DOI: 10.1007/s11676-007-0060-6

Allelopathic effects of *Lantana camara* on germination and growth behavior of some agricultural crops in Bangladesh

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Abstract: An experiment was conducted to understand the growth inhibitory effects of aqueous extracts derived from *Lantana camara* L. (a globally recognized invasive alien weed) on six popular agricultural crops of Bangladesh. The test was conducted in sterilized petridishes with a photoperiod of 24 hours and an average temperature of 29°C. The effect of different concentrations of *L. camara* leaf extracts were recorded and compared with control (i.e., distil water). Result showed different concentrations of aqueous leaf extracts caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of receptor crops. Bioassays also indicated that the inhibitory effect was proportional to the concentrations of the extracts and higher concentration had the stronger inhibitory effect whereas the lower concentration showed stimulatory effect in some cases. The inhibitory effect was much pronounced in root and lateral root development rather than shoot and germination.

Keywords: *Lantana camara* L.; Allelopathy; Agricultural crops; Germination and growth

Introduction

The term 'allelopathy' signifies the interactions between plants might lead to either stimulation or inhibition of growth. Different groups of plants like; algae, lichens, crops, and annual and perennial weeds have wide known allelopathic interactions (Jain *et al.* 1989; Horsley 1991; Lawrey 1993; Inderjit *et al.* 1994a; Inderjit *et al.* 1994b; Ahmed *et al.* 2004; Uddin *et al.* 2007). Chemicals that inhibit the growth of some species at certain concentrations can stimulate the growth of the same or different species at lower concentrations. Hence, we expected that due to the perceived ambiguous nature of allelopathy, the phenomenon is sometimes hesitantly accepted, or even refuted, as an important factor in crop production. A significant portion of the agricultural land in developing countries in the tropics is heavily infested by various native and alien (invasive) weeds (Akobundu 1992), and controlling weeds is a big challenge to Asian farmers. There is much evidence that allelochemicals liberated from certain weeds into the soil reduce crop growth (Putnam *et al.* 1986; Putnam *et al.* 1986; Hoque *et al.* 2003). Crop weed interactions were referred to as plant competition, i.e., crop-weed competition, although without adequate evidences to indicate whether such effects were owing to competition alone, allelopathy, or both. Very little research was done in the subject of weed allelopathy prior to 1970. Fortunately, the pace of research in this area has accelerated greatly since 1970.

Many weed species from India have been studied *in vitro* for their allelopathic potential on various field crop species such as allelopathic effect of *Amaranthus spinosus* L., *A. tricolo* L. and *A viridis* L. on pear millet sorghum, wheat, groundnut and sesame were reported (Rao 1991). *L camara*, one of the world's 10 worst weeds was introduced in this subcontinent during the early part of the nineteenth century (Bansal 1998). The weed is aggressively growing in forest, agriculture, tea garden and wastelands of all over the country (Ahmed 1997). This obnoxious weed poses a serious problem to flora and fauna because of its toxic substance (Lantadene A) and it contains certain allelopathic compounds (Jain *et al.* 1989). Although several researches have so far been done on the allelopathic effect of *Lantana* on various agricultural crops throughout the world (Bansal 1998) however such scientific activities didn't take place yet in the context of Bangladesh. Our present work was an attempt to explore the allelopathic effects of *L. camara* water extracts on some common agricultural crops of Bangladesh.

Materials and methods

The receptor plants

The receptor agricultural crops were *Brassica juncea* (L.) Czern. (Indian mustard); *Cucumis sativus* L. (Garden Cucumber), *Phaseolus mungo* L. (Black Gram), *Raphanus sativus* L. (Radish), *Vigna unguiculata* (L.)Walp. (Asparagus Bean) and *Cicer arietinum* L. (Bengal Gram).

Donor plant and preparation of leaf extracts

In the present experiment we have used *L. camara* (a widely found alien invasive weed species all over the country), as the

Received: 2007-05-12; Accepted: 2007-07-10

The online version is available at http://www.springerlink.com
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Responsible editor: Zhu Hong

donor plant. Beside, for preparation of aqueous *L. camara* leaf extracts, 100 g of fresh *L. camara* leaves was soaked in 500-mL distilled water and kept in a room temperature of 28-30°C, without allowing any possible chemical changes. After 24 h the aqueous extract was filtered through the sieve and then some extracts were diluted to make the concentration of 10%, 25%, 50% and 75% (on the basis of volume) and stored for seed treatment experiments.

Treatments

The following treatments were followed during the experiment:

T_0 Seeds of receptor plants grown in distill water only (Control);
T_1 Seeds of receptor plants grown in extracts of 10% concentration;
T_2 Seeds of receptor plants grown in extracts of 25% concentration;
T_3 Seeds of receptor plants grown in extracts of 50% concentration;
T_4 Seeds of receptor plants grown in extracts of 75% concentration;
T_5 Seeds of receptor plants grown in extracts of 100% concentration.

Germination and growth records

The germination test was carried out in sterile petridishes of 12 cm in size placing a Whatman® no.3 filter paper on petridishes. The extract of each concentration was added to each petridish of respective treatment daily in such an amount just enough to wet the seeds. The control was treated only with distil water. 20 seeds of each receptor crop were placed in the petridish replicating 5 times. The petridishes were set in the room temperature of 28–30 °C. The experiment was extended over a period of seven days to allow the last seed germination and the measurement of the shoot and root length. A seed was considered as germinated, when radicle emerged. The germination was recorded daily and the results were determined by counting the number of germinated seeds, number of lateral roots and measuring the length of primary root and main shoot on seventh day of the experiment. Data obtained through the study were analyzed in variance and Duncan's Multiple Range Test (DMRT).

The germination and elongation ratio were calculated by the following equations as suggested by Rho and Kil (1986).

$$R=G/G_r \times 100 \quad (1)$$

where, R is the relative germination ratio, G the germination ratio of tested plant, and G_r is the germination ratio of control.

$$R_s= M_s/ M_C \times 100 \quad (2)$$

where, R_s is the relative elongation ratio of shoot, M_s the mean shoot length of tested plant, M_C the mean length of control.

$$Rr=M/ M_c \times 100 \quad (3)$$

where, R_r is the relative elongation ratio of root and M the mean root length of tested plant. For the calculation of percentage of inhibitory (or stimulatory) effect on germination and growth parameters of treatment plants to control, we used the following formula:

$$I=100-(E_2 \times 100/E_1) \quad (4)$$

where, I is the % inhibition (or stimulation); E_1 the response of control plant, and E_2 the response of treatment plant.

Results and discussion

Germination

The germination percent of the 6-receptor plants is shown in Table 1. In most cases, variation of germination percent varied evenly due to different concentrations. With the increase of concentration, the inhibitory effect was progressively increased. In all cases, the maximum inhibitory effect was found at T_5 treatment (100% conc.) except *V. unguiculata* and *P. mungo*. The highest relative germination ratio (-75.00%) was found on *R. sativus* at T_5 treatment followed by (-71.93%) in *C. arietinum* at the same treatment and neither inhibitory nor stimulatory effect was found on *C. sativus* at T_1 treatment. Stimulatory effect (+3.94%) was found on *B. juncea* at the same (T_1) treatment. The maximum relative germination ratio was found in *B. juncea* (103.44%) at T_1 treatment while the minimum was (25.00%) in *R. sativus* at T_5 treatment (Fig. 1). Among the receptors, *P. mungo* was less sensitive to the exposure of different concentrated extracts. It was also observed that leaf extracts of *L. camara* delayed the germination significantly in all the receptor crops compared to the control treatment. These results are more or less similar to the findings of Bora *et al.* (1999), who found the allelopathic effect of leaf extracts of *Acacia auriculiformis* on seed germination of some agricultural crops. The allelopathic effect of *Bambusa arundinacea* on *Arachis hypogaea* was also reported (Eyini *et al.* 1989) to conclude that, aqueous extracts of weeds inhibited the seed germination of selected crops.

Table 1. Germination percent of receptor agricultural crops to distill water (T_0) and different concentrations of *L. camara* leaf extracts (T_1-T_5)

Treatment	Agricultural crops					
	C. arietinum	*R. sativus*	*V. unguiculata*	*C. sativus*	*B. juncea*	*P. mungo*
T_0	95.00 a*	93.33 a	98.33 a	81.67 a	96.67 ab	98.33 a
T_1	90.00 a (-5.26)	81.67 ab (-12.49)	91.67 ab (-6.77)	81.67 a (0)	100.00 a (+3.94)	86.67 bc (-11.86)
T_2	86.67 ab (-8.77)	80.00 ab (-14.28)	88.33 ab (-10.17)	66.67 a (-18.37)	93.33 ab (-3.45)	95.00 ab (-3.39)
T_3	68.33 b (-28.07)	68.33 bc (-26.79)	90.00 ab (-8.47)	70.00 a (-14.29)	86.67 ab (-10.34)	90.00 abc (-8.47)
T_4	31.67 c (-66.66)	53.33 c (-42.86)	80.00 b (-18.64)	61.67 a (-18.37)	78.33 b (-18.97)	83.33 c (-15.25)
T_5	26.67 c (-71.93)	23.33 d (-75.00)	81.67 b (-16.94)	61.67 a (-18.37)	50.00 c (-48.28)	95.00 ab (-3.38)

Notes: * Values in the columns followed by the same letter (s) are not significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Growth behaviors

Shoot elongation

The average shoot lengths (cm) of the germinated seedlings of agricultural crops in all the receptor are shown in Table 2. The study revealed that in some cases stimulatory effect was found at T_1 and T_2 treatment in comparison to control and the inhibitory effect was progressively increased with the increase of concentration. Statistically pronounced significant effect was found at T_5 treatment followed by T_4 and T_3 treatment respectively. Com-

plete inhibition (-100%) was occurred in *B. juncea* at T_5 treatment. Among the survivors the highest inhibition was found on *R. sativus* (-99.64) at T_5 treatment and the lowest inhibitory effect was found on *C. sativus* (-9.09%) whereas the highest stimulating effect was found on *B. juncea* (+37.45%) at T_1 treatment. Maximum elongation of shoot (17.15 cm) was observed in *V. unguiculata* followed by (13.94 cm) in *P. mungo* both at T_2 treatment. Maximum relative elongation ratio of shoot (137.45%) was observed in *B. juncea* at T_1 treatment while the minimum was in *R. sativus* (0.36%) at T_5 treatment (Fig. 2).

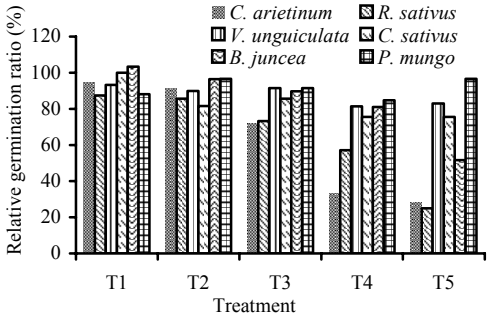

Fig. 1 Relative germination ratio of bioassay species grown in petridishes at different concentrations of *L. camara* leaf

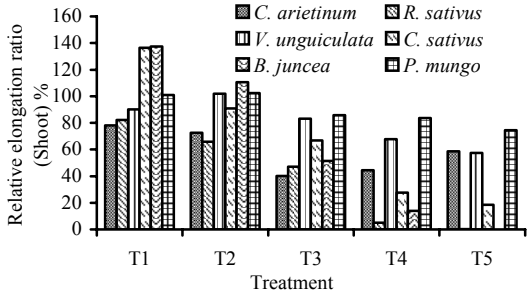

Fig. 2 Relative elongation ratio of shoot of bioassay species grown in petridishes at different concentrations of *L. camara* leaf extracts

Table 2. Shoot elongation (cm) of receptor agricultural crops to distill water (T_0) and different concentrations of *L. camara* leaf extracts (T_1-T_5)

Treatment	Agricultural crops					
	C. arietinum	*R. sativus*	*V. unguiculata*	*C. sativus*	*B. juncea*	*P. mungo*
T_0	7.44 a*	7.51 a	16.83 a	3.3 ab	2.67 b	13.63 a
T_1	5.81 ab (-22.64)	6.17 ab (-17.84)	15.17 ab (-9.86)	4.5 a (+36.36)	3.67 a (+37.45)	13.75 a (+0.88)
T_2	5.39 ab (-28.23)	4.95 bc (-34.09)	17.15 a (+1.90)	3.0 ab (-9.09)	2.95 ab (+10.49)	13.94 a (+2.27)
T_3	2.99 b (-60.19)	3.53 c (-53.40)	14.01 abc (-16.76)	2.2 bc (-33.33)	1.37 c (-48.69)	11.69 b (-14.23)
T_4	3.31 ab (-55.93)	0.38 d (-94.94)	11.42 bc (-32.14)	0.91 c (-72.42)	0.37 d (-86.14)	11.41 b (-16.29)
T_5	4.36 ab (-41.94)	2.67E-02 d (-99.64)	9.65 c (-43.20)	0.61 c (-81.52)	0.00 d (-100)	10.16 b (-25.46)

Notes: * Values in the columns followed by the same letter(s) are not significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatment.

Root elongation

The root length of all the 6 bioassay species were found to be greatly inhibited with the increase of the concentration of extract except *C. sativus*, stimulating effect was observed and relative elongation ratio was +87.95% and +93.98% at T_1 and T_2 treatment, respectively (Table 3). The inhibitory effect was much more pronounced at T_5 treatment followed by T_4, T_3 and T_2 treatments respectively. Complete inhibition was occurred in *B. juncea* at T_5 treatment. Among the survivors the highest inhibitory effect (-99.49%) was found on *R. sativus* at T_5 treatment followed by (-98.37%) in *B. juncea* at T_4 treatment. Maximum elongation of root (16.94 cm) was observed in *R. sativus* followed by (13.56 cm) in *P. mungo* both at control. Maximum RER of root (193.98%) was observed in *C. sativus* at T_2 treatment while the minimum (0.10%) was in *C. arietinum* at T_5 treatment (Fig. 3).

Table 3. Root elongation (cm) of receptor agricultural crops to distilled water (T_0) and different concentrations of *L. camera* leaf extracts (T_1-T_5)

Treatment	Agricultural crops					
	C. arietinum	*R. sativus*	*V. unguiculata*	*C. sativus*	*B. juncea*	*P. mungo*
T_0	13.56a*	16.94a	12.79 a	1.66 ab	9.8 a	7.74 ab
T_1	4.83 bc (-64.38)	10.23 b (.39.61)	10.98 ab (-14.15)	3.12 a (+87.95)	6.38 b (-38.93)	9.38 a (+21.19)
T_2	5.34 b (-60.62)	8.17 b (-51.77)	11.57 ab (-9.54)	3.22 a (+93.98)	3.93 c (-59.90)	6.55 bc (-15.37)
T_3	1.93 bc (-85.77)	3.53 c (-79.16)	8.03 b (-37.22)	1.44 ab (-13.25)	1.11 d (-88.67)	5.67 bcd (-26.74)
T_4	1.59 c (-88.27)	0.53 d (-96.87)	7.92 b (-38.08)	0.61 b (-63.25)	0.16 e (-98.37)	3.63 d (-53.10)
T_5	1.32 c (-90.27)	8.67E-02 d (-99.49)	3.48 c (-73.42)	0.39 b (-76.51)	0.00 e (-100)	4.78 cd (-38.24)

Notes: * Values in the columns followed by the same letter(s) are not significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Number of lateral roots development

Considering the number of lateral root development, it was revealed that this phenomenon is significantly inhibited with the increasing concentration. In all cases most significant effect was found at T_5 treatment and complete inhibition was occurred at this same treatment as well as at T_4 treatment in case of *R. sativus* and *B. juncea*. The effect was more or less evenly increased from 10% concentration to onward. In all cases control had the highest average lateral root number than that in other treatment except *C. sativus* and *P. mungo* on which stimulating effect (+26.64%) and (+15.18%) was found at T_1 treatment, respectively. Among the survivors the highest inhibitory (-99.53%) was found on *B. juncea* at T_4 treatment and the lowest (-1.14%) was found on *P. mungo* at T_1 treatment where as the maximum number of lateral roots (32 nos.) were found in *V. unguiculata* followed by (26.33 nos.) on *R. sativus* both with control treatment (Table 4). Lateral root development was completely inhibited in *R. sativus* seedlings at T_4 and T_5 treatments. The survivors exhibited varying degree of necrosis and chlorosis, thin and grayish in color. Many seedlings lost their ability to develop normally as

a result of reduced radicle elongation and root necrosis. So, it can be concluded that the inhibitory effect of *Lantana* extracts dependent very much on their concentration which was also by Daniel (1999) in other area.

Table 4. Number of lateral roots developed in receptor agricultural crops to distill water (T_0) and different concentrations of *L. camara* leaf extracts (T_1-T_5)

Treatment	Agricultural crops					
	C. arietinum	*R. sativus*	*V. unguiculata*	*C. sativus*	*B. juncea*	*P. mungo*
T_0	19.2 a*	26.33 a	32 a	6.42 ab	9.87 a	11.4 a
T_1	10.20 b (-46.88)	17.20 b (-34.68)	23.07 ab (-27.91)	8.13 a (+26.64)	6.13 b (-37.89)	13.13 a (+15.18)
T_2	9.8 b (-48.96)	6.53 c (-75.09)	26.4 a (-17.5)	4.40 bc (-31.46)	3.93 c (-60.49)	12.73 a (+11.67)
T_3	7.76 b (-59.58)	3.40 cd (-87.09)	19.13 ab (-40.22)	2.53 cd (-60.59)	0.40 d (-95.95)	11.27 a (-1.14)
T_4	9.0 b (-53.13)	0.00 d (-100)	19.6 ab (-38.75)	1.23 cd (-80.84)	4.67E-02 d (-99.53)	9.27 a (-16.68)
T_5	5.53 b (-71.20)	0.00 d (-100)	9.13 b (-71.47)	0.69 d (-89.25)	0.00 d (-100)	8.8 a (-22.81)

Notes: * Values in the columns followed by the same letter(s) are not significantly different (P≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments

Discussion

The observation of our study confirms the findings of Bansal (1998), who reported that the suppressed seed germination and seedling growth in all associated weeds and the suppressive effect increased with an increase in percent content increasing of *L. camara* extracts. The result also revealed that root elongation and lateral root developments of receptor crops were markedly inhibited compared to that of shoot elongation.

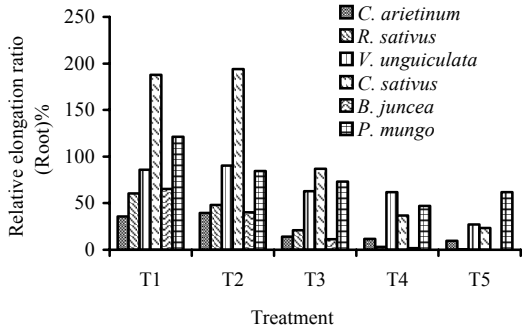

Fig. 3 Relative elongation ratio of root of bioassay species grown in petridishes at different concentrations of *L. camara* leaf extracts

These findings also were in accordance with the results of Alam 1990; Chou *et al* 1986 and Zackrisson and Nilsson 1992, in which root growth was more sensitive and responds more strongly to the increasing concentration of the aqueous extract. The suppressive effect of *Lantana* on other weeds may be caused by allelopathy. *Lantana* has also been reported to be allelopathic against milk weed vine (*Morrenia odorata*), velvet leaf (*Abutilon theophrasti*), and fern (*Cyclossus dentatus*) because of the presence of phenolic compounds (Jain *et. al.*, 1989). Allelochemicals from *L. camara* may, however, be different and need to be identified. Though laboratory bioassays in allelopathic researches are of great importance, a field study is recommend to confirm the allelopathic effects of *Lantana* on forest, tea garden and agricultural crops in various field conditions.

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