S.L. J. Tea Sci. 70 (2) 82-91, *2005, Printed in Sri Lanka*

Impact of Cultural and Agronomic Practices on the Management of 'Getakola' (*Spermacoce hispida*) in High-Grown Tea

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ABSTRACT

The weed, *Spermacoce hispida* L. (Family: Rubiaceae), which is locally known as 'Getakola', has become dominant in tea (*Camellia sinensis* (L.) O. Kuntz, grown at 600-1400 m amsl), as it is tolerant to some herbicides and difficult to control manually.

The present study was conducted in Patana, Sri Lanka (1200 m amsl), in 2000-2001, to investigate the efficacy of various cultural and agronomic techniques for the management of the weed. All the plots, each 2 m^2 in size, were slash-weeded prior to imposition of treatments in repeat applications in February, June and November 2000. Three types of mulches, *Cymbopogon confertiflorus* grass, shoots of *Eupatorium inulifolium* and shoots of *Tithonia diversifolia,* with envelope forking alone, compost alone, or envelope forking and compost, and untreated controls, were the treatments. Mulching was done at 3 kg m^{-2}, and compost was incorporated at 18 kg m^{-2}.

The weed's least fresh weight was recorded in the *C. confertiflorus* treatment. This was significantly lower ($p < 0.05$) than in the other treatments, except in the *T. diversifolia* treatment, 10 weeks after application (WAA). A higher fresh weight of *S. hispida* was recorded in the *E. inulifolium* and compost treatments, 15 WAA. The fresh weight of other weeds was not significantly affected ($p > 0.05$) by any treatment in the first two applications, but it was significantly higher ($p < 0.05$) in the mulch and compost treatments in comparison to forking alone and the controls. The least density of S. *hispida* (per cent of the total weed population) was also recorded in the *C. confertiflorus* treatment, 5, 10 and 15 WAA, and this was significantly lower ($p < 0.05$) than in the other treatments, except for *T. diversifolia* with forking and compost, 5 and 10 WAA.

Slash weeding, followed by mulching with *C. confertiflorus* or *T. diversifolia*, or slash weeding alone at 4 to 5-month intervals, were found to be effective in the management of *S. hispida* in tea fields.

Key words: compost, mulch decomposition, problem weeds, *S. hispida*, tea, weed suppression

INTRODUCTION

Tea (*Camellia sinensis* (L.) O. Kuntz) is a perennial crop, grown in Sri Lanka over an extent of 181,000 ha, at elevations up to 2000 m amsl. Tea is the major export crop of the country, which produces about 295 million kg of made tea annually, from which it earns an equivalent of Rs. 61,600 million in foreign exchange. The average yield in Sri Lanka is low, at only 1840 kg made tea per ha, although the potential yield is about 3000 kg (Anon, 2002 a). Among the many factors responsible for the low tea yields, the competitive effect of weeds is a partial contributor. Yield losses caused by weeds are reported to be 5-15% in mature tea (Wettasinghe 1971, a b) and 30% in young tea (Visser 1961).

Spermacoce hispida L. (Family Rubiaceae), locally known as 'Getakola', has in recent times developed into being the dominant weed in most of the tea plantations (Prematilake and Ekanayake 1999). It is a dicotyledonous biannual herb, with hairy, coarse leaves and a shallow root system. Propagation is by the mass production of seeds.

The manual removal of *S. hispida* is an arduous and laborious task because of its semi-woody nature. *S. hispida* is not controlled by the herbicides presently recommended for general weed control in tea. There was no effective control of the weed from a mixture of 2,4-D (73% a.i.) and paraquat (20% a.i.) (Basnayake, 1986; Prematilake 1999).

Recent studies have shown that some cocktail mixtures, and single herbicides at high dosages, have promise for the control of *S. hispida* (Prematilake and Gamage, 2002). However, resorting to chemical methods could result in the development of resistance to herbicides. The continuous use of herbicides has imposed selection pressure for increased resistance within species that were formally susceptible to herbicides (Valverde *et al.*, 2000). This makes the task of weed control more difficult.

Therefore, formulating an integrated method, which includes cultural and agronomic techniques, would be the most appropriate strategy for the management of *S. hispida*. Slash weeding is a recommended practice for the control of hard-to-kill weeds in tea fields. Mulching tea fields with *Cymbopogon confertiflorus* grass (Sandanam and Rajasingham, 1982), and various green manure crops, serves to conserve soil and moisture, and also to smother weed growth (Manipura *et al.*, 1969). The incidence of weeds depends upon the rate of breakdown of mulches, and the chemical and physical properties of soil following decomposition (Prematilake *et al.*, 1998).

The present study was undertaken to investigate the impact of various mulches and soil improvement methods on the suppression of *S. hispida* in tea fields, through the smothering effect of mulches and encouragement of the growth of other weeds.

MATERIALS AND METHODS

Field experiments were carried out at Patana (elevation: 1200 m amsl, mean temperature: 27 °C) in Talawakelle, Sri Lanka, during February 2000-June 2001. The soil type is Red Yellow Podsol (RYP) (Ultisol) with a total nitrogen content of 0.27% and organic carbon content of 2.52%.

Plots, 2 m x 1 m in size, were marked on the vacant patches of an old tea field which was heavily infested with the *S. hispida* weed. Weeds in all plots were slashed at the base, on 10th February, 2000, prior to imposition of treatments which were envelope forking alone, envelope forking and compost, or compost alone, with three types of mulches. *Cymbopogon confertiflorus* grass, which is commonly used in the rehabilitation of tea lands, shoots of *Eupatorium inulifolium*, and shoots of *Tithonia diversifolia* (wild sunflower), were the mulching treatments. An untreated control was also included.

Mulching with each material was done at 3 kg m^{-2} to give a proper ground cover. Compost was added to surface soil at 18 kg m^{-2}. Envelope forking was done using a fork with four tines, 35 cm long. The fork was driven vertically into the soil and levered while pushing the compost added into the pockets behind the fork. Impositions of the same treatments to the plots were repeated on 27th June and 14th November, 2000.

Assessments were made of the incidence of *S. hispida* and other weeds. All weeds found within two quadrats (0.09 m^2 each) in each of the plots, at different intervals, were cut from the base and their above-ground fresh weights determined. *S. hispida*, and other weeds were weighed separately. The percentage of *S. hispida* in the total weed density was thus determined on a weight basis.

The same was also determined on a count basis prior to, and five weeks after, application of treatments.

Soil samples were obtained at a depth of 0-10 cm, 15 WAA, for pH determinations using a laboratory pH meter (PHM 61). The nitrogen percentage was determined by the Kjeldhal method, and potassium (K) by the ammonium-chloride extractable K method. Soil carbon was determined using the Walkley-Black method.

The experiment was conducted in a Randomized Complete Block Design (RCBD), with three replicates. The software package (6.12) Statistical Analysis System (SAS) was used for statistical analysis.

RESULTS AND DISCUSSION

Effect of cultural and agronomic practices on the fresh weight of *S. hispida* and other weeds

The fresh weight of *S. hispida* was significantly affected ($p < 0.05$) by treatments 10 weeks after first application (WAFA), and 5 and 15 weeks after second application (WASA) (Figure 1). The fresh weight of *S. hispida* in the *Cymbopogon* treatment was the least; it was significantly lower ($p < 0.05$) than that in the other treatments, except for *T. diversifolia* mulch, 10 WAFA.

Further, the same was significantly reduced ($p < 0.05$) in *Cymbopogon* treatment when compared with that in the other treatments, 5 WASA. There was no significant difference in the weight of *S. hispida* between treatments, 15 WASA, and 15 and 30 weeks after third application (WATA). However, the least fresh weight of *S. hispida* was again recorded in the *Cymbopogon* treatment. Higher weed fresh weights were recorded in plots incorporated with compost and *Eupatorium* treatments, 15 weeks after both applications.

The fresh weight of other weeds was not significantly affected ($p > 0.05$) by treatments, 10 WAFA and 5 and 15 WASA (Figure 2). Higher weights of other weeds were recorded with the treatments *Cymbopogon, Tithonia* and forking + compost, 10 WAFA; *Cymbopogon* and forking + compost, 5 WASA; and with *Cymbopogon, Eupatorium* and compost treatments, 15 WASA. Whereas weed weights were significantly increased ($p < 0.05$) in mulch and compost treatments when compared to forking alone, and to the control treatments, 15 WATA, a significantly greater fresh weight of other weeds was only recorded in the forking + compost treatment, 30 WATA.

The density of *S. hispida* was determined as a percentage of the total weed population present on plots. The difference in density prior to the imposition of treatments was not significant ($p > 0.05$) (Table 1). After imposition of treatments, the least density was recorded with *Cymbopogon* mulch, 5 WA each application, and 10 WAFA and 15 WASA.

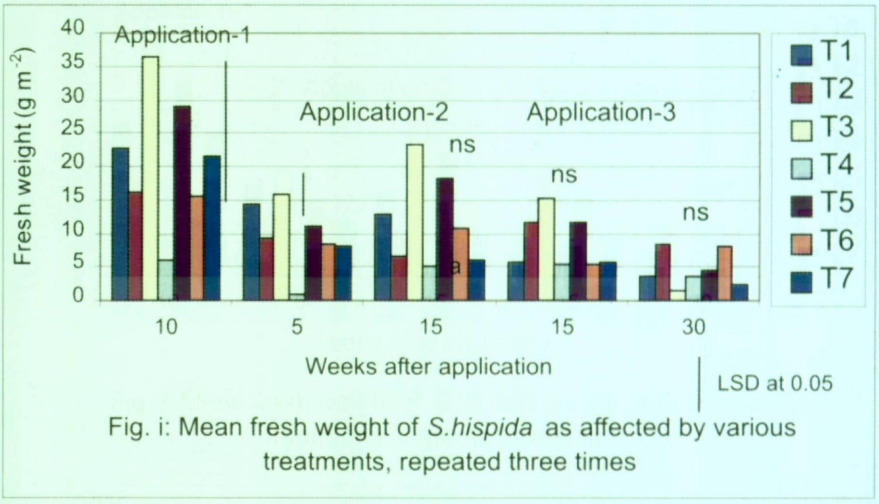

Fig. i: Mean fresh weight of *S.hispida* as affected by various treatments, repeated three times

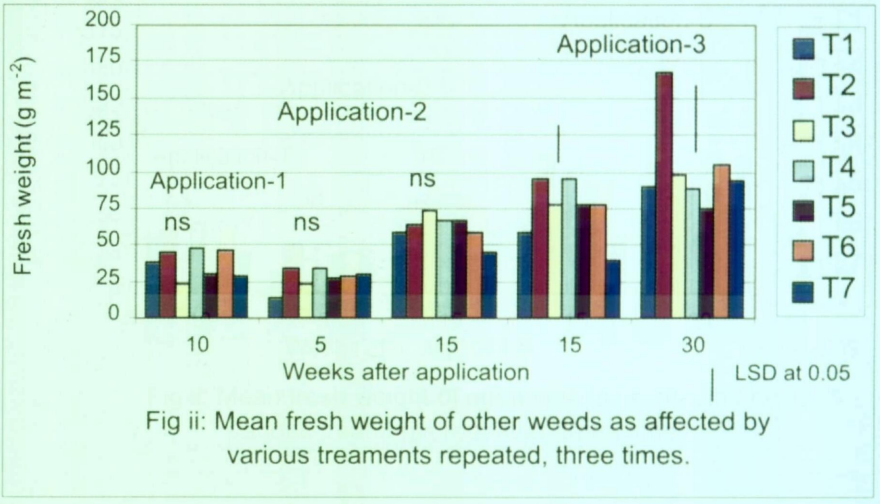

Fig ii: Mean fresh weight of other weeds as affected by various treaments repeated, three times.

ns = Treatments are not significant at 0.05 level

* T1) Envelope Forking, T2) Envelope Forking + Compost T3) Compost
T4) *C. confertiflorus* T5) *E. inulifolium* T6) *T. diversifolia*
T7) Untreated Control.

A significantly lower density ($p < 0.05$) was recorded with *Cymbopogon* when compared to other treatments, except for the *Tithonia* mulch and the envelope forking + compost treatments, 5 and 10 WAFA and 5 WATA. Although this was not significant, a greater reduction in percentage of *S. hispida* was observed in all plots, 15 and 30 WATA.

Effect of cultural and agronomic practices on soil chemical properties

Soil pH was not significantly affected by treatments imposed in all three applications (Table 2). Soil N (%) was consistently greatest in the treatment with compost alone; this was significantly greater ($p < 0.05$) than in the other treatments, except for forking + compost, 15 WASA.

The lowest level of K (ppm) was found in the treatment with *Cymbopogon* and in the control, and this was significantly lower ($p < 0.05$) than in the compost treatments, with and without forking. The highest soil carbon content (%) was also recorded in the compost treatments, with and without forking, and the lowest carbon content was recorded in the control. Carbon content in the control and the *Cymbopogon* treatments was comparable.

Table 1: Effect of various cultural and agronomic practices on the density of *S. hispida*, before and after application of treatments (three replicates).

	% Density of the total weed density							
		Application.1		Application 2		Application 3		
		(Weeks after imposition of treatment)						
Treatment	Before+	5+	10*	5 *	15*	5+	15*	30*
T1 Envelope forking	84 a	28 bc	39ab	52a	23ab	27abc	8a	3a
T2 E. forking + compost	70 a	14 cd	35abc	34a	26ab	12bcd	11a	5a
T3 Compost alone	81 a	50 a	60a	40a	35 a	25ab	19a	1a
T4 *C. confertiflorus* mulch	61 a	1.9 d	10c	1.9b	8b	1.3d	7a	4a
T5 *E. inulifolium* mulch	80 a	31abc	46ab	30a	35ab	16bc	14a	7a
T6 *T. diversifolia* mulch	86 a	19 bcd	24bc	35a	24ab	3.5dc	6a	7a
T7 Untreated c ontrol	72 a	36 ab	51ab	22a	15ab	43a	13a	3a

+on count basis * on weight basis

In each column, means followed by the same letter are not significantly different at $p < 0.05$.

Chemical properties of soil

Table 2: Mean chemical properties of soil as affected by various treatments, 15 weeks after application (three replicates).

Soil property	Application	Treatment						
		T1*	T2	T3	T4	T5	T6	T7
pH	1	4.65 a	4.75 a	5.17 a	5.02 a	4.93 a	5.05 a	4.72 a
	2	4.75 a	4.62 a	4.93 a	4.62 a	4.75 a	4.62 a	4.52 a
	3	4.25 a	5.17 a	5.48 a	5.20 a	5.25 a	5.20 a	5.08 a
N%	1	0.29 b	0.32 a	0.32 a	0.26 c	0.29 b	0.27 c	0.25 c
	2	0.31 cd	0.36 a	0.36ab	0.29de	0.33 bc	0.31 cd	0.27 e
	3	0.31 cd	0.34 b	0.39 a	0.29cd	0.34 b	0.31 bc	0.27 d
K	1	159 ab	172 a	172a	153bc	158 b	153 bc	139 c
(ppm)	2	169 bc	181 ab	183a	148e	168bc	162 cd	151de
	3	182 c	200 b	214 a	157 d	185 c	177 c	164 d
C%	1	2.87 b	3.22 a	3.33 a	2.56 c	2.90 b	2.72bc	2.29 d
	2	2.79 bc	3.58 a	3.62 a	2.71 bc	3.00 b	2.83 bc	2.46 c
	3	3.28 c	3.79 b	4..31a	2.85 cd	3.14 cd	3.02cd	2.76 d

In each row, means followed by the same letter are not significantly different at $p < 0.05$.

T1) Envelope forking; T2) Envelope forking + compost; T3) compost;
T4) *Cymbopogon confertiflorus*; T5) *Eupatorium inulifolium*;
T6) *Tithonia diversifolia*; T7) Untreated control.

There was a marked reduction in the growth of *S. hispida* in all the plots following imposition of the treatments, as all plots were slash-weeded prior to the treatments (Table 1). Thus, re-invasion by *S. hispida* was suppressed through the smothering effect of the treatments and by the resultant cover from other weeds.

The growth of *S. hispida* was suppressed by *Cymbopogon* mulch through its smothering effect, *Cymbopogon* decomposing at a slow rate and forming a proper ground cover for a period of 15 weeks. As a result, a substantial reduction in the percentage of *S. hispida* relative to the total weed density was recorded with *Cymbopogon* mulch.

The rate of decomposition of plant materials is generally governed by factors in the plant material, such as the C:N ratio, the N content, and the lignin and polyphenol content of leaves and stems. The initial N content of green manure is a better indictor of decomposition when comparing leguminous and non-leguminous plant material (Palm,

1995; Mugendi and Nair, 1997). A lower N, K and carbon content was recorded 15 WAA of *Cymbopogon.* Wickremasinghe (1985) also reported a high C:N ratio of 28.8, and a low N content of 1.4, in *Cymbopogon*, against a low C:N of 7.23, and a high N content of 4.76%, in *Tithonia.*

It was observed that more than 60% of the material was retained on the soil, 24 WATA. A slow rate of decomposition of the material could be attributed to the low N content and the high C/N ratio in *Cymbopogon.* Furthermore, a high content of lignin and polyphenol may also have reduced the rate of breakdown of the material (Palm and Sanchez, 1990, 1991). Prematilake *et al.* (1998) also reported a half-life of 9-16 weeks, and 14-27 weeks, for a 95% breakdown of the material at the low elevation of 60 m amsl.

Suppression of growth of *S. hispida* was not significantly affected by the other treatments, except the *Cymbopogon* and *Tithonia* treatments. Further, a lower percentage of *S. hispida* in the total weed population was recorded in the *Tithonia* and the envelope forking + compost treatments than with forking alone and in the untreated controls. Early ground exposure as a result of rapid breakdown of materials like *Eupatorium* mulch and compost, and continuous exposure of ground in forking alone and in untreated controls, after slash weeding, created more favourable conditions for re-invasion of *S. hispida*, even at 5 WAA. The moderate rate of breakdown of *Tithonia* mulch when compared to *Cymbopogon* could be attributed to its higher N content and lower C:N ratio, as indicated earlier. The lower lignin (20.6%) and polyphenol (6.0%) content, as reported by de Costa and Atapattu (2001), may also have caused a faster decomposition and a lower half-life of 8-17 weeks in the case of *Tithonia* leaves.

The compost treatments, with a high content of N, K and organic carbon, may have readily released nutrients which would facilitate re-invasion by *S. hispida* and other weeds at an early stage, since compost is in the form of humus following breakdown of protein, hemicelluloses and lignin compounds. A lower C:N ratio of 17 was also reported in compost (Smith, 2002). A faster decomposition of *Eupatorium*, compared to *Tithonia* mulch, would create more conducive conditions for re-invasion of *S. hispida* and other weeds at an early stage, such as 5 WAA. Prematilake and Prematunge (2000) reported that *Eupatorium* leaves were totally decomposed within 14 weeks after mulching, and this could be attributed to the low C:N ratio of 11.2 and the high N content of 3.15%. De Costa and Atapattu (2001) reported a short half-life of 2-8 weeks for *Eupatorium* leaves, together with a half-life of 1.8-4 weeks and 1.1-9 weeks, for the N and K, respectively.

It was observed that ground invasion by weeds in all the treatments, including the controls and forking alone, was faster towards the 2nd and 3rd applications of the treatments owing to high-intensity rainfall that occurred during these periods. The rate of decomposition generally increased with increasing rainfall as well, and decreased with increasing temperature and increasing pan evaporation (de Costa and Atapattu, 2001).

It was apparent that mulching *S. hispida*-infested tea fields with *Cymbopogon* grass or *Tithonia*, following slash weeding, effectively controlled the weed. In particular, the vacant patches could be infilled with these species, and their loppings used for *in situ* mulching as already established (Anon, 2002 b; Prematilake and Gamage, 2002). It was also apparent that the density of *S. hispida* over the total weed density becomes reduced by continuous slash weeding, followed by the occurrence of other weeds, irrespective of treatment effects. The other weeds could be chemically controlled subsequently. Thus, such an ecological aspect could also be considered as an important technique in the management of *S. hispida*.

ACKNOWLEDGEMENTS

The authors wish to thank the Tea Research Institute for funds and for facilities, and the Manager, Mount Vernon Estate, Patana, for allowing access to land and providing other requirements for this study.

REFERENCES

Anon 2002 a Infilling vacancies in tea fields. Advisory Circular No. PA 3 (Serial No.19/03), Tea Research Institute of Sri Lanka.

Anon 2002 b Tea Information. A supplement issued by the Tea Research Institute of Sri Lanka.

Basnayake A K 1986 Agronomy Division. TRI Annual Report, 1985, p. 34.

De Costa W A J M and Atapattu A M L K 2001 Decomposition and nutrient loss from prunings of different contour hedgerow species in tea plantations in the sloping highlands of Sri Lanka. Agroforestry Systems 51, 201-211.

Manipura W B, Somarathne A and Jayasooriya S G 1969 Some effects of mulching on the growth of young tea. Tea Quarterly 40, 153-159.

Mugendi D N and Nair P K R 1997 Predicting the decomposition patterns of tree biomass in tropical highland microregions of Kenya. Agroforestry Systems 35, 187-201.

Palm C A 1995. Contribution of agroforestry trees to nutrient requirements of intercropped plants. Agroforestry Systems 30, 105-124.

Palm C A and Sanchez P A 1991 Nitrogen release from the leaves of some tropical legumes as affected by their lignin and polyphenolic contents. Soil Biology and Biochemistry 23, 83-88.

Palm C A and Sanchez P A 1990 Decomposition and nutrient release patterns of the leaves of three tropical legumes. Biotropica 22, 330-338.

Prematilake K G 1999 Control of Problem weeds.*In* Proc., 199th Experimental and Extension Forum, Tea Research Institute of Sri Lanka.

Prematilake K G and Gamage A 2002 Management of "Getakola" (*Hedyoths* spp), a weed in tea. TRI Update 17, No 1.

Prematilake K G and Prematunge P 2000 Potential of various green matters being the sources of mulch and green manure for tea plantations. *In* Green Manuring and Fodder Tree Species for Crop-Livestock Productivity Improvement. Proc., 11th National Workshop on Multipurpose Trees, Kandy, Sri Lanka; p. 35-47.

Prematilake K G and Ekanayake P B 1999 Management of problem weeds in tea plantations. National Workshop on Weed Management in Sri Lanka, Council for Agricultural Research Policy; University of Peradeniya, Sri Lanka.

Prematilake K G, Froud-Williams R J and Ekanayake P B 1998 Potential of various green matters as mulches and their impact on weed suppression in tea lands. Tropical Agricultural Research 10, 309-323.

Sandanam S and Rajasingham C C 1982 Effect of mulching and cover crops on soil erosion and yield of young tea. Tea Quarterly 51, 21-26.

Smith R T 2002 Compost Making and Use. In: Organic Farming, Sustaining Earth and People. Centre for Organic Agriculture Development, Sri Lanka.

Valverde B E *et al.* 2000. Prevention and management of herbicide resistant weeds in rice: experiences from Central America with *Echinochloa colona*. Grafos, S. A., Costa Rica.

Visser T 1961 Interplanting in tea. 1. - Effect of shade trees, weeds and bush crops. Tea Quarterly 52, 81-83.

Wettasinghe D T 1971 a Report of the Research Officer for the Low Country Station and the Kottawa Substation for 1969. TRI Annual Report, p. 145-167.

Wettasinghe D T 1971 b Report of the Research Officer for the Low Country Station for 1970. TRI Annual Report, p.126-142.

Wickremasinghe K N 1985 Thatching materials for tea plantations. Report of the Agricultural Chemistry Division, Technical Report for 1984. TRI Annual Report, p. 35-36