

Allelopathic Effects of Different Concentration of Water Extracts of *Eupatorium odoratum* Leaf on Germination and Growth Behavior of Six Agricultural Crops

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Abstract: Allelopathic effects of different concentration of water extracts of *Eupatorium odoratum* leaf on germination and growth behavior were tested by using some agricultural crops e.g. *Cicer arietinum*; *Brassica juncea*; *Cucumis sativus*; *Phaseolus mungo*; *Raphanus sativus* and *Vigna unguiculata* as bioassay material. The experiment was conducted in sterilized petridishes with a photoperiod of 24 h on average temperature of 28.5°C. The effect of the different concentration of aqueous extracts was compared to distil water (control). The result revealed that different concentrations of *Eupatorium odoratum* leaf extracts caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of receptor crops. Bioassays indicated that the inhibitory effect was proportional to the concentrations of the extracts and higher concentration had the stronger inhibitory effect whereas in some cases the lower concentration showed stimulatory effect. The study also revealed that inhibitory effect was much pronounced in root and lateral root development rather than shoot and germination.

Key words: *Eupatorium odoratum*, allelopathy, germination, root and shoot length and side root number

Introduction

The term *allelopathy* signifies that interactions between plants might lead to either stimulation or inhibition of growth (Molisch, 1937). Allelopathic interactions are widely known in different groups of plants such as algae, lichens, crops, as well as annual and perennial weeds (Rice, 1984; Putnam, 1985; Horsley, 1991; Lawrey, 1993 and Inderjit and Dakshini, 1994a and b). Chemicals that inhibit the growth of some species at certain concentrations can stimulate the growth of the same or different species at lower concentrations (Rice, 1984). Hence, it should be 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 with 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 (Rice, 1964; Rice, 1974; Rice, 1979; Putnam and Tang, 1986 and Putnam and Weston, 1986). Approximately 6700 species, out of about 300,000 species of the flowering plants are

recorded as weed in agroecosystem of the world (Holm *et al.*, 1979). Prior to Molisch (1937), studies on crop weed interactions were referred to as plant competition i.e. crop-weed competition without adequate evidences 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 (Rice, 1974). Fortunately, the pace of research in this area has accelerated greatly since 1970. Anaya and Gomez-Pompa (1971) demonstrated that extracts of leaves and fruits of piru (*Schinus molle* L.) are strongly inhibitory against seed germination and seedling growth of cucumber and wheat. A great deal of research has been done over period of years on the allelopathic effects of couch grass, *Agropyron repens* (Minar, 1974 and Rice, 1974). Many weed species from India have been studied *in vitro* for their allelopathic potential on various field crop species (Kanchan and Joyachandra, 1979). Allelopathic effect of *Amaranthus spinosus* L., *A. tricolor* L., *A. viridis* L. was reported by Mohnot and Soni (1977); Murthy and Zakharia (1980); Singhal and Sen (1981); Arun (1983) and Rao (1991); *Imperata cylindrica* L. by Abdul-Waheb and Al-Naib (1972); *Saccharum spontaneum* L. by Amritphale and Mall (1978); *Cynodon dactylon* by Horowitz and Friedman (1971); Lucena and Doll (1976) and *Cyperus rotundus* L. by Singh (1968); Horowitz and Friedman (1971); Lucena and Doll (1976) and Mallik *et al.* (2000). Very few research have been done on the allelopathic effect of *Eupatorium odoratum* on crops but no research has so far been done on this aspect in Bangladesh. Therefore the experiment was conducted to explore the allelopathic effect of *Eupatorium* leaf extracts on some agricultural crops.

Materials and Methods

Eupatorium odoratum, Shrubby bush or weed was considered as the donor plant and the receptor agricultural crops selected were Indian mustard (*Brassica juncea* (L.) Czern and Coss), Cucumber (*Cucumis sativus* L.), Black gram (*Phaseolus mungo* L.), Radish (*Raphanus sativus* L.), and Falen (*Vigna unguiculata* (L.) Walp.), Chickpea (*Cicer arietinum* L.).

The aqueous extracts were prepared from fresh leaf of the donor plant. 100 gram of fresh senescent leaves of each species were soaked in 500 ml of distil water and kept at room temperature. After 24 hours the aqueous extract was filtered through the sieve and then some extracts were diluted to make the concentration of 10%, 25%, 50% and 75% and stored for seed treatment experiments. The following treatments were used in the experiment:

- T₀ = Seeds of receptor plants grown in distil water only (Control),
- T₁ = Seeds of receptor plants grown in leaf extracts of 10% concentration
- T₂ = Seeds of receptor plants grown in leaf extracts of 25% concentration
- T₃ = Seeds of receptor plants grown in leaf extracts of 50% concentration
- T₄ = Seeds of receptor plants grown in leaf extracts of 75% concentration
- T₅ = Seeds of receptor plants grown in leaf 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 is concentration was added to each

Petridish of respective treatment daily in such an amount just to keep the seed moist enough to get favorable condition for germination and growth. The control was treated with distilled water only. 20 seeds of each agricultural crop were placed in the Petridish replicating five times. The petridishes were set in the analytical laboratory of the Institute of Forestry and Environmental Sciences, Chittagong University, Bangladesh at a room temperature ranging from 28-30^o C. The experiment extended over a period of ten days to allow the last seed germination and the measurement of the shoot and root length. The seed was considered as germinated when the radicle emerged and the germination was recorded daily. 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 10th day of the experiment. The data were subjected to Analysis of Variance and Duncan's Multiple Range Test (DMRT).

Ratio of germination and elongation were calculated as suggested by Rho and Kil (1986):

$$\begin{aligned} \text{Relative Germination Ratio (RGR)} &= \frac{\text{Germination ratio of tested plant}}{\text{Germination ratio of control}} \times 100 \\ \text{Relative Elongation Ratio (RER) of shoot} &= \frac{\text{Mean root length of tested plant}}{\text{Mean root length of control}} \times 100 \\ \text{Relative Elongation Ratio (RER) of root} &= \frac{\text{Mean shoot length of tested plant}}{\text{Mean shoot length of control}} \times 100 \end{aligned}$$

For the calculation of percentage of inhibitory effect on the radicle and plumule elongation, percentage to the control was calculated as per formula evolved by Surendra and Pota, (1978):
 $I = 100 - (E_2 \times 100 / E_1)$

Where,

I = % inhibition,

E₁ = Germination, Radicle and plumule elongation and lateral root development of control plant,

E₂ = Germination, Radicle and plumule elongation and lateral root development of treatment plant.

Results

Germination (%)

The germination percentages of the receptor agricultural crops are shown in Table 1. Highest germination percentage of all the crops was observed at control (T₀) except *Brassica juncea*. Germination percentage of most of the crops was significantly reduced with T₅ treatment.

Table 1: Germination percent of receptor agricultural crops to distil water (T₀) and different concentrations of *Eupatorium odoratum* extracts (T₁-T₅). Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments

Agricultural crops						
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculato</i>	<i>C. sativus</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	73.33a*	81.67a	100.00a	56.67a	96.67a	96.67a
T ₁	70.00a (-4.54)	83.33a (+2.03)	98.33 a (-1.67)	45.00a (-20.59)	96.67a (0.00)	91.67a (-5.17)
T ₂	51.67ab (-29.53)	80.00a (-2.04)	83.33ab (-16.67)	35.00a (-38.24)	95.00a (-1.73)	85.00a (-12.07)
T ₃	46.67bc (-36.36)	68.33a (-16.33)	55.00bc (-45.00)	40.00a (-29.42)	71.67b (-25.86)	88.33a (-8.63)
T ₄	26.67c (-63.63)	40.00b (-51.02)	46.67c (-53.33)	45.00a (-20.59)	71.67b (-25.86)	88.33a (-8.63)
T ₅	26.67c (-63.63)	20.00c (-75.51)	41.67c (-58.33)	38.33a (-32.36)	40.00c (-58.62)	95.00a (-1.73)

* 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).

Table 2: Shoot elongation (cm) of receptor agricultural crops to distil water (T₀) and different concentrations of *Eupatorium odoratum* extracts (T₁-T₅). Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatment

Agricultural crops						
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>C. sativus</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	7.93a*	7.01a	15.76a	7.11bc	3.30ab	13.75ab
T ₁	5.64ab (-28.88)	6.79a (-3.14)	17.07a (+8.31)	10.87a (+52.88)	10.67a (+223.33)	15.09a (+9.74)
T ₂	5.76ab (-27.36)	7.03a (+0.29)	15.52a (-1.52)	6.63bc (-6.75)	4.65ab (+40.90)	14.62a (+6.33)
T ₃	4.36ab (-45.02)	4.98b (-28.96)	10.77a (-31.66)	9.69ab (+36.29)	3.97ab (+20.30)	13.47ab (-2.04)
T ₄	3.64b (-54.10)	3.87b (-44.79)	9.47a (-39.91)	5.10c (-28.27)	2.39ab (-27.57)	12.25bc (-10.91)
T ₅	2.73b (-65.57)	1.78c (-74.61)	12.58a (-20.17)	3.34c (-53.02)	1.29b (-60.90)	11.04c (-19.71)

*- 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).

Irregular inhibitory effect was observed in *Phaseolus mungo* and *Cucumis sativus*. Among the survivors the highest inhibition (-75.57%) was found on *Raphanus sativus* at T₅ treatment and lowest (-1.67%) was on *Vigna unguiculata* at T₁ treatment. Maximum Relative Germination Ratio (RGR) was recorded as 102.03% in *R. sativus* at T₁ treatment while the minimum as 36.37% in *Cicer arietinum* both at T₄ and T₅ treatment (Fig. 1).

Shoot elongation (cm)

Table 2 represents the average shoot length (cm) of the germinated seedlings of all the receptor agricultural crops. The study revealed that T₁ and T₂ treatment and even T₃ treatment

Table 3: Root elongation (cm) of receptor agricultural crops to distil water (T₀) and different concentrations of *Eupatorium odoratum* extracts (T₁-T₅). Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatment

Agricultural crops						
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>C. sativus</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	7.91a*	14.70a	11.91a	5.10b	9.11a	7.85a
T ₁	5.08ab (-35.80)	15.38a (+4.63)	13.77a (+15.62)	8.87a (+73.92)	7.28b (-20.09)	8.27a (+5.35)
T ₂	6.69ab (-15.42)	12.05a (-18.02)	5.82b (-51.13)	4.40b (-13.73)	5.85c (-35.78)	8.24a (+5.00)
T ₃	2.89b (-63.46)	4.825b (-67.18)	3.45c (-71.03)	3.18b (-37.65)	20.01b (+119.65)	6.31ab (-19.62)
T ₄	4.93ab (-37.67)	2.95b (-79.93)	1.57c (-86.82)	2.29b (-55.10)	1.00e (-89.02)	2.63c (-66.50)
T ₅	2.48b (-68.65)	1.22b (-91.70)	5.63b (-52.73)	2.21b (-56.67)	0.54e (-94.07)	4.52b (-42.42)

Table 4: Number of lateral roots developed in receptor agricultural crops to distil water (T₀) and different concentrations of *Eupatorium odoratum* extracts (T₁-T₅). Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatment

Agricultural crops						
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>C. sativus</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	12.93a*	21.93	21.00a	14.47a	8.47a	11.60a
T ₁	11.27ab (-12.84)	18.13ab (-17.33)	21.90a (+4.29)	13.80ab (-4.63)	6.40ab (-24.44)	10.87a (-6.30)
T ₂	9.40abc (-27.30)	14.93bc (-31.92)	14.13ab (-32.71)	11.78ab (-18.59)	7.73a (-8.74)	7.87b (-32.16)
T ₃	9.00 abc (-30.40)	9.93cd (-54.72)	7.60b (-63.81)	8.30bc (-42.64)	4.80b (-43.33)	6.20b (-46.55)
T ₄	5.63bc (-56.46)	6.60de (-69.90)	8.18b (-61.05)	5.07c (-64.96)	4.60b (-45.69)	7.00b (-39.66)
T ₅	4.93c (-61.87)	0.58e (-97.36)	8.07b (-61.60)	3.73c (-74.22)	1.13c (-86.66)	6.07b (-47.67)

*- 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).

in some cases stimulated the shoot elongation of most of the crops. The highest stimulatory effect (+223.33%) was found in *B. juncea* at T₁ treatment while the lowest (+0.29%) was found in *R. sativus* at T₂ treatment. Maximum reduction of shoot length of most of the crops was caused by T₅ treatment followed by T₄ treatment. Among the survivors the highest inhibitory effect (-74.6%) was found on *R. sativa* at T₅ treatment while the lowest inhibitory effect (-1.52%) was found on *V. unguiculata* at T₂ treatment. Maximum relative elongation ratio (RER) of shoot (323.33%) was observed in *B. juncea* at T₁ treatment and the minimum (25.39%) was in *R. sativus* at T₅ treatment (Fig. 2).

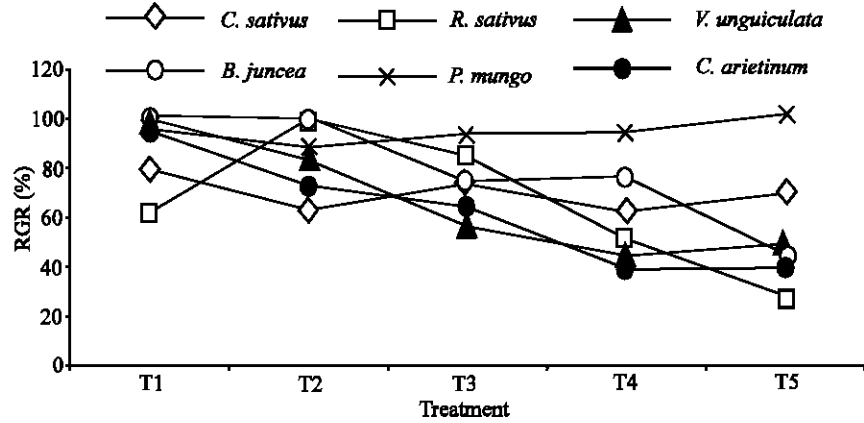


Fig. 1: Relative germination ratio (RGR) of bioassay species grown in petridishes at different concentrations of *Eupatorium odoratum* extracts

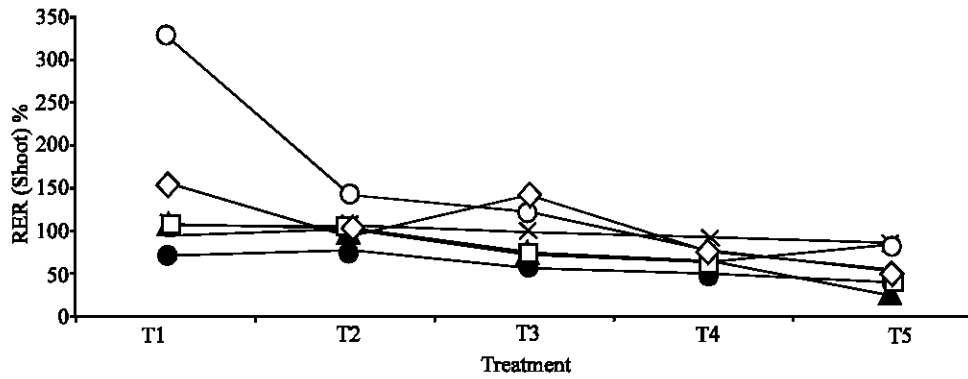


Fig. 2: Relative elongation ratio (RER) of shoot of bioassay species grown in petridishes at different concentrations of *Eupatorium odoratum* extracts

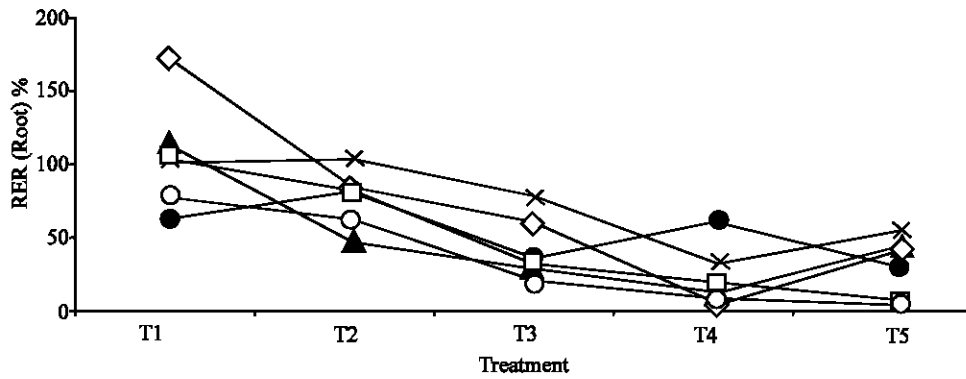


Fig. 3: Relative elongation ratio (RER) of root of bioassay species grown in petridishes at different concentrations of *Eupatorium odoratum* extracts

Root elongation (cm)

In comparison to germination and shoot length, the root length of all the six-bioassay species was greatly inhibited with the increase of extract concentration (Table 3). T₁ treatment stimulated the root development of all the crops except *C. arietinum* and *B. juncea*. The highest stimulatory effect (+73.92%) was recorded in *C. sativus* and lowest (+4.63) was found in *R. sativus*. The inhibitory effect was much more pronounced at T₅ treatment as well as at T₄ treatment. Among the survivors the highest inhibitory effect (-94.07%) was found on *B. juncea* followed by (-91.70%) in *R. sativus* at T₅ treatment while the lowest (-13.73%) was found on *C. sativus* at T₂ treatment. Maximum relative elongation ratio (RER) of root 173.92% was recorded in *C. sativus* at T₁ treatment while the minimum was in *B. juncea* at T₅ treatment (Fig. 3).

Number of lateral roots development

The study revealed that lateral root development was significantly inhibited with the increasing of concentration in most cases (Table 4). Most significant effect was found at T₅ treatment on all crops except *V. unguiculata* followed by T₄, T₃ and T₂ treatments. Control had the highest average lateral root number than other treatment except *V. unguiculata* on which stimulating effect (+4.29%) was found at T₁ treatment. Among the survivors the highest inhibition (-97.36%) was found on *R. sativus* at T₅ treatment while the lowest (-4.63%) was found on *C. sativus* at T₁ treatment.

Discussion

This study clearly demonstrated the suppressive effect of *Eupatorium odoratum* leaf extract on the germination and seedling growth of selected bioassay species. The suppressive effect was significantly reduced the germination and overall seedling growth of *R. sativus* and *C. arietinum*. The minimum suppressive effect was reported on *P. mungo* followed by *C. sativus* and *B. juncea*. This findings are correlated with the findings of Sharma *et al.* (1967); Swami Rao and Reddy (1984); Eyini *et al.* (1989); Bora *et al.* (1999) who found the inhibitory effect of leaf extracts of some agroforestry tree species on certain food crops. Suppressive effect was increased with an increase of extract concentration indicating that the effect of plant extracts dependent very much on their concentration. Similar observation was found by Ballester *et al.* (1982); Rai and Tripathi (1984); Rizvi and Rizvi (1987); Bansal (1998); Daniel (1999).

The suppressive effect of *Eupatorium* weeds may be caused by allelopathy. This results are correlated with the findings of Kanchan and Jayachandra, (1979) who found the allelopathic potential of many Indian weed species on various field crop species, Jain *et al.* (1989) who reported the allelopathic potentials of *Lantana* weeds and Mallik *et al.* (2000) who found the growth inhibitory effect of a weed Nutgrass (*Cyperus rotundus*) on Rice (*Oryza sativa*) seedlings.

It was inferred from the present study that root growth was found more sensitive and responds more strongly to the increasing concentration of the aqueous extract. Similar findings were also reported by Chou and Waller (1980a, 1980b); Meissner *et al.* (1982); Swami Rao and Reddy (1984); Chou and Kuo (1986); Alam (1990); Zackrisson and Nilsson (1992).

Allelopathic studies of weeds on crops are much limited in Bangladesh. Priority should be given on weed survey and identification of dominant and widespread weeds according to ecoclimatic zone of the country, while wide scope for the allelopathic studies of weeds will be recognized.

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