in Table 2 in concurrence with the degradation of mulch as depicted in Figures 1 a, b, c. It was assumed that 50% ground exposure reflects the loss of half the thatching material since the squares were evenly thatched and the time taken was considered its half-life.

The shortest half–life period and time taken for 95% ground exposure were recorded with *G. sepium* during the three successive thatchings. During the second thatching, mulch of *G. sepium* recorded the shortest overall half–life period *i.e.* 3.4 weeks. A two–fold increase in time taken for 95% ground exposure was recorded with C. confertiflorus when compared to *G. sepium*.

During the third thatching, *G. sepium* decomposed at a similar rate to that of the first thatching (Table 2; Figure 1). The half life of F. *congesta* and *C. confertiflorus* was almost doubled than that of the first thatching. In these two mulches, the time taken to expose the ground by 95% was longer in the third thatching when compared to previous thatchings.

Table 2. The rate of ground exposure (weeks) following three successive thatchings with three different mulches.

Source	% Exposure					
	Thatching 1		Thatching 2		Thatching 3	
	50%	95%	50%	95%	50%	95%
Gliricidia sepium	5.9	9.0	3.4	11.0	6.0	8.9
Cymbopogon confertiflorus	8.8	14.0	12.6	21.2	16.0	27.0
Flemingia congesta	9.2	17.0	17.0	22.0*	19.9	28.0

* 87% exposure 22 weeks after second thatching *i.e.* before third thatching.

Decomposition of mulch materials is a result of microbial activities, termites, some arthropods and snails which feed on the mulch. In addition, a small proportion could be lost due to removal by birds and squirrels especially in the case of *C. confertiflorus*. Budelman (1988b) reported that the microbial decomposition as well as removal by some soil–dwelling fauna such as insects and arthropods are mainly responsible for the break down of green matters used in mulching.

Weather conditions prevailed during thatching could also make a major contribution to mulch decomposition. In the present study, the period of first and third thatchings coincided with wet weather compared to the period from December 1994 to early May 1995 during which the second thatch was present (Figure 2). A relatively low rain fall was experienced during mid–August and late September whilst first thatch was in the field. A soil moisture deficit was experienced soon after second thatching for about a month period, and again from late January to mid March 1995 due to low rainfall (Figure 2 a, b). The mean weekly difference between rainfall and evaporation (moisture balance) was 5 mm during the second thatching phase. The moisture balance was 11 mm when the third mulch was in the field.

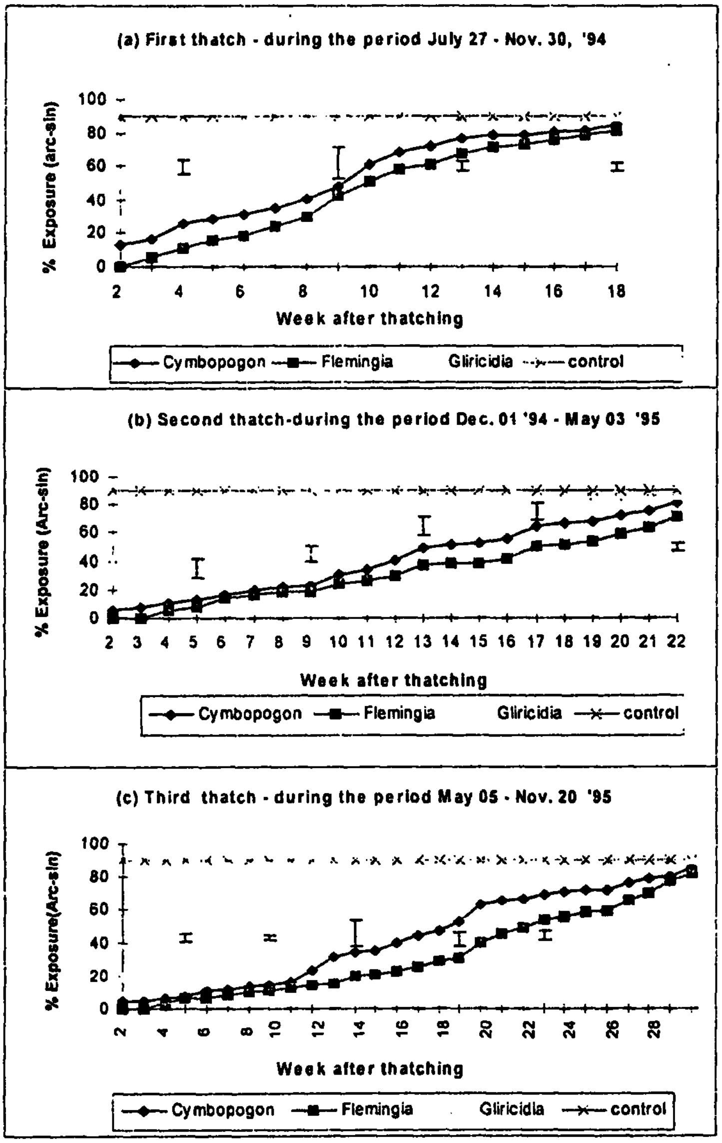

Figure 1. **The mean cumulative rate of ground exposure following decomposition of three thatching materials on three occasions.**

[Note: Vertical bars indicate LSD at p = 0.05].

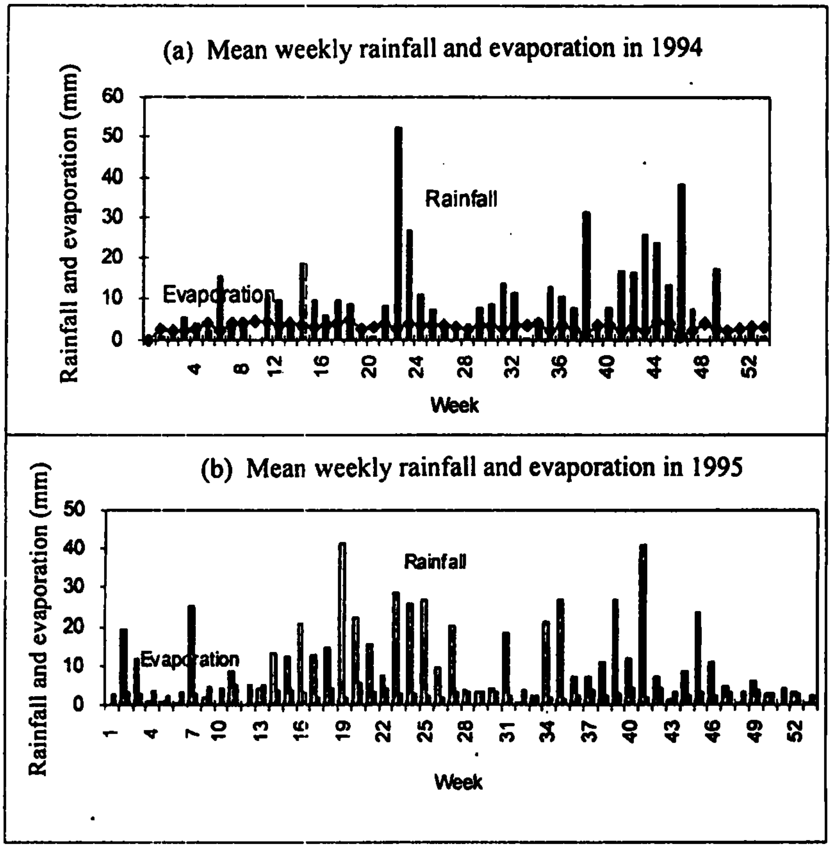

Figure 2. **Mean weekly rainfall and evaporation in 1994 and 1995 at the Low Country Station of Tea Research Institute, Ratnapura.**

In all three thatchings, *G. sepium* showed the fastest decomposition rate exposing soil earlier than the other materials. This is mainly attributable to its low C:N ratio. Budelman (1988 b) reported a C:N ratio of 12:1 for *G. sepium* whilst Wickramasinghe and Wijedase (1985) reported a C:N ratio of 9.3:1.

Under wet conditions, leaflets of *G. sepium* separated rapidly from the rachis and thus the mulch formed a more compact structure pasting the leaflets together, with more contact with the soil underneath. Such adherence of materials with the wet soil may give rise to microbial and other related soil fauna activity on the mulch thus enhancing the rate of decomposition.

It is a common phenomenon that termites are instantly attracted to litter with a high moisture content, particularly when a short dry spell follows showers abruptly. The occasional attacks of the low country scavenging termite (*Coptotermes ceylonicus*) was observed for *G. sepium* and *C. confertiflorus* mulches once there was sufficient moisture underneath. Such incident on both mulches was observed with the short dry spell experienced in mid August and late September 1994 following initial thatching. On the other hand, with gradual losing of moisture following thatching, *G. sepium* leaflets became folded under dry sunny weather causing exposure of the soil surface.

Rapid soil exposure combined with a very short half–life period of *G. sepium* mulch recorded during second thatching was attributed to the termite damage following their attraction to the mulch in early December 1994 and late January 1995 which coincided with a soil moisture deficit. The greater termite damage done to *G. sepium* may be due to its low C:N ratio and succulent nature of fresh leaves with high moisture content. A rapid drying of leaflets under dry weather resulted in an increased soil exposure. Reduced leaf–soil contact and low moisture may have diminished the microbial and other faunal activities within the mulch, eventually delaying break down of materials compared to the wet season. Jordan (1985) also emphasized that optimum situation for fast decomposition is where high average temperatures are found together with a continuous moisture supply.

The slow rate of disappearance in *C. confertiflorus* when compared to *G. sepium* may be due to the relatively high C:N ratio of the former. Wickremasinghe and Wijedase (1985) reported a C:N ratio of 28:1 for *C. confertiflorus*. Although *F. congesta* has a C:N ratio of 21:1 (Budelman, 1988b) its decomposition was not as fast as *C. confertiflorus* and is not vulnerable to termites. The presence of high lignin content in leaves possibly explain the persistency of *F. congesta* (Budelman, 1988a). Perera (1993) also reported a lower digestibility in *F. congesta* compared to other leguminous shrub species and this was associated with a high lignin content of 30%. The same reasons may be attributed to its tolerance to termites. In contrast to *G. sepium*, large leaflets of *F. congesta* were firmly attached to the petiole when drying started. Similar observations were made by Budelman (1988a). The leaflets have a strong tendency to curl during drying and hence, the litter has less contact with the soil where microbial and other fauna activities occur. The *C. confertiflorus* grass was thatched at a relatively high density (w/v) and the grass culms were closely placed parallel to each other. Higher % of moisture can also be retained in leaf sheath and folded leaf blades. Such structures could result in close soil contact which may in turn enhance its breakdown. *Cymbopogon confertiflorus* was largely affected by the same scavenging termites as of *G. sepium* during the coincidence of short dry spells following intermittent showers. Such attack resulted in a fast decomposition of *C. confertiflorus* during late January to early February and late February, to early March '95 resulting in a rapid ground exposure.

The long persistency of *C. confertiflorus* and *F. congesta* during third thatching could mainly be due to the slow rate of decomposition from the initial phase until mid–July '95 as a result of lesser intervention of termites on mulches. Heavy showers associated with low soil temperature during May–June '95 (Figure 2) may be the causal factor for the low activity of soil meso and micro fauna on *C. confertiflorus* delaying the decomposition when compared to the first thatching. However, a termite attack on the same mulch recurred during mid and late July '95. Thatching with a proportionately low amount of biomass equivalent to 1 kg of DM (low moisture content) of both mulches compared to first thatch may also have contributed to a such delay (Table 1). The differences in biomass weights were due to the seasonal variation in weather although they were obtained from same field and at particular heights of plants. The GTZ–UMWMP (1991) reported a possible seasonal variation in moisture level in *G. sepium* leaves whilst Kruijs *et al.* (1989) reported that the rate of break down of leaves depend on the species, time of pruning, and age of leaves.

Weed infestation

All thatched treatments had significantly lower weed density than that of the unthatched control ($p<0.05$) at one month after second and third thatchings (Figure 3). Although the results were not statistically significant, a similar trend was shown with the first thatching. There was a significantly higher number of weeds with *G. sepium* when compared to *F. congesta* and *C. confertiflorus* ($P<0.05$) at 2 months after thatching (MAT), which was comparable to that in unthatched control with all three thatching rounds.

Weed density was significantly reduced by *F. congesta* treatment at 3 MAT when compared to other treatments. However, a significant difference between treatments was not recorded 4 months after first thatching (November 30 '94) (Figure 3). The weed density after second thatching of *G. sepium* exceeded that of the unthatched control. *C. confertiflorus* and *F. congesta*

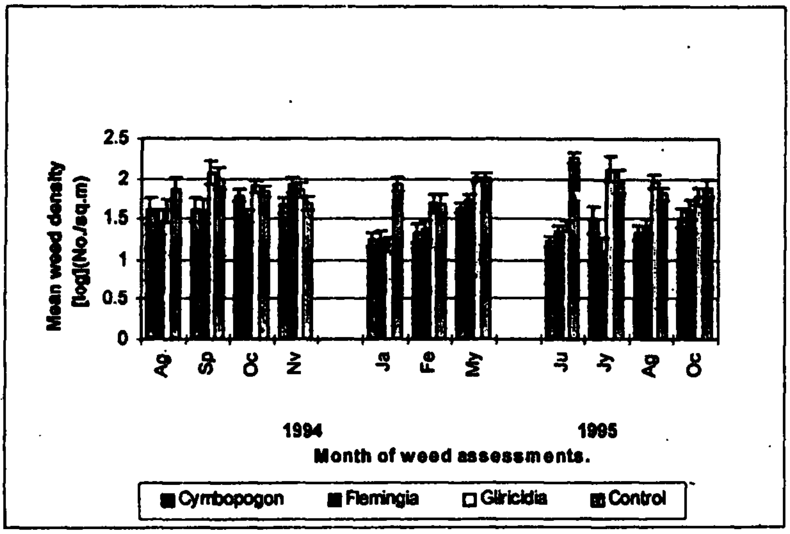

Figure 3. **Mean weed density as affected by thatching treatments at various stages of break–down and different seasons.**
[Note: Vertical bars indicate LSD at p = 0.05].

treatments showed significantly lower weed densities at 5 MAT when compared to *G. sepium* or the unthatched control ($p<0.05$). In the third thatching, however, only *C. confertiflorus* gave a significantly low weed density ($p<0.05$) when compared to the unthatched control.

Dry matter production of weeds

Dry matter content of weeds at various stages while the mulch was on plots and the total dry matter production for the entire duration of first and third thatch were significantly ($p<0.05$) affected by treatments (Figures 4 a, c). Weed dry matter yield in plots thatched with *F. congesta* and *C. confertiflorus* was always lower than that in *G. sepium* and unthatched control. The final overall weed dry weight recorded in *F. congesta* treatment was two and three times less than that of the unthatched control and *G. sepium* mulch respectively during first thatching. Although both treatments gave similar dry weights, initially *G. sepium* out–weighed the unthatched treatment 3 MAT.

A relatively low weed density and dry weight was recorded during the second thatching period compared to the former (Figure 4b). Unlike in the first thatching, *F. congesta* treatment resulted in a relatively greater total dry weight for the entire period of 28 weeks than that of *C. confertiflorus*. Moreover, the overall weed dry weight yielded from *G. sepium* treatment over three thatching rounds was greater than that of *F. congesta* and *C. confertiflorus*.

The higher density and dry weight of weeds in *G. sepium* thatched plots was invariably due to the early exposure of surface soil as a consequence of rapid decomposition of the mulch. Furthermore, exceptional weed growth associated with this mulch when compared to the unthatched control shortly after decomposition of each thatching was ascribed to high organic matter content and nutrient release to the soil. As a leguminous species *G. sepium* shoots contain as much as 4.4% N (GTZ–UMWMP, 1991). Budelman (1988c) and Yamoah *et al.* (1986) also indicated that *G. sepium* and *Leucaena leucocephala* are not suitable for weed suppression since both decompose too rapidly.

In contrast, the durability of *F. congesta* and *C. confertiflorus* resulted in suppressed weed growth. Budelman (1988a) also indicated the suitability of *F. congesta* as a thatching material. The experiments conducted at IITA (1982) confirms that *F. macrophylla* combines durability with a favourable ratio between volume and weight.

However, there was some tendency for a relatively greater density and unit weed dry weight in thatched treatments with gradual degradation of the mulch than that in unthatched control. This may accrued from favourable conditions of high soil moisture retention, organic matter and soil nutrient status particularly with *F. congesta* mulch. According to GTZ–UMWMP (1991), *F. congesta* contains about 3.3% N. Budelman (1988a) showed that nitrogen in *F. congesta* and *G. sepium* is lost at the same rate *i.e.* 53.4 and 21.8 days half–life, respectively. A similar rate of weed infestation in *C. confertiflorus* and *F. congesta* treatments during the latter phase of decomposition may describe the favourable soil moisture and high organic matter status although *C. confertiflorus* contains a lower N level (1.4%) (Wickremasinghe and Wijedase, 1985).

The effective life span (ELS) of each material *i.e.* 'the period during which weed biomass yield from each thatched treatment differed significantly from that of unthatched treatment' (Budelman, 1988a), is more important than comparing weed dry matter yield itself in evaluation of the suitability of any

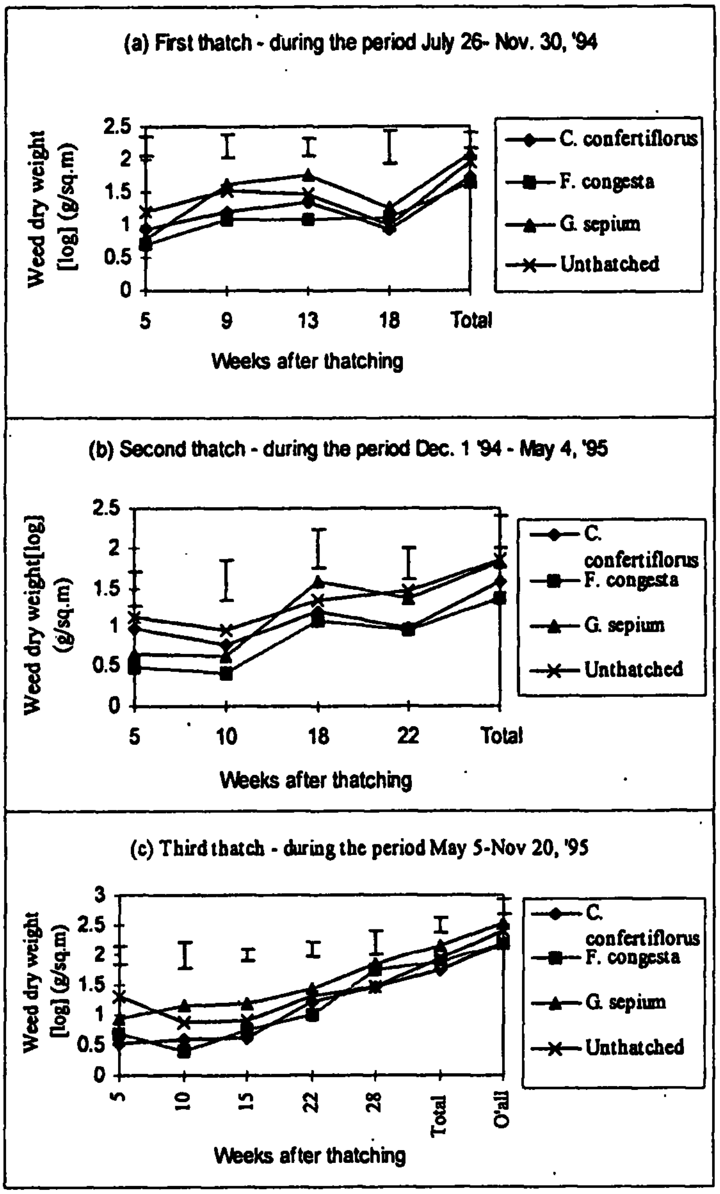

Figure 4. **Mean monthly and total weed dry matter production as affected by various mulch treatments during the period July '94 – Nov. '95.**
[Note: Vertical bars indicate LSD at p = 0.05].

material as a thatching source for weed control. The, the ELS of *G. sepium* was about 5–6 weeks in all three thatching rounds. *F. congesta* and *C. confertiflorus* showed an ELS of 14 and 9 weeks, respectively, with a significantly low weed dry weight during both first and third thatchings when compared to the unthatched control. Budelman (1988a) also reported an ELS of 12.5 weeks for *F. macrophylla* when mulched at a rate of 3 t dry matter ha^{-1}. Weed growth pattern during second thatching with both these treatments was not clear due to interference from drought. However, a suppressed weed growth was recorded for 12–15 weeks with thatching (Figure 3). Prevention of viable seed rain onto the soil surface by the mulch may also contribute to a reduced weed burden.

The varied correlation between weed dry weight and density gave a good indication that there was a treatment effect on the types of weeds occurred on plots. A significant correlation (R^2 = 51–78%) was found between weed dry weight and density of *F. congesta*. This was due to the fast emergence of weeds through open patches under favourable conditions accrued from gradual decomposition of the mulch. Inconspicuous species of low weight such as *Mollugo pentaphylla, Bulbostylis barbata* and *Stemodia verticillata* which are generally present under poor soil conditions were not prominent in this treatment.

Results also indicated that climatic changes had a significant impact on weed growth. Low rain fall experienced during February and March '95 directly restricted weed growth. Furthermore, a low correlation between density and weed dry weight was indicated for the same period irrespective of treatment. In March there was insufficient weed canopy to assess all the treatments.

Thatching treatments did not result in presence or absence of any specific weed although they had attributed to the smothering of weed growth and soil improvement following decomposition of materials.

Soil carbon content was increased significantly (p=0.05) with *F. congesta* at 6 MAT of third mulch since it's decomposition was still taking place having only 82% exposure. However, with *C. confertiflorus* and *G. sepium* which showed 95% to 100% decomposition, respectively, organic matter might have been lost from the soil, through continuous process of chemical reactions and leaching out with rains.

CONCLUSIONS

It is evident that the rapid rate of decomposition of thatching materials increases the weed density due to higher soil exposure. It appears that *Flemingia congesta* is more promising than *Cymbopogon confertiflorus* as a mulch due to high durability and longer effective life–span thus smothering of weed growth and soil conservation. The use of *Gliricidia sepium* as a mulch for weed control appears to be limited. Re–thatching within the effective life span (ELS) of materials could be recommended to suppress weed emergence. Establishment of *F. congesta* could be recommended on waste lands, fences and vacant patches in tea fields. Potential exists to plant this species on tea inter–rows of new clearings but closer attention and regular pruning are required to avoid any competition with tea.

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