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Original Article: Durability of mulch materials and their effect on weed growth in newly planted low-grown tea

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ABSTRACT

Mulching is a recommended cultural practice for weed growth suppression and soil and moisture conservation in newly planted tea lands. However, tea growers have neglected this practice due to the scarcity of thatching materials like *Cymbopogon confertiflorus* (Mana grass) and the high labor cost. Hence, it lasted too long to explore the feasibility of using alternative sources. Furthermore, any used material as mulch should be more durable. An investigation was conducted to find low-cost and durable alternative plant materials such as tertiary shoots of Diyapara (*Dillenia suffruticosa*), *Flemingia congesta*, and *Acacia auriculiformis*, together with black/silver polythene mulch that were field-tested against C. confertiflorus grass mulch. Mulch was applied to tea plots at 1.0 kg m^{-2} on a dry weight basis. The experiment was laid out in a Randomized Complete Block Design with four replicates. The results showed that *C. confertiflorus* mulch was retained on plots for 18 weeks and *F. congesta* and *A. auriculiformis* were disappeared in 20 weeks after mulching, but *D. suffruticosa* and Agricultural mulch were remained occurring at only 85% and zero ground exposure reporting the highest weed growth suppression by 52% and 100%, respectively compared with *C. confertiflorus*. Weed growth was suppressed by 18% and 14% when mulched with *A.auriculiformis* and *F. congesta* compared with *Cymbopogon confertiflorus*. Tea growth was not affected by any mulch treatment. *D. suffruticosa* and agricultural mulch were more durable and promising mulches, while *F. congesta* and *A. auriculiformis* can be further used as alternative mulches to *Cymbopogon confertiflorus* to suppress the weed growth in newly planted tea fields.

Introduction

Tea is the major plantation crop in Sri Lanka, which plays a vital role in economic, environmental, and social sustainability. Sri Lanka produces the finest and the cleanest tea in the world and maintained the same almost for the last 150 years (Peiris et al., 2015). In newly planted tea fields, the ground remains exposed until tea itself forms a canopy providing an adequate soil cover. As a consequence of ground exposure, such fields are highly vulnerable to weed occurrence, other than the severe soil erosion, nutrients, organic matter degradation, and soil moisture evaporation. Mulching the ground of a newly planted tea field with live or dead materials is a recommended practice. Organic mulching positively regulates the soil microbial communities and eco-system functions (Zhang et al., 2020). Mulching is capable enough to cover the ground, smother the weed growth, and conserve the soil and moisture (Iqbal et al., 2020).

Moreover, with the current issue of the unavailability of herbicides for weed control in tea, emphasizing ecological weed control strategies is the only way out. Ekanayake et al. (2003) indicated that a good ground cover with dead or live mulch is to be provided to minimize the weed problem and other adverse effects in an eco-friendly manner. Mulching with grass-like *Cymbopogon confertiflorus* was commonly practiced in young tea fields (Wijeratne et al., 1994). However, growers do away with this practice due to the scarcity of materials and the high cost of thatching. Hence, lasted too long to explore the possibility of using alternative sources of mulch. Furthermore, the weed suppression ability of such materials is varied depending on their durability on soil without breaking down. Hence, a field experiment was carried out to investigate the durability of different mulch materials and their weed growth suppression ability in a newly planted tea.

Materials and Methods

An experiment was carried out at the Low Country Regional Station, Tea Research Institute, Ratnapura, Sri Lanka in the early October 2018 to February 2019. The experimental site was situated in the WL_{1a} Agro-ecological Region where the elevation is 30 m/amsl. Mean annual rainfall is around 2250 mm and mean annual temperature is 27 °C. Treatments of the experiment are given in the Table 1.

Table 1. Fresh and dry weight of each material used for mulching 01 m^2 area of the plot

Treatment	Fresh weight (Kg)/ m^2	Dry weight (Kg/ m^2)
T1. Agricultural mulch	-	-
T2. *C. confertiflorus*	2.51	01
T3. *D. suffruticosa*	1.98	01
T4. *F.congesta*	3.29	01
T5. *A. auriculiformis*	3.42	01

The experiment was carried out in Field No. 01 of St. Joachim Estate of the TRI, planted with TRI 2023 VP cultivar. Each plot was sized 14.4 m^2 having 20 tea plants. All plots were thoroughly weeded before the imposition of mulching sources. Four plant materials used as dead mulches were collated from the site's surrounding area. Lopped Mana grass, conventionally used as the mulch, was considered the "Control". Each mulch source was thatched at 1 $kg.m^{-2}$ on the same day. For this, fresh and dry weights of each material were initially measured, and the fresh weight required to make 1 kg of each material was calculated and thatched accordingly (Table 2). Likewise, agricultural mulch was laid on plots as a treatment. The experiment was laid out in a Randomized Complete Block Design with four replicates. T-200 tea fertilizer mixture was applied at 15 g/plant 2 months after planting tea.

Table 2. Chemical composition and C:N ratio of different mulch sources

Mulch source	Carbon%	Nitrogen %	C/N Ratio	Cellulose%	Lignin %
C.confertiflorus	29.0^{a}	1.11^{a}	26:1	23.94^{a}	9.95^{a}
D. suffruticasa	34.4^{a}	1.23^{a}	28:1	23.45^{a}	2.47^{bc}
F.congesta	37.5^{a}	1.96^{a}	19.1	23.82^{a}	4.23^{b}
A.auriculiformis	36.8^{a}	2.94^{a}	12.5:1	19.57^{b}	1.88^{c}

* Means with the same letters are not significantly different at P<0.05

Assessments

Each mulch source was allowed to remain on plots for 20 weeks period and the following parameters were taken during this period.

I) Ground exposure percentage

The rate of material breakdown was measured in terms of the degree of ground exposure (%) that occurs with the decomposition of each mulch source with time. A quadrat-sized 2x2 ft^{-2} with 36 sub-divisions (squares) was randomly placed on two spots in each mulched plot to determine the ground exposure at fortnight intervals. Thus, the degree of ground exposure in every 36 quadrats was visually observed and recorded to calculate each plot's average exposure percentage.

II) Weed growth measurements

a) Weed density (No. ft^{-2}): Weed number was counted by randomly placing a 1x1 ft^2 quadrat on three spots of each plot at four weeks intervals.

b) Weed dry weight ($g.m^{-2}$): Weeds that emerged on each plot with mulch break down were hand-pulled from one m^2 to measure the above-ground fresh weight, and dry weight was measured with oven drying at 65 ºC for 48 hours at four weeks intervals.

III) Quality of mulch sources

a) C: N Ratio: The carbon content of plant mulch materials was analyzed by using Walkley-Black method, and Nitrogen was analyzed through the Kjeldahl method. The C:N ratio was accordingly calculated.

b) Cellulose and lignin contents of plant mulch materials were analyzed through the Anthrone and modified acetyl bromide methods.

c) Moisture retention in mulch materials: A small portion of each mulch material was immediately collected to a bag from randomly selected two spots of each plot and broad to the laboratory, measured 100 g from each, and allowed to oven-dry at 65 ºC for 48 hours.

IV) Tea growth parameters

Plant height was measured by using a meter ruler, collar width was measured by using a vernier caliper (0.01 readability), and the number of primary branches was counted.

Results and Discussion

Rate of the breakdown of mulch materials in terms of ground exposure percentage

The breakdown of mulch materials could be visually observed from 4 WAM onwards. Among different mulch sources, the ground surface of C. confertiflorus (Mana) grass treatment was exposed at the fastest rate throughout compared with that of other mulch sources (Figure 1).

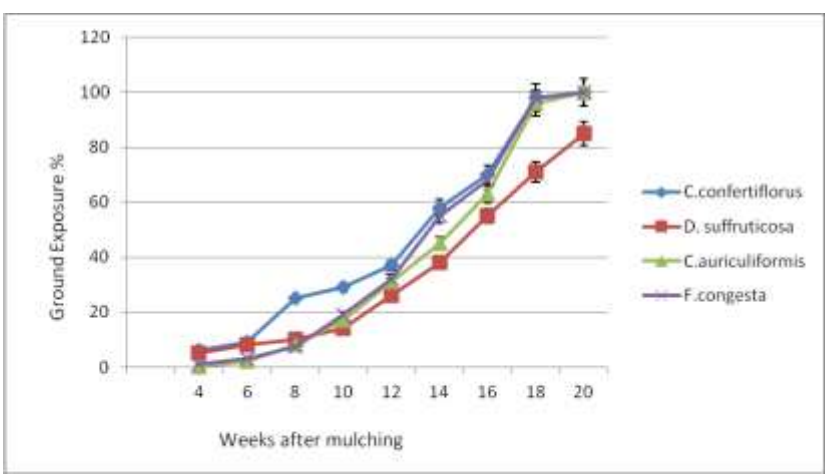

Figure 1. Mean percentage of ground exposure with breakdown of different mulch materials

Leaf blades of *C. confertiflorus* started to roll up, making openings between leaf sheaths with culms thatched parallel. Therefore, the round es at 8 and 10 WAM. With the onset of rain, moisture was trapped inside the rolled-up leaf sheath, and leaf blades of *C. confertiflorus* and such structure made close contact with soil, which may have enhanced its breakdown resulting from high moisture. Even though *C. confertiflorus* mulch characterized a high C:N ratio; it was further damaged by low country scavenging termite (*Coptotermes ceylonicus*). Hence, *C. confertiflorus* mulch was totally disappeared at 18 WAM.

F. congesta leaves started to dry up under the sunny weather, curl up initially, and large leaflets were firmly attached to the petiole. Due to curling, the litter had less contact with the soil where microbial and other fauna activities occur. However, with breaking down the leaf parts, they were adhered to soil with rains, accelerated the further break down until 18 weeks, and then materials were disappeared from the ground surface at 20 WAM.

Besides, *A. auriculiformis* leaves started to dry up first, broke into pieces, and were subjected to decomposition by soil microbes. Moreover, it was damaged by low country scavenging termites under wet weather conditions, and it disappeared at 18 WAM, leaving a few woody parts on plots until 20 WAM. 50% ground exposure (half-life) was thus taken place 91, 93, 99, and 107 days after mulching in *C. confertiflorus, F. congesta, A. auricularia,* and *D. suffruticosa* mulches, respectively. However, a mean of 87 and 105 days half-life was earlier reported for *C. confertiflorus* and *F. congesta*, respectively (Prematilake, 1997).

A little early breakdown of *F. congesta* and *A. auriculiformis* may be attributed to the lower C: N ratio of 19:1 and 13:1 and lower lignin exposure was significantly higher with *C. confertiflorus* mulch when compared with that of other mulch sourc contents, 4.23%, and 1.88%, respectively, compared with *D. suffruticosa* (Table III). However, the C: N ratio of *F. congesta* was earlier reported as 21:1(Budelman, 1988). Such a lower C: N ratio of *F. congesta* may be attributed to the collection of shoots at the tender phase. Bending of Diya para (*D. suffruticasa*) leaf on convex shape, which is a specific morphological characteristic, was observed with sun drying until 6 WAM. Hence, the leaf did not adhere to the soil under the rainy situation. As a result, mulch material decomposition took place at the slowest rate throughout compared with other treatments and only 85% decomposition could be observed in *D. suffruticosa* mulch even at 20 WAM. High C: N ratio and high cellulose content, together with the leaf's morphological characteristics, i.e., convex shape may have caused this slower decomposition rate.

In all cases, the decomposition of mulch materials may be mainly attributed to the increased microbial activity under moist conditions and termite damage. In addition, Budelman (1988) reported that the loss of materials was due to microbial decomposition, eating, or removal by soil-dwelling fauna such as insects and arthropods.

Weed growth suppression with mulching

Weed growth was suppressed underneath the agricultural mulch. There is no room for weed growth due to no sunlight as the light is reflected by the ultraviolet-resistant thin layer of black/silver polythene. Weed growth was suppressed very significantly in *D. suffruticosa* (Diyapara) treatment compared with all mulch treatments from 12 WAM onwards (Figure 2).

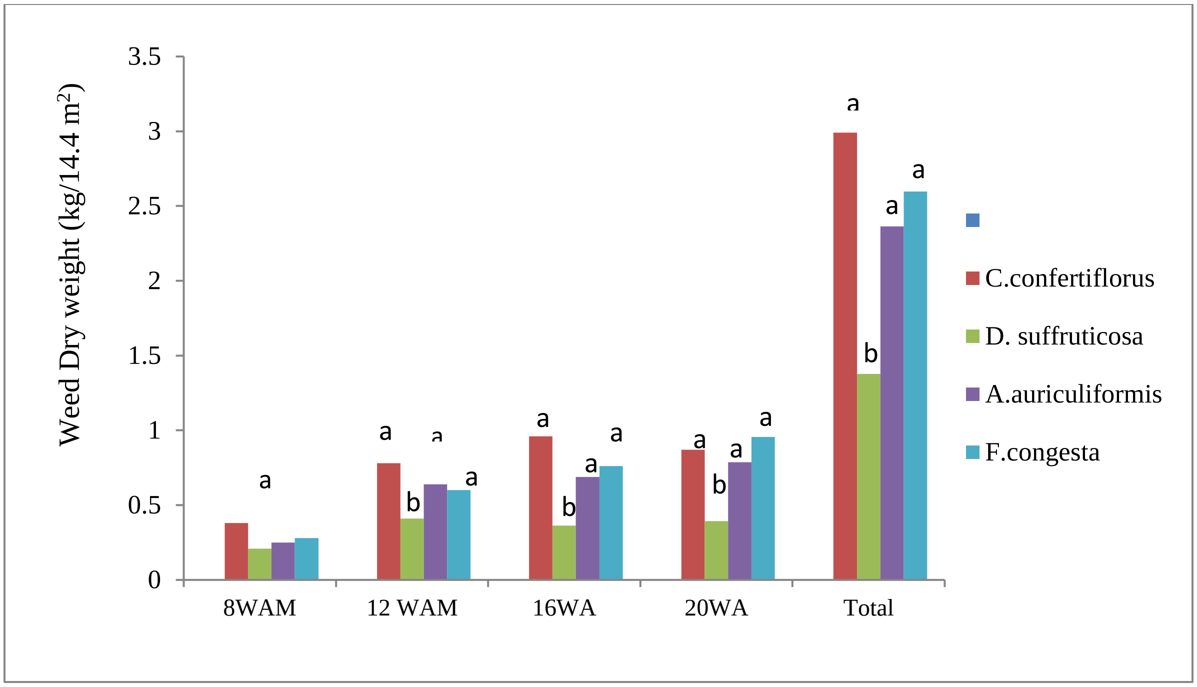

Figure 2. Occurrence of weeds as affected by different mulch treatments at different intervals

There was a 52% reduction in weed weight in *D. suffruticosa* treatment compared with *C. confertiflorus*. The Smothering effect of *D. suffruticosa* mulch, which provided a good ground cover, has been caused to suppress the weed growth. It appears that weed growth was gradually increased with the breakdown of mulches except for *D suffruticosa* mulch. Weed growth was relatively more significant in *C. confertiflorus* treatment (2.87kg m^{-2}) compared with *A. auriculiformis* (2.37kg m^{-2}) and *F. congesta* (2.46 kg m^{-2}), this was 18% and 14% reduction, respectively, when compared with *C. confertiflorus*. However, Prematilake (1997) reported a 28% reduction in weed growth with *F. congesta* compared with *C. confertiflorus* mulch. Furthermore, weed growth was suppressed by 52% and 41% with *F. congesta* and *C. confertiflorus* mulch, respectively, when compared with that of unthatched control (Prematilake, 1997). The higher weed growth was attributed to the early breakdown of materials of *C. confertiflorus* and resultant soil improvement with organic matter, nutrients, and soil moisture level which favor the emergence of new weeds. Like weed dry weight, the highest weed density was also reported under *C. confertiflorus* mulch at all three intervals (Figure 3). This was followed by *F congesta*, *A. auriculiformis*, and *D suffruticosa* mulches. Thus, the lowest weed density was reported with *D. suffruticasa* mulch.

Early ground exposure may have caused many weeds on plots treated with *C. confertiflorus*. With the gradual opening of the ground resulting from each mulch breakdown with time, there were more rooms to occur weeds. Hence, agricultural mulch and *D. suffruticasa* (Diyapara), *A. auriculiformis, and F. congesta* plant mulches were more promising as alternative mulch sources *for C. confertiflorus* to suppress the weed growth in newly planted tea fields.

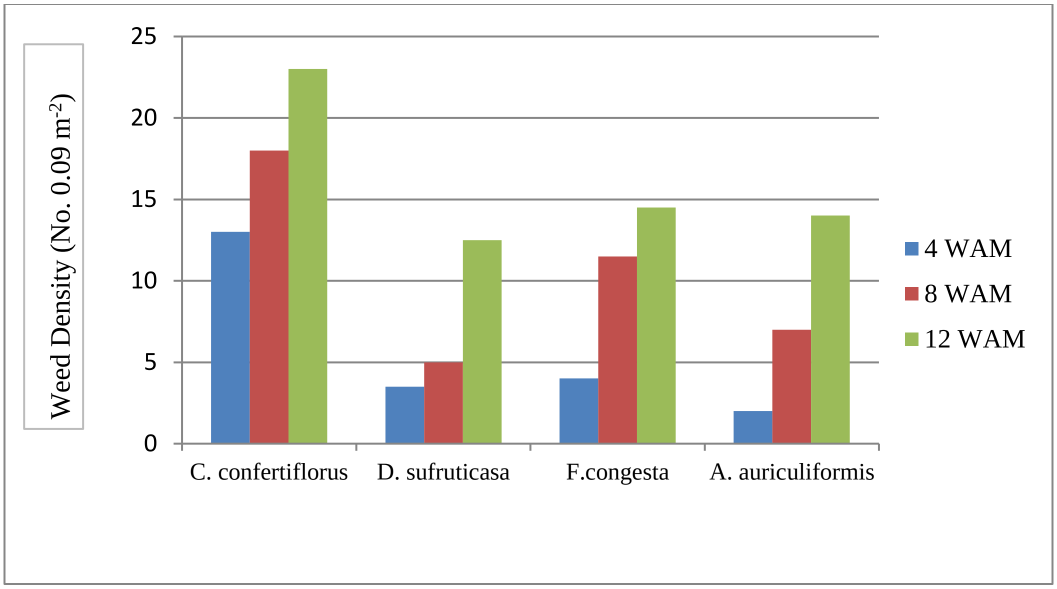

Figure 3. Mean weed density under different mulch materials at different intervals

Chemical composition of mulch sources

As listed in *Table III*, there was no significant difference in Carbon % or Nitrogen % between any treatments. The highest C:N ratio of 28:1 was reported with *D. suffruticosa*. This was followed by *C.confertiflorus* (26:1) and *F. congesta* (19:1). The lowest C:N ratio and significantly a lower cellulose content were reported with *A. auriculiformis*. The highest lignin content was reported with *C. confertiflorus* and the lowest 1.88% with *A. auriculiformis*. A C:N ratio of 28.8:1 was earlier reported with *C. confertiflorus* and 11.28:1 with *A. auriculiformis* (Zoysa and Wijetunga, 2008). The C:N ratio of 21:1 was reported with *F. congesta* (Budelman ,1988). A little lower C:N ratio with *F. congesta* and *C. confertiflorus* in the present study may be attributed to the collection of materials at a tiny tender stage of growth.

Moisture Retention capacity of mulch sources

The moisture retention capacity of each mulch material was measured during a short dry spell. The highest moisture percentage was retained in *C. confertiflorus* mulch, followed by *F. congesta* and *A. auriculiformis* mulches (Figure 4).

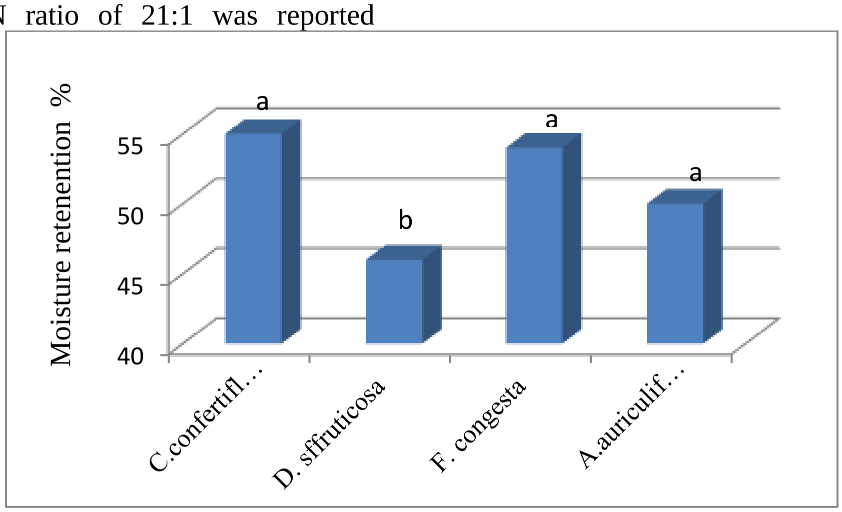

Figure 4. Moisture retention capacity in different mulch sources

The lowest was reported in *D. suffruticosa* mulch. The convex shape of the leaf surface of *D. suffruticosa* may not have allowed retaining moisture in the leaf. Whereas in *C. confertiflorus* mulch, more water can be trapped inside as the leaf sheath is rolled up. With the breaking down of leaf material, leaf particles adhered to the soil, and with rains, moisture was retained with leaf particles. These conditions have been caused to accelerate the decomposition of *Cymbopogon*, *Flemingia*, and *Acacia* mulches.

Impact of mulching on growth of tea

There was no significant difference in plant height, collar width, and the number of tea branches between mulch treatments. Weed occurrence at very slower rate under the different mulches due to their smothering effect might have prevented any competition with tea. Moreover, it cannot be expected any growth differences in tea in response to different mulches within such a short period of 20 weeks in a perennial crop like tea.

Conclusion

Agricultural mulch (Black/Silver polythene) is a highly durable and a more promising technique to suppress weed growth and conserve soil and moisture in tea lands. Tertiary shoots of *Dillenia suffruticosa* (Diyapara) are highly durable, hence, more promising to use as alternative dead mulch on tea lands in the low country to suppress weed growth and conserve soil and moisture. Tertiary shoots of *Flemingia congesta* and *Acacia auriculiformis* are also suitable for use as alternative dead mulch sources to *C. confertiflorus* (Mana grass) in the low country.

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Conflict of interests

No conflict of interests has been declared.

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