Proc. Indian natn. Sci. Acad. **B47** No. 3 pp 458-465 (1981)

Allelopathic Potential of *Eupatorium adenophorum*— A Dominant Ruderal Weed of Meghalaya

R S TRIPATHI, R S SINGH and J P N RAI

Botany Department, School of Life Sciences, North-Eastern Hill University, Shillong 793014

(Received 19 December 1980; after revision 23 March 1981)

The aqueous plant extracts of a number of species were tested for inhibitory action on wheat seed germination. Amongst the species tested, *Eupatorium adenophorum* Spreng, a common ruderal weed of Meghalaya, showed strong inhibitory effect. The field observations indicated that growth of this weed also causes elimination or reduction in frequency and density of certain plant species.

Seed germination and radicle and plumule growth of four plant species viz. *Trifolium repens*, *Rumex nepalensis*, *E. riparium* and *Paspalum dilatatum*, which are the common herbaceous species of the local flora, are also suppressed due to aqueous extract treatment. The inhibitory effect was correlated with the concentration of the extract. The aqueous extract also caused significant reduction in leaf number and dry matter production of *T. repens* which was used as a test species to measure the allelopathic effect of *E. adenophorum* on plant growth. The soil microbial population also declined considerably due to presence of *E. adenophorum*.

Key Words: Allelopathy, *Eupatorium adenophorum*, Aqueous plant extract, Soil microbial population

Introduction

Eupatorium adenophorum Spreng, a perennial herb of family Asteraceae is a native of Mexico. It is distributed on the far north coast of New South Wales, Australia—where it has been declared as a noxious plant under the local Government Act (Auld 1969). In India, it grows abundantly in Meghalaya State, particularly at higher altitude (from 553 to 1750 m) as one of the serious weeds of ruderal habitats. It shows a dense and luxuriant growth on wastelands and roadsides, covering a large tract with its pure patches. This suggests that *E. adenophorum* might have developed certain strategies which probably cause adverse effect on the associated plant species which would have otherwise confronted it as its potential competitors. One such strategy could be the production of chemical substances that may be harmful to other plant

species. In several studies, the plant species belonging to Asteraceae have been reported to produce substances that are toxic to germination and growth of other plant species. Some examples are *Helianthus annuus* (Wilson & Rice 1968), *Chrysanthemum morifolium* (Kozel & Tukey 1968), *Parthenium hysterophorus* (Sarma et al. 1976, Kanchan & Jayachandra 1979), *Ambrosia psilostachya* (Neill & Rice 1971), *Ambrosia artimisiifolia* (Raynal & Bazzaz 1975, Jackson & Willemsen 1976), *Artemisia herba-alba* (Friedman et al. 1977) and *Eupatorium riparium* (Rai & Tripathi, unpublished data). While reports of the toxic effect of *Eupatorium odoratum* on fishes (Chopra et al. 1956) and *E. adenophorum* on horses (O'Sullivan 1979) are available, no such report seems to have been published on allelopathic effect of *E. adenophorum* on associated plant species.

Materials and Methods

Detection of allelopathy: Aqueous extracts of leaves, roots and litter of some common plant species of Meghalaya were tested for their effect on seed germination of wheat *(Triticum aestivum)* in order to detect the allelopathic potential. Fresh leaves, roots and litter of six plant species, viz., *Eupatorium adenophorum*, *E. riparium*, *Anaphalis araneosa*, *Lantana camara*, *Galinsoga ciliata* and *Trifolium repens* were collected from field populations. The aqueous extracts of 5% and 10% concentrations were obtained by crushing 5 and 10 g of fresh plant materials with 100 ml distilled water with a pestle and mortar and by filtering the crushed material through a muslin cloth. The effect of the extracts on seed germination was studied by soaking the wheat seeds in extracts for 20 hr. Two hundred soaked seeds were kept for germination on moist filter paper underlain by cotton moistened with 10 ml distilled water in the Petri dishes. The seeds were kept for germination in dark at 25–30°C in a BOD incubator and observations were made over a 5-day period. A control was run using distilled water as soaking medium.

Field observations on the effect of E. adenophorum on abundance of other plant species: Field observations on presence and density of plant species growing in the neighbourhood of *Eupatorium adenophorum* on the university campus at Shillong (Altitude 1500 m) were recorded with a view to study the community structure as influenced by the weed. Vegetation in 10 sample plots was analysed using $1m^2$ quadrat at both weed-infested and weed-free sites.

Allelopathic effect of E. adenophorum extracts on seed germination and radicle and plumule elongation of other species: Aqueous extracts of leaves, roots and litter of *E. adenophorum* prepared in distilled water were separately tested for their effect on seed germination and radicle and plumule growth of four plant species, viz., *Trifolium repens*, *Rumex nepalensis*, *Eupatorium riparium* and *Paspalum dilatatum*. Two hundred mature seeds of each of the four species were soaked in 5% and 10% aqueous plant extract of *E. adenophorum* for 20 hr. and were placed for germination in Petri dishes as in Expt. 1 and the observations were recorded over a 15-day period after which the seed germination practically ceased to occur. For studying the effect of extract on plumule and radicle elongation, the growth attained after 24 hr of radicle emergence (germination) was measured with the help of a calliper. Ten germinated seeds of each species were used for each treatment. The seeds soaked in distilled

water served as controls. The effect of extract was also studied on seed germination and plumule and radicle elongation of *E. adenophorum*.

Growth of Trifolium repens as affected by E. adenophorum extract: Freshly collected mature seeds of *T. repens* were germinated in a tray and 5 seedlings of 4-leaf stage were transplanted on 20th January, 1980 in each of the 27 pots of 20.7 cm diam. containing 4 kg of garden soil. The pots were separated in three lots for application of 10%, 5% and 0% (control) extracts. There were three replicates and three harvests for each of the three treatments. The pots were numbered and completely randomised. The aqueous extracts of 5% and 10% concentrations were prepared by crushing appropriate quantity of plant material (equal quantities of leaf+root+litter) of *E. adenophorum* using distilled water. Five hundred ml of each extract was supplied to each pot of the respective treatments at 2-day interval from the date of transplantation. In the control set, 500 ml of distilled water was supplied. The harvests were taken 3, 4 and 5 months after the date of transplantation. The observations pertaining to total number of leaves and dry matter yield per plant of *T. repens* were made at each harvest. The dry-matter production was determined after drying the plant material at 70°C for 48 hr. in an oven.

Effect of E. adenophorum on microbial population: The allelopathic potential of *E. adenophorum* was also studied with respect to soil microbial population. Ten pots (20.7 cm diam.) were filled with garden soil, and *E. adenophorum* plants of 6–8 leaf stage were transplanted—one each in five of the pots in March, 1980. The other set of 5 pots contained no plant. After 3 months, the soil samples were collected from both sets of pots for the quantitative analysis of the microbial populations. The populations were also estimated from the soil samples collected from a natural habitat; where *E. adenophorum* grew luxuriantly, through 'dilution-plate' technique using 'nutrient-agar media' for bacteria and 'Martin Rose-Bengal media' for fungi and 'starch-caesin agar media' for Actinomycetes.

Results

The aqueous extracts of all the plant species except *T. repens* had inhibitory effect on the germination of wheat seeds (table 1). The maximum inhibition was brought about by *E. adenophorum* extracts and minimum by *G. ciliata*. The seed germination inhibition was a function of extract concentration in almost all the cases. However, the extracts of different plant parts of a species had almost the same effect. The field observations indicate that several plant species were either absent or showed relatively low frequency and density on the sites infested with *E. adenophorum*. However, certain species viz. *C. cruciata*, *H. radicata* and *A. araneosa* showed the reverse trend (table 2). Besides, the aqueous extracts of different plant parts of *E. adenophorum* also inhibited the plumule and radicle growth of certain plant species viz. *T. repens*, *R. nepalensis*, *E. riparium* and *P. dilatatum*. The inhibition of seed germination and plumule and radicle growth of these species was also directly correlated with extract concentration. The maximum inhibition was observed in *T. repens* and the minimum in *E. riparium* (tables 3 & 4). The aqueous extracts of different plant parts caused differential effect on the test species. For example, the leaf

Table 1 *Wheat seed germination inhibition* (%) *caused by aqueous extract of different parts of various plant species*

Plant species	Leaf extract		Root extract		Litter extract	
	10%	5%	10%	5%	10%	5%
Eupatorium adenophorum	25.5	23.9	38.9	28.9	41.1	29.5
E. riparium	20.0	18.34	6.67	11.1	24.5	13.3
Anaphalis araneosa	20.0	15.0	18.8	18.8	10.0	11.1
Lantana camara	10.7	10.2	7.5	9.6	28.5	14.5
Galinsoga ciliata	12.09	9.35	12.0	12.6	20.8	13.74
Trifolium repens	+3.33	+1.11	+6.66	0	+1.11	+4.44

Source of variation	Probability
Between species	<.01
Between treatments (extract of different plant parts)	<.01
Between concentrations	<.01
Species × Treatments	<.01
Treatments × Concentrations	<.05
Species × Concentrations	not significant
Species × Treatments × Concentrations	not significant

Table 2 *Community structure and frequency and density of plant species as affected by the presence of* Eupatorium adenophorum*

Plant species	Weed-infested site		Weed-free site	
	Frequency (%)	Density/ m^2	Frequency (%)	Density/ m^2
Eupatorium riparium Regel.	90	15.3	90	16.2
Trifolium repens Linn.	Absent	0	40	6.8
Rumex nepalensis Spreng.	40	4.3	100	18.2
Plantago major Linn.	60	6.8	80	11.1
Galinsoga ciliata (Rafin) Blake	50	5.5	80	8.7
G. parviflora Cav.	Absent	0	20	2.5
Paspalum dilatatum Poir.	40	6.6	60	12.1
Carex cruciata Nees	50	6.7	30	5.3
Hypochaeris radicata Linn.	90	6.1	70	4.8
Drymaria cordata Willd.	40	3.2	60	7.4
Osbeckia crinata Benth.	60	7.9	60	9.7
Eurya japonica Thunb.	90	7.2	80	6.7
Lantana camara Linn.	80	9.5	80	10.1
Potentilla mooniana Wight	100	9.1	100	3.9
Anaphalis araneosa DC.	80	5.1	60	4.0
Arundinella khaseana Nees	Absent	0	40	2.1

*Per metre^2 density of *E. adenophorum* was 18 on the weed-infested site

extract had greater effect on seed germination of *R. nepalensis* and *P. dilatatum* whereas in *T. repens* and *E. riparium* greater inhibition was caused by root extract and litter extract (table 3). The radicle and plumule growth of *R. nepalensis* was most affected by the leaf extract while that of *T. repens* by the root extract (table 4). Besides, the litter extract also inhibited the growth of *T.*

Table 3 *Seed germination inhibition* (%) *of various plant species caused by aqueous extracts of different parts of* E. adenophorum

Test species	Leaf extract		Root extract		Litter extract	
	10%	5%	10%	5%	10%	5%
T. repens	59.2	43.2	66.6	59.2	62.9	45.6
Rumex nepalensis	63.6	48.5	27.3	21.2	45.5	39.3
E. riparium	6.8	1.7	8.6	3.4	13.7	6.8
Paspalum dilatatum	18.7	16.6	10.4	10.4	16.6	12.5

Source of variation	Probability
Between species	<.01
Between Treatments	<.01
Between Concentrations	not significant
Species × Treatments	<.05
Concentrations × Treatments	not significant
Species × Concentrations	not significant
Species × Treatments × Concentrations	not significant

Table 4 *Plumule (P) and radicle (R) growth inhibition* (%) *of various plant species caused by aqueous extracts of different parts of* E. adenophorum

Test species	Extract concentration (%)	Leaf extract		Root extract		Litter extract	
		P	R	P	R	P	R
T. repens	10	14.3	20.0	25.0	80.0	14.3	60.0
	5	10.7	40.0	21.5	80.0	10.7	40.0
R. nepalensis	10	60.0	47.6	20.0	23.8	40.0	33.3
	5	40.0	38.1	20.0	19.0	40.0	23.8
E. riparium	10	20.0	12.5	22.5	12.5	27.5	28.1
	5	2.5	6.2	15.0	9.4	25.0	28.1
P. dilatatum	10	21.4	17.4	17.8	13.0	32.1	28.7
	5	14.3	8.7	14.3	13.0	25.0	17.4

Source of variation	Plumule growth Probability	Radicle growth Probability
Between species	<.01	<0.1
Between Treatments	<.01	<.01
Between concentrations	not significant	<.01
Species × Treatments	<.05	<.01
Concentrations × Treatments	not significant	<.01
Species × Concentrations	not significant	<.05
Species × Treatments × Concentrations	not significant	not significant

repens and plumule growth of *R. nepalensis*. The growth of *T. repens* was also adversely affected by the application of aqueous extract of *E. adenophorum* to the pot soil (figure 1). The number of leaves and dry matter yield of *T. repens* were significantly reduced due to extract application (figure 2). The inhibitory action was more pronounced on shoot growth as compared to the root growth. The extract, however, did not show any inhibitory effect on seed germination and radicle and plumule elongation of *E. adenophorum*.

The populations of fungi, bacteria and actinomycetes in soil were considerably reduced due to presence of *E. adenophorum* (table 5). Bacterial population was much more affected than the populations of fungi and actinomycetes (table 5). The qualitative analysis of fungal flora revealed the absence of *Aspergillus flavus*, *Cladosporium herbarum* and *Mucor hiemalis* from the soils in whicn *E. adenophorum* was growing.

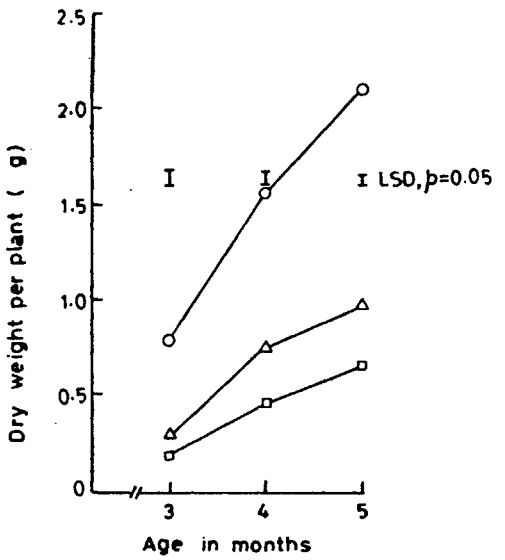

Figure 1 Growth of *T. repens* as affected by varying concentrations of aqueous extract of *E. adenophorum* (O—O), control; (Δ—Δ), 5% and (□—□), 10% extract concentrations.

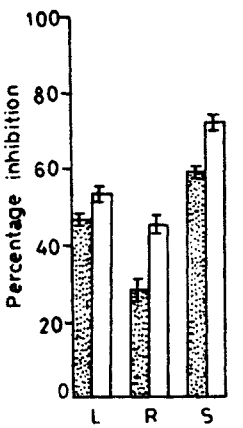

Figure 2 Inhibition (%) caused by 5% (dotted columns) and 10% (open columns) concentrations of aqueous extract of *E. adenophorum* on the number of leaves per plant (L) and per plant dry weight of root (R) and shoot (S) of of *T. repens* after 5 months of growth. Vertical lines represent S.E. values.

Table 5 *Soil microbial populations as affected by the growth of* E. adenophorum

Nature of soil sample	Microbial population in thousands		
	Fungi	Bacteria	Actinomycetes
Collected from the pot containing *E. adenophorum*	9.06	68.30	70.03
Collected from the pot devoid of *E. adenophorum*	12.36	118.24	78.10
Collected from natural habitat occupied by *E. adenophorum*	8.23	58.31	73.14
LSD at p=0.05	0.67	0.70	0.88

Discussion

The experimental results suggest that the aqueous extract of *E. adenophorum* adversely affects seed germination of wheat and other associated plant species. Besides this, it has got potential to inhibit radicle and plumule growth of the associated plant species. These associates are either absent or poorly represented in the vegetation dominated by *E. adenophorum* (table 2) as the suppression in growth of the associates due to inhibitory action of *E. adenophorum* might render them weak enough to successfully compete with the weed. However, the competitive ability of *E. adenophorum* with respect to these plant species needs to be investigated. Amongst the test species, *T. repens* suffers the most while *E. riparium* is least affected, which explains why the latter species can manage to grow with *E. adenophorum* while *T. repens* is normally absent from *E. adenophorum*-dominated vegetation (table 2). This is also confirmed by a considerably high inhibitory effect of the weed on further growth of *T. repens* (figures 1 & 2). Our results confirm the contention of Whittaker (1971) and Akhtar et al. (1978) that allelopathic action depends on the nature of test species and concentration of the allelochemics. Newman and Rovira (1975) observed that the test species show specificity to the allelochemics. We found that *E. adenophorum* extract does not retard its own germination and growth which means that this weed might suppress other plant species growing in its neighbourhood without being itself affected by the extract. This is in conformity with the argument of Putnam and Duke (1978) that the allelopathic action depends on the strain of donor and recipient plant species in a given community.

In nature, the allelochemics contained in the weed plant might be incorporated in soil by throughfall (i.e. leaching of the substances from shoot canopy of the weed due to dissolving action of rain water) and by action of water on litter (Rice 1974). However, these substances are likely to be considerably diluted owing to high rainfall in the region especially during May to September, the period representing the wet season in Shillong (Yadav 1980). But during the rest of the year the allelochemics that might be added through the root exudation and litter decomposition might attain such concentrations as may adversely affect the seed germination and radicle and plumule elongation of neighbouring plant species. Besides, the soil in the immediate vicinity of the weed plant harbours much reduced population of microbes. The decrease in microbial population may be the direct result of toxic substances and/or it may be mediated through *p*H changes in soil caused by the allelochemics. The decreased soil microbial population in the immediate vicinity of *E. adenophorum* assumes significant importance when viewed in context of general belief that rhizosphere harbours greater population of microbes (Mishra & Kanaujia 1974). The change in microbial population might modify various structural and functional attributes of the soil system. For example, Rice (1974, 77) and Lodhi (1978) observed inhibition of nitrification in grassland and forest communities respectively due to presence of allelochemics.

E. adenophorum is an aggressive weed of ruderal habitats at high altitudes in Meghalaya although this exotic weed was introduced in our country very recently

(early part of this century). But due to its rapid spread it has become a notorious and dominant weed of this region. Besides other attributes that make this weed successful, its allelopathic potential as indicated by the present study also seems to be one of the means by which it gains dominance over other species. The bio-assay tests employed to study the allelopathic effect of *E. adenophorum* suggest the presence of growth inhibitors which are water soluble and are produced during normal metabolism of the plant. The exact nature and the mechanism of action of the allelochemics produced by the weed, remains unknown.

Acknowledgement

Financial Support from the CSIR, New Delhi is gratefully acknowleged.

References

Akhtar N, Naqui H H and Hussain F 1978 Biochemical inhibition (allelopathy) exhibited by *Cenchrus ciliaris* Linn. and *Chrysopogan aucheri* (Bioss) Staff; *Pak. J. For.* **28** 194–200

Auld B A 1969 The distribution of *Eupatorium adenophorum* Spreng. on the Far North Coast of New South Wales; *J. Proc. Roy. Soc. New South Wales* **102** 159–161

Chopra R N, Nayar S L and Chopra I C 1956 *Glossary of Indian Medicinal Plants* (New Delhi: CSIR)

Friedman J, Orshan G and Ziger-cfir Y 1977 Suppression of annuals by *Artemisia herba-alba* in Negev desert of Israel; *J. Ecol.* **65** 413–426

Jackson J R and Willemsen W 1976 Allelopathy in the first stages of secondary succession on the Piedmont of New Jersey; *Am. J. Bot.* **63** 1015–1023

Kanchan S D and Jayachandra 1979 Allelopathic effect of *Parthenium hysterophorus* L.I. Exudation of inhibitors through roots; *Pl. Soil* **53** 27–35

Kozel P C and Tukey H B 1968 Loss of gibberellins by leaching from stems and foliage of *Chrysanthemum morifolium* Princess Anne; *Am. J. Bot.* **55** 1184–1189

Lodhi M A K 1978 Comparative inhibition of Nitrifiers and Nitrification in a forest community as a result of allelopathic nature of various tree species; *Am. J. Bot.* **65** 1135–1142

Mishra R R and Kanaujia R S 1974 Investigation into rhizospheric mycoflora XIII. Effect of foliar application of certain plant extracts on *Pennisetum typhoides* (Burn.) Staff and Hubb; *Israel J. agric. Res.* **22** 3–9

Neill R L and Rice E L 1971 Possible role of *Ambrosia psilostachya* on patterning and succession in old fields; *Am. Midl. Nat.* **86** 344–357

Newman E I and Rovira A D 1975 Allelopathy among some British grassland species; *J. Ecol.* **63** 727–737

O'Sullivan B M 1979 Crofton Weed (*Eupatorium adenophorum*) toxicity in horses; *Aust. Vet. J.* **55** 19–22

Putnam A R and Duke W B 1978 Allelopathy in agroecosystems; *Ann. Rev. Phytopathol.* **16** 431–451

Raynal D J and Bazzaz F A 1975 Interference of winter annuals with *Ambrosia artimisiifolia* in early successional fields; *Ecol.* **56** 35–49

Rice E L 1974 *Allelopathy;* (New York, London: Academic Press)

——1977 Some roles of allelopathic compounds in plant communities; *Biochem. Syst. Ecol.* **5** 201–206

Sarma K K V, Giri G S and Subrahmanyam K 1976 Allelopathic potential of *Parthenium hysterophorus* on seed germination and dry matter production in *Arachis hypogea, Crotalaria juncea* and *Phaseolus mungo; Trop. Ecol.* **17** 76–77

Whittaker R H 1971 The chemistry of communities; in *Biochemical Interactions Among Plants* (Env.ronmental Physiology Sub. Commi. U.S. Nat. Comm. IBP, Nat. Acad. Sci. Washington, D C)

Wilson R E and Rice E L 1968 Allelopathy as expressed by *Helianthus annuus* and its role in old field succession; *Torrey Bot. Club.* **95** 432–448

Yadav A S 1980 *Studies on Population Dynamics of Eupatorium odoratum, E. adenophorum* Spreng. *and E. riparium* Regel; Ph.D. Thesis. North-Eastern Hill University, Shillong