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# BIOLOGICAL CONTROL OF *PARTHENIUM* II: ALLELOPATHIC EFFECT OF *DESMOSTACHYA BIPINNATA* ON DISTRIBUTION AND EARLY SEEDLING GROWTH OF *PARTHENIUM HYSTEROPHORUS* L.

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## ABSTRACT

In Punjab waste-lands are being rapidly occupied by a noxious weed *Parthenium hysterophorus* L.. field surveys revealed that the allelopathic grass *Desmostachya bipinnata* Stapf. restricts the spread of this weed. The field study disclosed that both the frequency and density of *P. hysterophorus* was lower at *D. bipinnata* dominating localities as compared to nearby areas without the infestation of this grass. Aqueous root and shoot extracts of *D. bipinnata* of 5, 10, 15 and 20% (w/v) concentrations significantly reduced the germination of *P. hysterophorus.* A 20% root and shoot extract completely arrested the germination of *P. hysterophorus.* Aqueous extracts also inhibited the root and shoot length as well as seedling biomass of *P. hysterophorus.* Shoot extract was more inhibitory than root extract.

**Key-words:** Biological control, *Parthenium hysterophorus*, *Desmostchya bipinnata,* allelopathy.

## INTRODUCTION

*Parthenium hysterophorus* L. is a native to the subtropics of North and South America. The allelopathic nature of this weed has been well documented and water soluble phenolics and sesquiterpene lactones have been reported from the roots, stems, leaves, inflorescences, pollens and seeds (Evans, 1997). This weed has been reported to be rapidly spreading in Pakistan (Shabir, 2003). This weed is very common along the roadsides, around the agricultural fields and on wastelands. There is not any report at present that this weed is a problem in crops in our county. There is, however, threat that this weed may invade agricultural lands in Pakistan in future as it has become a major problematic weed in agricultural lands in some areas in neighbouring country India (Evans, 1997).

During the last half of the 20$^{th}$ century, weed management became almost completely dependent on synthetic herbicides. This was due to many factors, but was primarily due to the relatively low cost of effective weed control with herbicides (Duke *et al*., 2001). The introduction of herbicide-resistant crops, combined with the advantage of inexpensive, nonselective herbicides, promises to make farming dependent on herbicides for the foreseeable future (Hess and Duke, 2000). However, the increased use of herbicides poses serious environmental and public health concerns (Balogh and Anderson, 1992). Furthermore, herbicide resistant weeds have become common during the last 20 years (Friesen *et al.*, 2000). Because of these problems much attention is being focused on alternative methods of weed control. In the past two decades, much work has been done on plant-derived compounds as environmentally safe alternatives to herbicides for weed control (Duke *et al.,* 2000, 2002; Kuk *et al*., 2001).

The phenomenon of allelopathy has been widely reported in grasses. Many grasses are known to exhibit allelopathy to preclude the associated species by reducing their germination, regeneration, growth and yield (Dirvi and Hussain, 1979; Begum and Hussain, 1980; Hussain *et al.*, 1984; Hussain and Abidi, 1991). *Desmostachya bipinnata* is a common wasteland weed in Pakistan especially on dry lands. This grass is also known to exhibit allelopathic potential (Bajwa *et al*., 1998). During surveys of different *P. hysterophorus* infested areas, we observed a marked reduced density of *P. hysterophorus* at *D. bipinnata* dominating localities as compared to nearby areas without the infestation of this grass. It was hypothesized that low density of *P. hysterophorus* at *D. bipinnata* dominating localities could be due to allelopathic nature of this grass. The present study was, therefore, undertaken to investigate for the suppressive ability of aqueous extracts of *D. bipinnata* on germination and early growth of *P. hysterophorus.*

## MATERIALS AND METHODS

### Analysis of *Desmostachya* dominated communities:

Sampling was done at two districts of province Punjab viz. Lahore and Sialkot. From each of the two districts two *P. hysterophorus* dominating localities were selected in close proximity to the *D. bipinnata* dominating localities. Sampling was done with a 1-m2 quadrates. The following analytical attributes were calculated: absolute frequency, relative frequency, absolute density and relative frequency. The following formulae were used:

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

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

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

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

**Plant aqueous extract bioassay**

Shoot (leaves and stem) and roots (including rhizomes) extracts of *D. bipinnata* were obtained by soaking 25g fresh plant material in 100 ml sterilized water for 48 hours at room temperature. Extracts were filtered and diluted to 20, 15, 10 and 5% by adding distilled water and stored at 4 ºC. Seeds of *P. hysterophorus* were sown on twice folded filter paper seedbeds in sterilized petri dishes. Tests were moisten 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 25 ºC for one week. At the end of the experiment germination, root and shoot length, and seedling biomass was recorded. Data were analyzed by performing ANOVA, followed by Duncan's Multiple Range Tests (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

### Analysis of *Desmostachya* dominated communities:

*Desmostachya bipinnata* colonization markedly suppressed the *P. hysterophorus* infestation. Absolute frequency (AF) of *P. hysterophorus* was reduced from 80% in non-*Desmostachya*-dominating to 50% in *Desmostachya* dominating zone. *P. hysterophorus* exhibited the highest relative frequency (RF) of 18.6 in non-*Desmostachya* zone. However, at *Desmostachya* dominating localities, its RF was slightly lower i.e. 17.2 and was second to *Cynodon dactylon* (Table 1).

Absolute density (AD) of *P. hysterophorus* was 41 at non- *Desmostachya* zone that was markedly greater than any of the other species in that zone. At *Desmostachya* dominating zone AD of *P. hysterophorus* was reduced to 4.6. Highest relative density (RD) of 37.4 was exhibited by *P. hysterophorus* in non- *Desmostachya* zone. By contrast, at *Desmostachya*-dominating zone, RD of *P. hysterophorus* was reduced to 14.2, the highest being exhibited by *C. dactylon* (41.6) followed by *Malvestrum coromandelianum* (19.7) (Table 1). 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 Anjum *et al.* (2005) have reported similar reduced frequency and density of *P. hysterophorus* and other weed species at *Imperata cylindrica* (allelopathic grass) dominating localities.

### Aqueous extract bioassay

Both aqueous shoot and root extracts of *D. bipinnata* significantly suppressed germination of *P. hysterophorus.* The inhibitory potential of the extracts increased with the increase in extract concentration. Aqueous extracts of 25% concentration completely arrested the germination of *P. hysterophorus* (Fig. 1A). Similar reduction in germination percentage of *P. hysterophorus* has also been reported due to aqueous extracts of other allelopathic grasses such as *I. cylindrica* (L), *C. penicetiformis, Dicanthium annulatum* and *Sorghum helepense* (Anjum *et al.*, 2005; Javaid and Anjum, 2005).

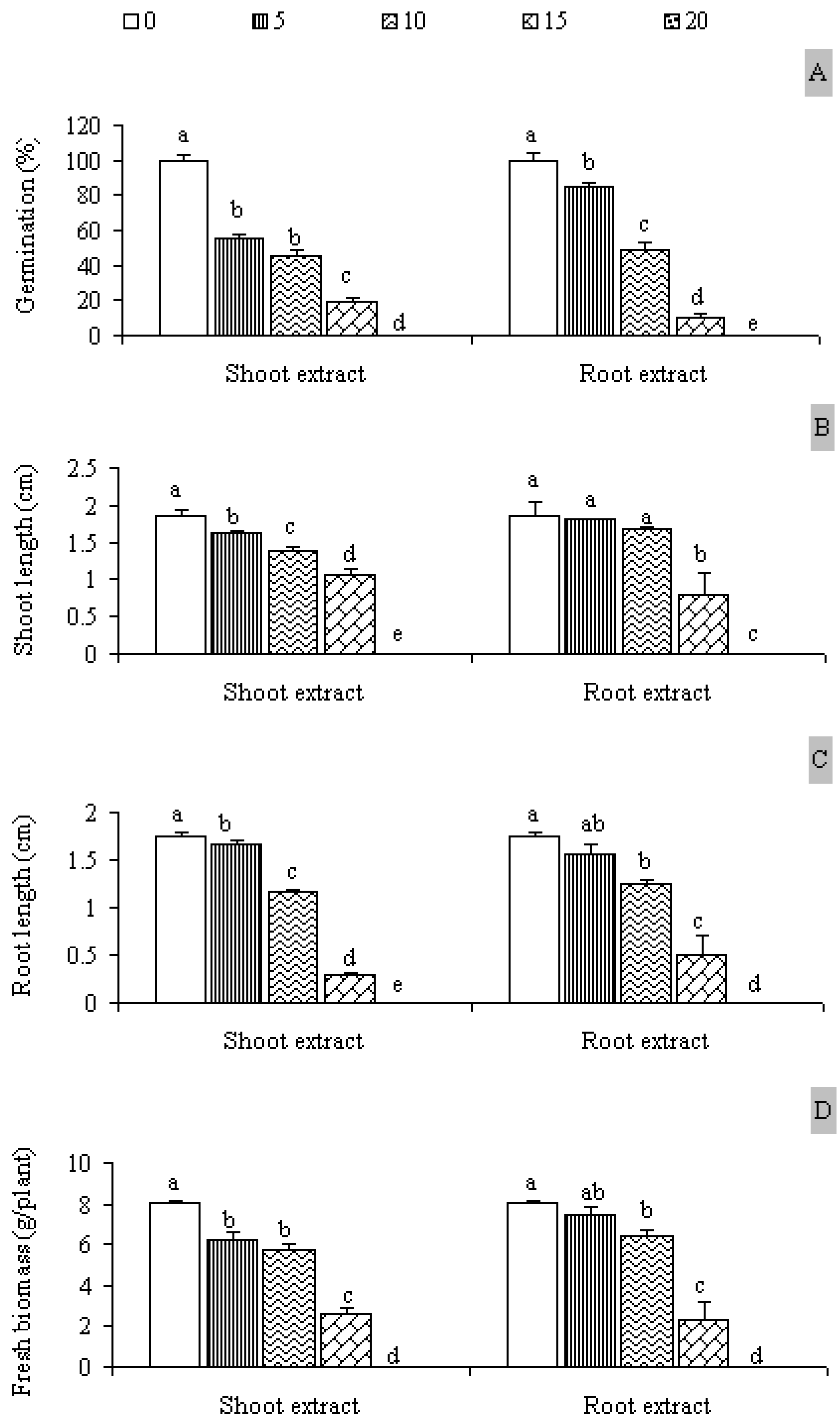


Fig. 1. Effect of aqueous shoot and root extract of *Desmostachya bipinnata* on germination and early seedling growth of *Parthenium hysterophorus*. Vertical bars sshow standard errors, different letters show significant differences as determined by DMR Test.

Table 1. Frequency and density of *P. hysterophorus* and other weeds at sites with and without *Desmostachya* domination.

| Species | Non- *Desmostachya* zone | | | | *Desmostachya* dominating zone | | | |
|---|---|---|---|---|---|---|---|---|
| | AF | RF | AD | RD | AF | RF | AD | RD |
| *Parthenium hysterophorus* L. | 80 | 18.6 | 41 | 37.4 | 50 | 17.2 | 4.6 | 14.2 |
| *Achyranthus aspera* L. | 40 | 9.3 | 3.9 | 3.5 | 50 | 17.2 | 4 | 12.3 |
| *Alhagi maurorum* Desv. | 10 | 2.3 | 0.2 | 0.18 | 0 | 0 | 0 | 0 |
| *Cannabis sativa* L. | 10 | 2.3 | 0.1 | 0.09 | 10 | 3.44 | 0.1 | .31 |
| *Carthamus oxycantha* Bieb. | 50 | 11.6 | 5.9 | 5.3 | 20 | 6.89 | 1.5 | 4.6 |
| Cenchrus pennicitiformis Hochst | 10 | 2.3 | 0.5 | 0.45 | 0 | 0 | 0 | 0 |
| *Chenopodium album* L. | 30 | 6.9 | 0.9 | 0.82 | 10 | 3.44 | 0.2 | .62 |
| *Croton sparsiflorus* | 30 | 6.9 | 3.6 | 3.2 | 20 | 6.89 | 1.2 | 3.7 |
| *Cyanodon dactylon* L. | 60 | 13.9 | 39 | 35.6 | 60 | 20.68 | 13.5 | 41.6 |
| *Dicanthium annulatum* **Staph.** | 10 | 2.3 | 0.5 | 0.45 | 0 | 0 | 0 | 0 |
| ***Euphorbia prostrate*** L. | 10 | 2.3 | 0.5 | 0.45 | 10 | 3.44 | 0.5 | 1.5 |
| *Imperata cylindrica* **(L). Beauv.** | 10 | 2.3 | 1 | 0.91 | 0 | 0 | 0 | 0 |
| ***Malvestrum coromandelianum*** L. | 50 | 11.6 | 11.8 | 10.7 | 40 | 13.79 | 6.4 | 19.7 |
| ***Oxalis pes-caprae*** L. | 10 | 2.3 | 0.3 | 0.27 | 0 | 0 | 0 | 0 |
| ***Solanum nigrum*** L. | 10 | 2.3 | 0.1 | 0.09 | 0 | 0 | 0 | 0 |
| *Trianthema monogyna* L. | 10 | 2.3 | 0.2 | 0.18 | 20 | 6.89 | 0.4 | 1.2 |

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

Both shoot and root extracts of *D. bipinnata* reduced seedling length and biomass of the test species. Recently Anjum *et al.*, (2005) and Javaid and Anjum (2005) have also reported similar reduction in seedling growth of *P. hysterophorus* due to aqueous extracts of other allelopathic grasses such as *I. cylindrica* (L), *C. penicetiformis*, *D. annulatum* and *S. helepense*. The reductions 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). The reduced seedling length resulted in reduced biomass. The shoot extract was comparatively more inhibitory than root extract. Root and shoot length as well as biomass of *P. hysterophorus* seedlings were significantly reduced by all the applied concentrations of aqueous shoot extracts of *D. bipinnata*. Inhibitory potential of the extracts increased with the increase in extract concentration (Fig. 1 B-D). By contrast, 5 and 10% root extracts of *D. bipinnata* failed to exhibit any significant impact on shoot length and seedling biomass. Similarly 5% root extract of *D. bipinnata* did not show any significant impact on root length of *P. hysterophorus* (Fig. 1 B-D). 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 and Yun, 1992; Noor and Khan, 1994). It could be attributed to different types and/or different concentrations of allelochemicals in root and shoot. The decline in frequency and density of *P. hysterophorus* and other associated species at *D. bipinnata* dominating localities may be attributed to some allelopathic interaction. Since the allelochemicals present in *D. bipinnata* 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 cooccurring species. The present study indicates that allelochemicals present in *D. bipinnata* have the potential to suppress germination and plant growth of *P. hysterophorus.* Further studies are required to evaluate the *P. hysterophorus* control potential of aqueous extracts of *D. bipinnata* under field conditions. Studies are also required to isolate and evaluate the inhibitory potential of the different allelochemicals present in *D. bipinnata,* against germination and growth of *P. hysterophorus* and other noxious weeds. The effective natural product would then be used as template to prepare environment friendly herbicides to control the noxious weeds.

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