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Biological Control of *Parthenium* I: Effect of *Imperata cylindrica* on Distribution, Germination and Seedling Growth of *Parthenium hysterophorus* L.

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ABSTRACT

Natural products have been the source of many pesticides, used either directly as crude preparations or as pure compounds. The present study was undertaken evaluate prospects of control of *P. hysterophorus* by using crude preparations of *Imperata cylindrica* (L). Beauv., an allelopathic grass. Ecological survey revealed that frequency and density of *P. hysterophorus* was significantly lower in *I. cylindrica* dominating localities as compared to nearby areas without *I. cylindrica* infestation. Aqueous extracts of *I. cylindrica* exhibited the potential to control germination and seedling growth of *P. hysterophorus* Aqueous root and shoot extracts of 5, 10, 15, 20 and 25% (w/v) concentration were employed against germination and seedling growth of *P. hysterophorus.* Root and shoot aqueous extracts of all the applied concentrations significantly suppressed the germination of *P. hysterophorus.* Early seedling growth of *P. hysterophorus* was generally reduced significantly by extracts of 10% and of higher concentrations. Increasing the concentration of the extract increased the inhibitory potential. Shoot extract was more inhibitory than root extract.

Key Words: *Imperata cylindrical*; Germination; Seedling; *Parthenium hysterophorus* L.

INTRODUCTION

High weed infestation is one of the major causes of low crop yield in Pakistan. Rabbani and Bajwa (2001) collected 18 weeds from rice fields in Punjab. Similarly Siddiqui and Bajwa (2002) have reported 31 weeds species from wheat fields of Punjab. In recent years a new weed species, *Parthenium hysterophorus* has been reported to be rapidly spreading in Pakistan (Shabir, 2003). There are reports that *P. hysterophorus* has become a major problematic weed in agricultural lands in some areas of neighbouring country India (Evans, 1997). This weed is generally infesting wastelands in our country and there is not any report at present that this weed is a problem in crops. There is, however, threat that this weed may invade agricultural lands in Pakistan in future.

Weeds are generally controlled either through conventional methods or by using herbicides. Although chemical herbicides are effective in controlling weeds yet risks are involved in their usage. Due to increased awareness about the risks involved in the use of pesticides, nowadays there is much emphasis to search for alternate methods of weed control, which are safe for the environment. Allelopathy has been recognized as a natural weed control approach (Cheema *et al*., 1997; Akhtar *et al*., 2001).

Imperata cylindrica is an aggressive perennial grass that is distributed throughout Pakistan from plains up to 2000 m in the chir-pine zone. It is a common weed and a wasteland species especially on poorly drained soils (Hussain & Abidi, 1991). It is a strong competitive and serious weed in Nigeria (Oladokun, 1978). Harlan (1975) reported that *I. cylindrica* suppresses the seedling growth and root sprouting of forest trees and associated species. Sajise and Lale (1975) observed that *I. cylindrica* reduces the growth of *Stylosanthus guyanensis* in mixed cultures. Mendoza (1978) showed that *I. cylindrica* hampers the regeneration of forests in Philippine. Hussain and Abidi (1991) reported that *I. cylindrica* exhibit allelopathy against *Setaria italica*, *Dicanthium annulatum*, *chrysopogon montanus*, *Medicago polymorpha* and *Pinus roxburghii*. They identified Caffeic, ferulic, p-hydroxybenzoic, p-coumaric, vanillic, chlorogenic and syringic acids as the allelopathic agents. During surveys of different *P. hysterophorus* infested areas, we observed a marked reduced density of *P. hysterophorus* at *I. cylindrica* dominating localities as compared to nearby areas without the infestation of this grass. We hypothesized that this low density of *P. hysterophorus* at *I. cylindrica* dominating localities could be due to allelopathic nature of this grass. The present study was, therefore, undertaken to investigate for the allelopathic effects of aqueous extracts of *I. cylindrica* on germination and early growth of *P. hysterophorus.*

MATERIALS AND METHODS

Analysis of *Imperata* dominated communities. Three *I. cylindrica* dominating sites were selected near Lahore along the bank of BRB Canal for phytosociological study. At each locality the frequency and density of *P. hysterophorus* was estimated by using 0.5 x 0.5 m quadrate. Data regarding the frequency and density of *P. hysterophorus* were also recorded from nearby areas without *I. cylindrica* infestation. The following equations were used to determine frequency and density of *P. hysterophorus* and other weed species in

herb zone and *I. cylindrica dominating* zone.

$$\text{Absolute frequency (AF) (\%)} = \frac{\text{Number of quadrates in which species occurs}}{\text{Total number of quadrates}} \times 100$$

$$\text{Relative frequency (RF) (\%)} = \frac{\text{Absolute frequency value for a species}}{\text{Total absolute frequency values for all species}} \times 100$$

$$\text{Absolute density (AD)} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates}}$$

$$\text{Relative density (RD) (\%)} = \frac{\text{Absolute density for a species}}{\text{Total absolute density for all species}} \times 100$$

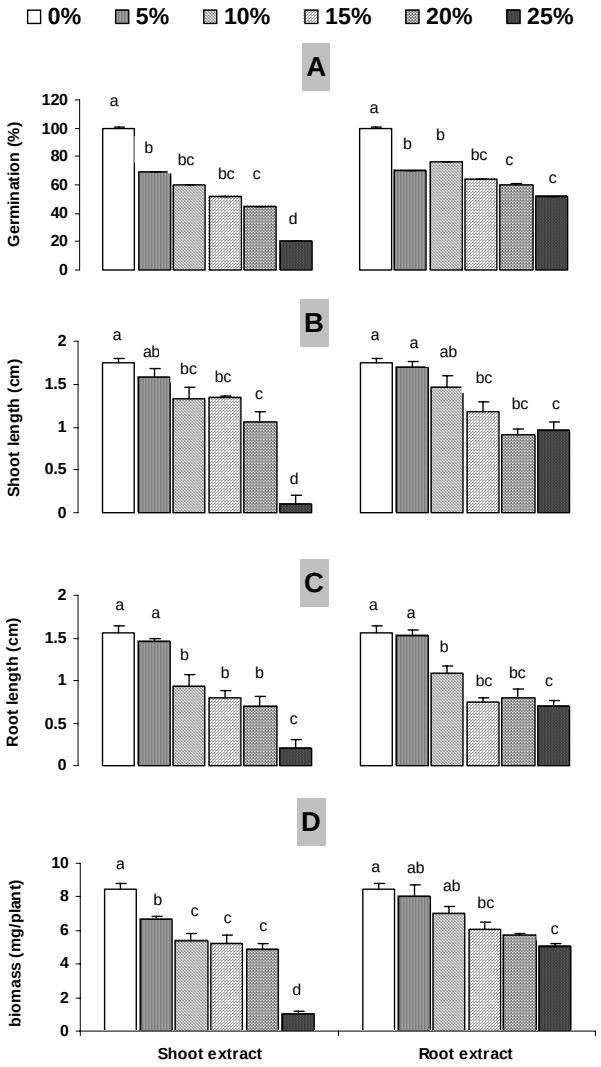
Aqueous extract bioassays. Shoot (leaves & stem) and roots (including rhizomes) extracts of *I. cylindrical* were obtained by soaking 25 g fresh plant material in 100 mL sterilized water for 48 h at room temperature. Extracts were filtered and diluted to 20, 15, 10 and 5% by adding distilled water and stored at 4ºC. Seeds of *P. hysterophorus* were sown on twice folded filter paper seedbeds in sterilized petri dishes. Tests were moistened with aqueous root and shoot extracts of different concentrations while control received distilled water. There were three replicate plates with 10 seeds each. Dishes were incubated at 25ºC for one week. At the end of the experiment germination, root and shoot length, and seedling biomass was recorded. Data were analyzed by applying Duncan's Multiple Range Tests (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Analysis of *Imperata* dominated communities. Data presented in Table I revealed that the *P. hysterophorus* had markedly lower values of absolute and relative frequency as well as absolute and relative density in *I. cylindrica* dominating localities as compared to nearby areas without infestation of this grass. Similarly, other weed species, except *Cynodon dactylon*, were found less frequently in *I. cylindrica* dominating zone. Most of the species present in non-*Imperata* zone were entirely lacking in *I. cylindrica* dominating zone. Similar reduction in frequency and density of associated species in *I. cylindrica* dominating localities has also been reported by Harlan (1975) and Hussain and Abidi (1991). The decline in frequency and density of *P. hysterophorus* and other associated species at *I. cylindrica* dominating localities can be attributed to some allelopathic interaction. Other allelopathic grasses like *Cenchrus ciliaris* L. and *Bothriochloa pertusa* (L.) A. Camus are also known to suppress and preclude the associated species (Hussain *et al.*, 1982). Recently, Javaid *et al.* (2005) have reported similar low frequency of *P. hysterophorus* and other weed species at *Desmostachya bipinnata* (allelopathic grass) dominating localities.

Aqueous extract bioassays. Root and shoot aqueous extracts of all the applied concentrations significantly suppressed the germination of *P. hysterophorus.* Generally,

Fig. 1. Effect of aqueous extracts of Imperata cylindrica on germination and early seedling growth of Parthenium hysterophorus Vertical bars show standard errors Bars with different letters show significant difference as determined by DMR Test.



increase in the concentration increased the inhibitory potential of the extracts. Shoot extract was more inhibitory than root extract. There was 31–80% reduction in germination of the test weed species due to shoot extracts as compared to 30–48% reduction due to root extract of *I. cylindrica* (Fig. 1A). The greater inhibitory effect of aqueous extracts of aerial parts on germination than the effect of sub-aerial parts has also been reported in other plant species (Kil & Yun, 1992; Noor & Khan, 1994). It could be attributed to different types and/or different concentrations of allelochemicals in root and shoot.

Table I. Frequency and density of *P. hysterophorus* and other weeds in herb and *Imperata zones*

Species	Non-*Imperata* zone				*Imperata* zone			
	AF	RF	AD	RD	AF	RF	AD	RD
Parthenium hysterophorus L.	90	19.5	87	45	20	10	2.8	9
Achyranthus aspera L.	30	6.5	1.5	0.80	0	0	0	0
Amaranthus viridus L.	30	6.5	2.2	1.1	0	0	0	0
Boerhaavia diffusa L.	20	4.4	0.7	0.36	0	0	0	0
Chenopodium album L.	10	2.2	5.0	0.26	0	0	0	0
Conyza ambigua DC	10	2.2	2.0	1.1	20	10	0.4	1.3
Cyanodon dactylon L.	100	22	70	36	90	45	25	80
Cyprus rotundus L.	30	6.5	19	10	0	0	0	0
Euphorbia pilulifera L.	10	2.2	0.2	0.1	0	0	0	0
Euphorbia prostrata L.	10	2.2	0.8	0.4	0	0	0	0
Launea nudicalus Less	10	2.2	0.3	0.15	0	0	0	0
Malvestrum coromandelianum L.	50	11	4.7	2.4	10	5	.5	1.6
Oxalis pes-caprae L.	0	0	0	0	10	5	1	3.2
Setaria glauca L.	40	8.7	3.7	1.9	10	5	0.2	0.6
Setaria verticillata L.	10	2.2	0.8	0.4	10	5	0.2	0.6
Sonchus arvensis L.	10	2.2	0.3	0.15	30	15	1	3.2

AF: Absolute frequency; RF: Relative frequency; AD: Absolute density
RD: Relative density

Aqueous extracts of the *I. cylindrica* suppressed the shoot and root length of the seedlings. The effect of lower concentration of 5% of both root and shoot extract was insignificant. However, inhibitory effect of rest of the concentrations was significant except effect of 10% root extract on shoot length. The inhibitory potential of extracts generally enhanced with increase in concentration (Fig. 1B & C). The reduction in seedlings root and shoot length may be attributed to the reduced rate of cell division and cell elongation due to the presence of allelochemicals in the aqueous extracts (Buckolova, 1971). Seedling biomass was also adversely affected by the extracts. All the concentrations of the shoot extract significantly suppressed the shoot biomass of the seedlings. By contrast, the effect of lower concentrations of 5 and 10% root extract on seedling biomass of the test species was insignificant (Fig. 1D). Shoot extracts were generally more toxic to seedling shoot and root growth of the test species. Shoot extract of 25% showed highest inhibitory potential resulting in 94, 87, and 88% reduction in shoot length, root length and seedling biomass, respectively (Fig. 1B–D). The reduced seedling growth could be attributed to the presence of phenolic allelochemicals in *I. cylindrica*. Since these allelochemicals are soluble in water, they are leached from living and decomposing plant materials by rain water and accumulate in the soil underneath the grass cover to express toxicity against *P. hysterophorus* and other coexisting species. Recently, Javaid *et al.* (2005) showed a reduction in germination and growth of *P. hysterophorus* by aqueous extracts of allelopathic grass *Desmostachya bipinnata.* Similarly germination and growth suppression of *P. hysterophorus* due to aqueous extracts of three allelopathic grasses namely *Dicanthium annulatum, Cenchrus pennisiformis* and *Sorghum helepense* have been reported by Javaid and Anjum (2005). The present study clearly indicates that allelochemicals present in *I. cylindrica* have the potential to suppress germination and plant growth of *P. hysterophorus.* Further studies are required to evaluate the *P. hysterophorus* suppression potential of aqueous extracts of *I. cylindrica* under field conditions. Studies are also required to isolate and evaluate the inhibitory potential of the different allelochemicals present in *I. cylindrica*, against germination and growth of *P. hysterophorus.* The effective natural product would then be used as an environment friendly herbicides to control the noxious weed *P. hysterophorus.*

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