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The Allelopathic Effects of *Lantana camara* on Seed Germination and Growth of Selected Bioassay Species

Senarathne, S. H. S.[1]*, R. D. V. Fernando[2] and U. R. Sangakkara[2]

ABSTRACT The allelopathic effects of *Lantana camara* L. (Family : Verbenaceae) on germination and seedling establishment of some agricultural crops and weed species have been identified. Aqueous extracts of dry leaves and contaminated soil where *L. camara* is grown were used to verify allelopathic effect on seed germination of five bioassay species; *Raphanus sativas, Capsicum annum, Lycopersicum esculantem, Crotalaria juncia* and *Chromoleana odorata*. Fifty seeds from each bioassay species were placed in a petri dish containing leaf extracts or contaminated soil, and seed germination were examined after 3 days. The plant house experiments were carried out to evaluate the impact of *L. camara* contaminated soil and leaf debris using *L. esculantem* as the indicator plant. Seed germination of *L. esculentem, C. junica* and *Capsicum annum* was significantly inhibited by *L. camara* contaminated soil. However, the degree of inhibition varied among the bioassay species. The aqueous extract of dry leaves of *L. camara* was highly phytotoxic and it significantly reduced seed germination of all bioassay species. There was a decline in plant height, leaf area and shoot dry weight of tomato only in early growth stages when grown in *L. camara* contaminated soils. However, incorporation of leaf debris into soil affected the vegetative growth of tomato in early stages when the leaf debris concentration was increased. Growth recovered at the latter part of the life cycle. On the basis of these results it can be concluded that the allelochemicals in *L. camara* contaminated soils are harmful to the seed germination of crop species. The adverse effect was present only during the early growth stages and it did not suppress the latter part of the plant growth. These responses are attributed to allelopathic effects which need confirmation under field conditions.

Key words: allelopathy; germination; *Lantana camara;* weed seed.

[1] Agronomy Division, Coconut Research Institute, Lunuwila 61150, Sri Lanka.
[2] Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.
* Corresponding author : Phone) +94-77-9351163, Fax) +94-31-2257391, E-mail) shsumith71@yahoo.com

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INTRODUCTION

Allelopathy is the negative effect of chemicals released by one plant species on the growth or reproduction of another plant species (Weidenhamer *et al.* 1989; Schenk *et al.* 1999; Callaway and Aschehoug, 2000). Allelopathy also is described as interference in the growth of neighboring plants or microorganisms by allelochemicals that are released through volatilization, eluviations and decomposition of the plant or root exudates during growth (Rice 1984; Putman and Tang 1986). Allelochemicals also can indirectly affect plants through the inhibition of microorganisms, including nitrogen fixing and nitrifying bacteria (Rice 1964), and ectomycorrhizae (Walker *et al.* 1999). Allelopathy widely exists in nature and plays a vital role in crop cultivation systems, controlling weeds, preventing crops from disease and insect infection.

L. camara L. (Family : Verbenaceae) is considered as an invasive woody shrub, and is found throughout Sri Lanka. Its toxic properties against cattle, small ruminants (Ghisalberti 2000), spores of liverwort *Aserella angusta* (Kothari and Chaudhary 2001), cyanophyte *Microcystis aerugina* (Kong *et al.* 2006), antimicrobial activity on *Bacillus subtillis* has been well documented (Loset *et al.* 2000; Misra and Laatsch 2000). Further, the toxic effects brought out by allelopathy of Lantana on root growth of soya bean and wheat have also been reported (Oudhia 2000; Oudhia and Tripathi 2000). On the other hand, some beneficial effects of *L. camara* have also been recognized. It is used, either along or together with other plants such as *Croton lacciferus* as mulch in paddy fields in the conventional agricultural practices for pest control. Allelochemicals of Lantana are composed of Lantadene A and Lantadene B, volatile oils such as caryophyllene, cieol and pinene (Kong *et al.* 2006; Abdel-Hady *et al.* 2005). However, its effect on weeds has not been reported.

The present study was undertaken to determine the alleopathic activity of *L. camara* on seed germination of selected bioassay species. The study focused on some important vegetables and weed species, namely *L. esculentum, Raphanus sativas, C. annum, C. junica* and *Chromoleana odorata*, which are a noxious weeds in coconut plantations. The aim of the study was to identify the impact of Lantana on germination of selected weed and crop species and seedling growth of *L. esculentum*.

MATERIALS AND METHODS

The experiments were carried out in the plant house of the Coconut Research Institute located in the Low country Intermediate Zone of the North Western province of Sri Lanka from March to August 2007. In the plant house, the photo-synthetically active radiation (PAR) ranged between 500～1,150 μmol m^{-2} s^{-1} and the average day and night temperatures were in the range of 30～34 ℃ and 26～30℃, respectively. Relative humidity varied between 35～60% during the day and 20～27% during the night. In the bioassay, *R. sativas, C. annum, L. esculentem, C. junica* and *C. odorata* seeds were used as the test species due to their high sensitivity to the phytotoxic activity of *L. camara* as observed in a preliminary study. Seeds of the selected weed species namely *C. odorata* and *C. junica* were collected from five different locations in the major coconut growing regions of Sri Lanka between in March 2007 and were stored at 5℃ under dark conditions. Seeds of radish (*R. sativa*), chillie (*C. annum*), and tomato (*L. esculentem*) were taken from the Seed and Plant Material Development Centre, Department of Agriculture, Sri Lanka. The selected treatments of the experiments were arranged in a Complete Randomized Design (CRD) with ten replicates (each Petri dish and pot representing one replication of a single species in each trial) in the respective studies.

Effect of residual toxicity of contaminated soil on seed germination of bioassay species

Contaminated soil (top soil obtained from an area covered by a well grown canopy of Lantana plants

continuously for 5 years) was collected to a depth of 5 cm. Soil from a field that did not have *Lantana camara* was used as a control. These soils were of the same soil group with similar chemical and physical properties. Soil was classified as Madampe soil series (light textured high productive soil series; bulk density = 1.48±0.02 g cm^{-3}; total available water = 5.71±0.89%; penetrometer resistance = 240±16.3 N cm^{-2}) was located in Bandirippuwa Estate, Lunuwila in the low country Intermediate climate zone (08°02N, 79°E, 35m altitude) (Senarathne *et al.* 2010).

The two soils were dried at room temperature and sieved through a 2 mm mesh. Ten grams of test and control soils were uniformly spread on separate 9 cm diameter petri dishes, fifty seeds of the bioassay species were placed uniformly on these soils and covered with the same soil. Soil was adequately moistened with distilled water. The dishes were kept in plant house at 27～30℃. Each treatment was replicated ten times.

Effect of aqueous extracts of dry leaves on seed germination of bioassay species

Dry leaves of *L. camara* were cut into small pieces, dried under full sunlight for 1 week and ground to a powder with an electrical grinder (Thomas Wiley, Thomas Company, U.S.A). The dried powdered leaves were immersed in distilled water in the ratio of 1 : 20 w /v and agitated for 24 hours on an orbital shaker at room temperature (29℃). The extract was strained through two layers of filter paper (Whatmans No. 02). The extract was refrigerated at 5℃ until use. One concentration of the dry leaf aqueous extract was used in this experiment. Fifty seeds each of selected bioassay species were placed separately in 9 cm diameter petri dishes lined with cotton wool and 5 ml volumes of the leaf extracts was added per dish, distilled water was used for the control. The perti dishes were kept in a plant house for 72 hours at 28～30℃. Treatments were replicated ten times.

Effect of residual toxicity of contaminated soil on growth of *Lycopersicum esculentem*

Soils obtained from Lantana grown and Lantana free fields were dried at room temperature and sieved through a 2 mm mesh. Uniform three weeks old tomato seedlings were transplanted in polythene bags (28 cm diameter, 40 cm height and 500 gauges) filled with either of the two soils, to determine the impact of Lantana contaminated soil on growth and yield of tomato. Each treatment had 16 replicates and one polythene bag was referred to as a replicate.

Effect of Lantana debris on growth of *Lycopersicum esculentem*

Mature Lantana leaves were collected from a coconut estates and air dried for one week. The dried leaves were grounded using a laboratory mill (Thomas-wiley, Thomas Company, U.S.A.) and kept in a refrigerator until use.

The soil was prepared by mixing four rates of Lantana leaves as given below

T_1 - 0 g of leaf debris / kg soil (control)
T_2 - 10 g of leaf debris / kg soil
T_3 - 20 g of leaf debris / kg soil
T_4 - 30 g of leaf debris / kg soil

Uniform three weeks old tomato seedlings were transplanted in separate polythene bags (28 cm diameter and 40 cm height and 500 gauges) filled with these prepared soils to determine the impact of Lantana leaf debris on growth and yield of tomato. Sixteen replicates of each treatment were used, where one polythene bag was a replicate.

Data collection

Germination of *R. sativas*, *C. annum, L. esculentem, C. junica* and *C. odorata* were recorded daily for 12 days according to the method of the Association of Official Seed Analysis (1985) to determine the germination percentage using the following formula.

$$\text{Germination } \% = \frac{\text{No of Germinated seeds}}{\text{Total no of seeds}} * 100$$

Statistical analysis

An Analysis of Variance (ANOVA) using Statistical software SAS was carried out and the significance was tested using Least Significant Differences (LSD) at 5% probability (<B31>SAS Institute 1999</C>).

RESULTS AND DICUSSION

Residual toxicity of contaminated soil on seed germination of selected bioassay species

Seed germination of bioassay species in soil from the field with Lantana for 5 years was lower than those in the soil from the area without Lantana (Table 1). These demonstrated that soil collected from the *L. camara* rhizosphere had a strong inhibitory effect on the seed germination of *L. esculentem, C. junica* and *C. annum.* However, there was no significant difference of the allelopathic effect of *L. camara* on *R. sativas* and *C. odorata* seeds. The lowest germination percentage (17%) was recorded in *C. junica* seeds, when those seeds were sown on the *L. camara* contaminated soil, while the highest germination percentage was found in *R. sativas* (69%) seeds when grown in the same soil (Table1). This is in agreement with the results of Chung and Miller (1995) who reported the inhibitory effect of soil collected from the surrounding area of alfalfa plants on their test bioassay species. This inhibition may be due to the release of phytotoxic substances by the root itself or through interaction between microorganisms and tissue litter.

However, this interpretation needs further study because several factors are involved in allelopathic activity and seed germination. In addition, the alteration of the physico-chemicals characteristics of the soil may affect the quantitative and qualitative of phyto-chemicals, which, in turn influences the allelopathic expression of plants (De Moral and Muller 1970). However, Achhireddy and Singh (1984) reported that soil collected under Lantana had no effect on germination and growth of milkweed (*Asclepias syriaca*) vine. However, in our experiment *L. camara* contaminated soil inhibited germination of the above species to a greater extent than the control treatment.

Effect of aqueous extracts of dry leaves on seed germination of selected bioassay species

Application of *L. camara* dried leaf extract significantly reduced the seed germination and the lowest germination percentages (7% and 13%) were found in *C. juncia* and *C. odorata*, while the highest germination percentage (34%) was found in *C. annum* seeds (Table 2).

These results are supported by the findings of Helgeson and Konzak (1950) where aqueous extracts of field bindweed (*Convolvulus arvensis*) and Canada thistle (*Crisium arvense*) inhibited the germination of seeds and growth of seedlings of many crops. Overall results

Table 1. Effect of residual toxicity of contaminated soil on seed germination of selected bioassay species.

Treatment	Seed germination %				
	Raphanus sativas	*Lycopersicum esculentem*	*Capsicum annum*	*Crotalaria junica*	*Chromoleana odorata*
T_1 Control	76	78	89	58	42
T_2 *Lantana camara*	69	42	35	17	38
Significance	ns	**	**	*	ns
LSD (P = 0.05)	-	26.5	24.4	29.5	

*Significant **Highly Significant.

Table 2. Effect of dried leaf extract on seed germination of selected bioassay species.

Treatment	Seed germination %				
	Raphanus sativas	*Lycopersicum esculentem*	*Capsicum annum*	*Crotalaria junica*	*Chromoleana odorata*
T_1 Control	95	72	68	35	56
T_2 *L. camara*	22	29	34	7	13
Significance	**	**	**	**	*
LSD (P = 0.05)	31.8	30.4	11.2	11.3	16.7

*Significant **Highly Significant.

suggested that allelopathic effect of dried leaves extract of *L. camara* significantly (P≥0.05) suppressed the seed germination of all the bioassay species seeds.

Effect of residual toxicity of contaminated soil on growth of *Lycopersicum esculentem*

The seedling height, leaf area and shoot dry weight of tomato plants increased with time, irrespective of the soil type (Fig. 1, 2 and 3). However, the shoot growth of plants grown on the Lantana contaminated soil was significantly reduced up to 6th week after planting when compared to that of plants grown in non-contaminated soil. At the latter part of the vegetative growth period there were no significant differences.

This clearly implies an allelopathic effect on the measured parameters only in the early vegetative growth period, due to the contamination of the soil by Lantana. Results reported here are contrary to those of

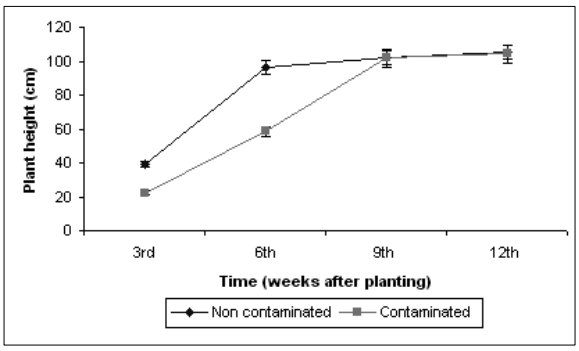


Fig. 1. Effect of Lantana-contaminated soil on plant height of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.

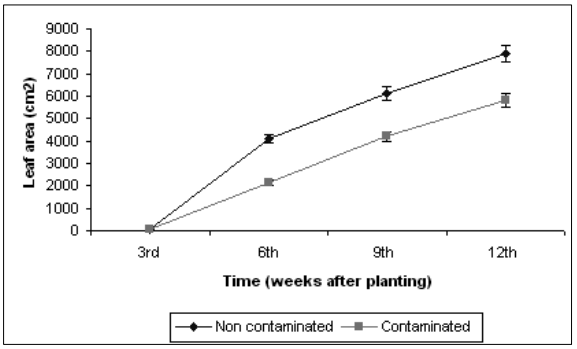


Fig. 2. Effect of Lantana-contaminated soil on leaf area of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.

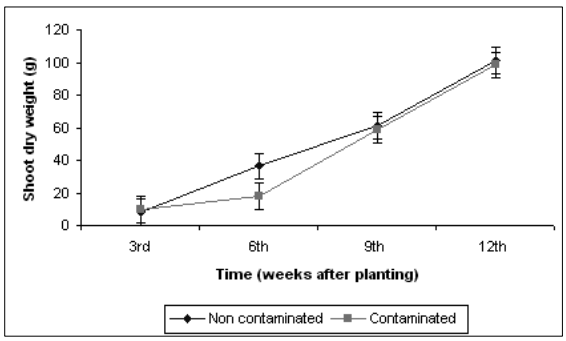


Fig. 3. Effect of Lantana-contaminated soil on shoot dry weight of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.

Achhireddy and Singh (1984) which indicated that soil collected under Lantana had no effect on germination and growth of milkweed vine. It should be noted that response to allelochemicals varies widely among species (Whittaker 1970).

Effect of Lantana leaf debris on growth of *Lycopersicum esculentem*

The effect of the *Lantana camara* leaf debris on the shoot growth of *Lycopersicum esculentem* seedlings in the soil incorporated with the debris was investigated because the tomato shoots were found to be the most sensitive in a preliminary study. The plant height of tomato plants increased with time in all four treatments, showing a typical sigmoid growth pattern. Generally, the application of leaf debris reduced plant height of tomato at early growth stages. The allelopathic effect emerged at the 3rd week after planting and the effect was observed until the 9th week after planting. The allelopathic impact was not present at the last sampling 12 weeks after planting (Fig. 4).

However, the leaf area of tomato plants grown in the control treatment was significantly decreased that of plants grown in other three treatments. The allelopathic effect was observed due to the leaf debris only up to 9th week after planting (Fig. 5).

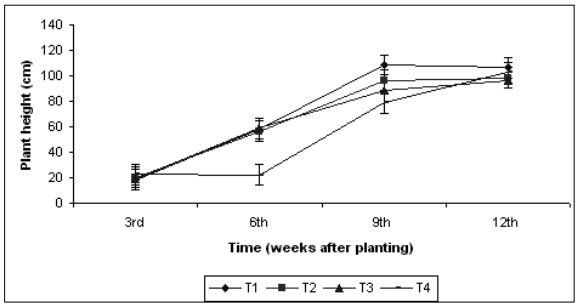


Fig. 4. Effect of *Lantana camara* leaf debris on plant height of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.

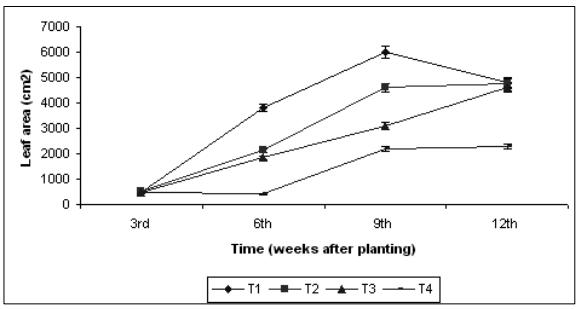
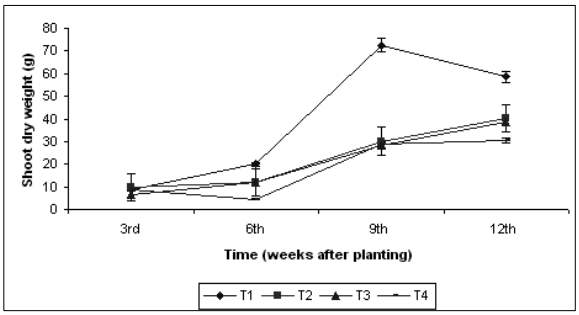


Fig. 5. Effect of *Lantana camara* leaf debris on plant leaf area of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.



Vertical bars indicate ± SE of the mean

Fig. 6. Effect of *Lantana camara* leaf debris on plant shoot dry weight of *Lycopersicum esculentem*. The vertical bars indicate SE of the mean.

The shoot dry weight of tomato plants increased with time, irrespective of the treatments (Fig. 6). However, the significant effect of treatments on shoot dry weight was observed during the growth period of tomato plants. The mean shoot dry weight of T_1 in tomato was significantly higher than that in the other treatments. The allelopathic effect of Lantana leaf debris was observed up to the 9th week. These results suggest that Lantana plant materials have phototoxic activity because it is well known that the possible toxic substances are released directly and or indirectly from the plant debris after degradation in the soil, as was shown with Mexican sunflower (*Tithonioa diversifolia*) (Tongma *et al*. 1998). Test plants in the debris studies responded not only to amount of debris but also to change in debris location. Phytotoxicity was enhanced by soil incorporation of plant debris. Incorporation of debris into soil may promote its chemical and microbial decomposition accompanied by release of soluble organic constituents (Sahid and Sugau 1993).

CONCLUSION

The selected bioassay species were more sensitive to inhibitory effects of dry leaf extracts, plant debris and contaminated rhizosphere soil of *L. camara*. Hence, *L.*

camara has a significant allelopathic potential and is likely to release allelopathic substances to the environment. However, the sensitivity to allelochemicals and extent of inhibition varied between species. The allelopathic effect of *L. camara* may be an important mechanism involved in invasive success of this plant. Under natural conditions, where a great number of interactions with other organisms occur, these allelopathic effects can enhance or restrain plant growth and species diversity. Field experiments must be carried out to test the effectiveness of the allelopathic potential of above grass species under natural conditions.

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