# Chemical, phytochemical and biological control of *Parthenium hysterophorus* L. in Pakistan

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**Summary** *Parthenium hysterophorus* L. (parthenium) has been rapidly spreading and replacing the local flora in Pakistan for the last 20 years. Various studies were carried out for chemical, phytochemical (through allelopathic plant extracts), and biological control of this noxious alien weed. Two chemical herbicides namely Chwastox™ and Buctril Super™ were employed at recommended (R) as well as lower rates i.e. 0.75R, 0.50R and 0.25R. Buctril Super proved highly effective and all the employed concentrations killed the target weed within two days of spraying. In a phytochemical control study, aqueous extracts of different concentrations (2–10% w/v) of five allelopathic trees: *Azadirachta indica* (L.) A.Juss., *Ficus bengalensis* L., *Melia azedarach* L., *Mangifera indica* L. and *Syzygium cumini* (L.) Skeels, were evaluated for their herbicidal potential against germination and early seedling growth of parthenium. Extracts of all the test plant species were found effective in arresting germination and suppressing seedling growth of parthenium. Extracts of *F. bengalensis* and *M. azedarach* were found to be highly effective. So far no biological control agents for parthenium have been reported from Pakistan. Recently we found a Mexican beetle *Zygogramma bicolorata* Pallister feeding on parthenium. Furthermore, we also found very heavy infestation of larvae of an unidentified insect species feeding on the weed during the months of October and November 2005, resulting in complete death of the weed plants.

**Keywords** *Parthenium hysterophorus*, chemical, phytochemical, biological control, Pakistan.

## INTRODUCTION

Parthenium is an aggressive weed from the Asteraceae family that is native to the subtropics of North and South America and has invaded Asia, Africa and Australia during the last 50 years. Since then the weed has not only naturalised in many countries but has spread at an alarming rate. Parthenium poses a serious health risk, particularly to urban populations as it moves into new areas and consolidates in established ones. Chemical analysis has indicated that all plant parts, including trichomes and pollens, contain toxins called sesquiterpene lactones. The major components of the toxin are 'parthenin' and other phenolic acids such as caffeic acid, vanillic acid, anisic acid, chlorogenic acid and parahydroxy benzoic acid, which are lethal to human beings and animals (Oudhia 1998). In addition to health hazards, available data also highlights its impact on agriculture as well as natural ecosystems (Evans 1997). There are reports of total habitat change in native Australian grasslands, open woodlands, riverbanks and floodplains due to parthenium invasion (Chippendale and Panetta 1994). Similar invasions of national wildlife parks have also been reported in southern India (Evans 1997).

Parthenium was introduced accidentally in India in 1955 through imported food grains and presently occurs in almost all parts of India (Ramaswami 1997). Parthenium has been rapidly spreading in Pakistan for the last 15–20 years and has now become a major wasteland weed. It is rapidly replacing native flora in rain-fed areas of the province Punjab and is also spreading in North Western Frontier Province and Kashmir (Javaid and Anjum 2005). The weed grows luxuriously around agricultural fields and is also found in some crops like watermelon and *Trifolium* species. The present paper presents various chemical, phytochemical, through allelopathic plant extracts, and biological management options for the control of this noxious alien weed in Pakistan.

## MATERIALS AND METHODS

**Chemical control** Parthenium seeds were sown in earthen pots containing sandy loam soil. Two chemical herbicides Chwastox and Buctril Super were selected to evaluate their potential to control parthenium. Recommended doses of Chwastox and Buctril Super were 4 mL $L^{-1}$ and 2.5 mL $L^{-1}$, respectively. The recommended (R) as well as lower doses (0.75R, 0.50R and 0.25R) of each of the two chemical herbicides were sprayed on parthenium plants of 2, 5 and 10 weeks old, corresponding to early vegetative, pre-flowering and maturity stages, respectively. Efficacy of herbicides was monitored for seven days.

**Phytochemical control** Fresh leaves of five allelopathic trees: *Azadirachta indica*, *Ficus bengalensis*, *Melia azadarach*, *Mangifera indica* and *Syzygium*

*cumini* were collected from University of the Punjab, Quaid-e-Azam Campus Lahore, Pakistan. After thorough washing with sterilised water, leaves were dried in an oven at 40°C. To obtain a 10% w/v aqueous extract, 10 g crushed dry leaf material of each of the five test species was soaked in 100 mL distilled water for 36 hours at 25°C and filtered. Further dilutions of 8, 6, 4 and 2% (w/v) were prepared by adding appropriate quantity of distilled water to the 10% stock solution.

Seeds of parthenium were sown on a filter paper in sterilised Petri dishes. The filter papers were moistened with 2.5 mL of aqueous leaf extracts. Controls were treated similarly with distilled water. There were three replicates of each treatment with 10 seeds per Petri plate. The plates were incubated at 25°C for seven days. Germination, root and shoot length, and fresh biomass of parthenium seedlings were recorded at the end of the experiment after seven days. Data were analysed by ANOVA with means separated by Duncan's Multiple Range Test (Steel and Torrie 1980).

**Biological control** Field surveys of various parthenium growing areas of the province Punjab, Pakistan were carried out from 2003–2005 in search of any potential biological control agent against the target weed.

## RESULTS AND DISCUSSION

**Chemical control** Plants sprayed with Chwastox started getting pale from the day after spraying, with complete mortality achieved after seven days. All concentrations of this herbicide used were effective in controlling the target weed. Buctril Super proved more effective than Chwastox in controlling parthenium as it killed within two days of treatment (Figure 1). As the lowest concentration of this herbicide (0.25R) was effective there is a possibility that concentrations lower than 0.25R may also be effective in controlling parthenium.

**Phytochemical control** Aqueous extracts of all the five test tree species exhibited herbicidal effects on the germination of parthenium. However, extracts of all test species were not equally toxic. Extracts of *F. bengalensis* and *M. indica* were more inhibitory than extracts of the remaining test species. The lowest concentration of extract (2%) of these two test species also significantly retarded the germination of parthenium. The most effective treatment in suppressing germination was 10% extract of *F. bengalensis*, where germination was reduced to 5% as compared to 100% in the control (Figure 2a).

Aqueous extracts of *M. azadarach* proved the most effective in reducing both plumule and radicle length

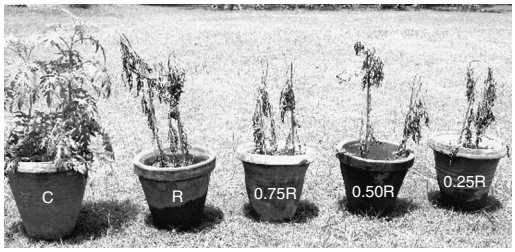


**Figure 1.** Effect of different concentrations of Buctril Super on five week old *P. hysterophorus*. C: control, R: recommended dose.

of parthenium seedlings. All the applied concentrations of 2–10% aqueous extract significantly reduced the plumule and radicle length. Generally, toxicity of the extract increased with increasing concentration (Figure 2b and c). Among the rest of the tree species, extracts of *F. bengalensis* and *S. cumini* were very effective in retarding plumule and radical length. (Figure 2b). There was a similar impact from *F. bengalensis* extracts on radicle length. The effect of the aqueous extracts of *M. azedarach*, *S. cumini* and *F. bengalensis* on seedling biomass was similar to their effects on plumule and radical length (Figure 2c and d). The reduction in the 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 (Bukolova 1971).

Aqueous extracts of *A. indica* were the least toxic, exhibiting an insignificant impact on both plumule and radicle length. However, seedling biomass of parthenium was significantly reduced by 10% extract of *A. indica*. Similarly, extracts of *M. indica* failed to significantly retard the plumule and radical length, as well as seedling biomass of parthenium. (Figure 2b-d).

Aqueous extracts of *F. bengalensis*, and *M. azedarach* were found to be highly effective against germination and seedling growth of parthenium. However, these results need to be validated by field trials.

**Biological control** Over 260 phytophagous arthropod species have been collected from parthenium in its native homeland, of which 144 species actually feed on the weed (McClay *et al.* 1995). Among these, *Zygogramma bicolorata* Pallister, *Smicronyx lutulentus* Dietz, *Epiblema strenuana* Walker, *Bucculatrix parthenica* Bradley, *Stobaera concinna* Stal and *Listronotus setosipennis* Hustache are the most important (Evans 1997). However, there are no reports of plant pathogen or insect pests of this weed from Pakistan. Recently, in 2005, we observed the Mexican beetle

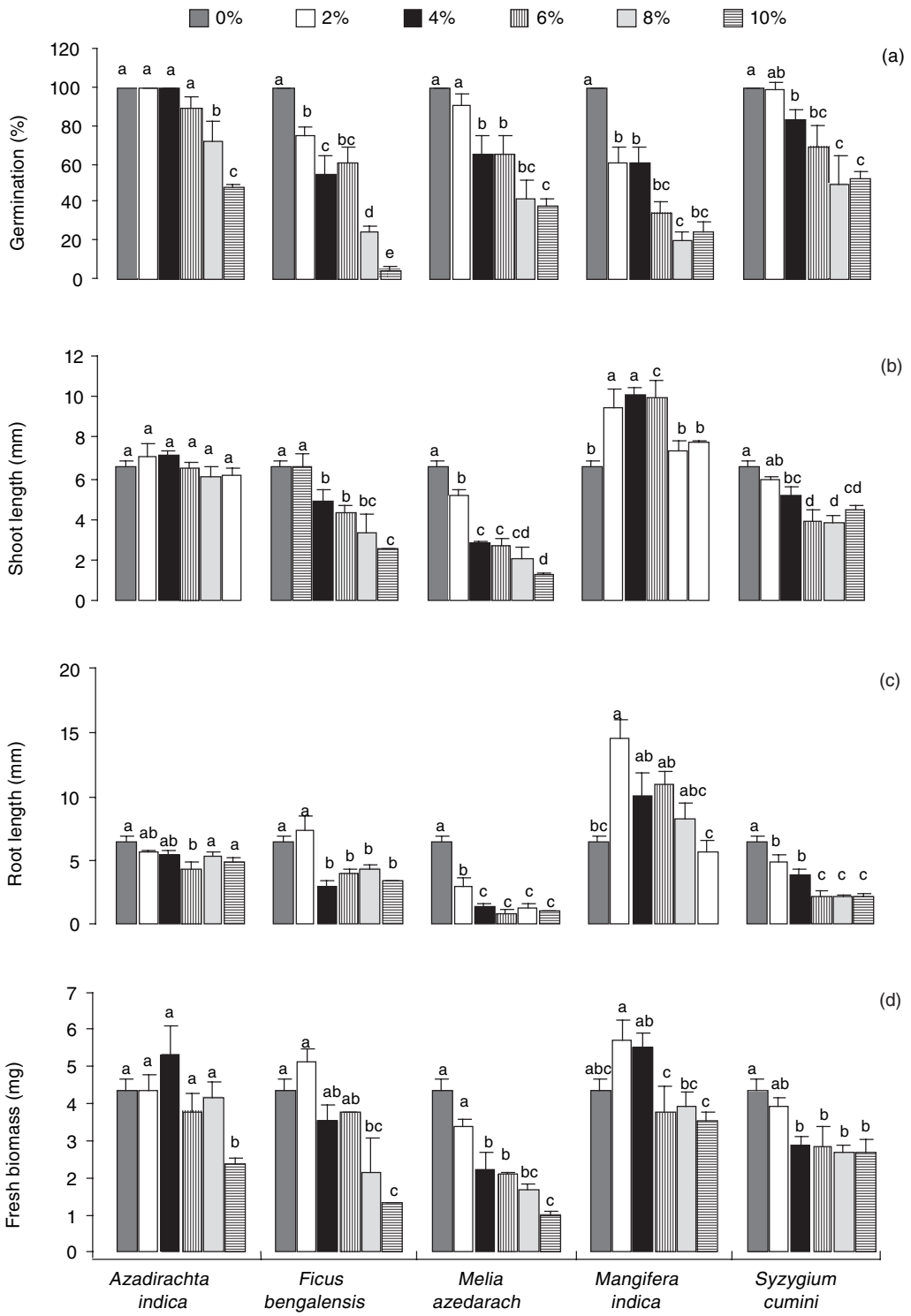


**Figure 2a-d.** Effect of aqueous leaf extracts of five allelopathic trees on germination and early seedling growth of *Parthenium hysterophorus*.

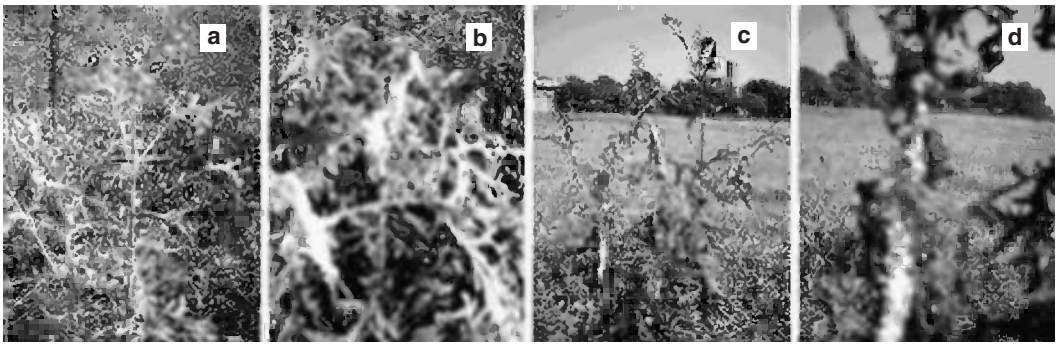


**Figure 3a-d.** Different stages of damage of *Parthenium* by an unidentified insect larvae (white patches show the population of insect larvae, c and d are dead plants).

*Zygogramma bicolorata* on parthenium leaves in different parts of Lahore (capital of province Punjab) and about 100 km away in Chhanga Manga Forest. Both the adult and larvae of the beetle were found feeding on leaves of parthenium. However, defoliation of parthenium by the beetle was not found, possibly because of the low populations of the beetle present. The beetle was introduced to India in 1984 (Jayanth 1987). Possibly the beetle entered Pakistan from neighbouring India. In October-November 2005 we also found a very heavy infestation of larvae of an unidentified insect species feeding on parthenium. The insect larvae were found feeding on leaves, stem and flower heads of parthenium. The infected plants first showed symptoms of dieback and ultimately desiccated (Figure 3). The insect larvae were also found feeding on four other weed species namely *Achyranthes aspera* L., *Malvestrum tricuspidatum* A.Gray, *Sida spinosa* L. and *Xanthium strumarium* L. However, none of the field crops of the season in the area, rice (*Oryza sativa* L.), maize (*Zea mays* L.) or sorghum (*Sorghum bicolor* L.), were attacked. Further studies regarding the identification, ecology and biology of the insect are in progress.

Since parthenium is spreading so rapidly, a single control method is not enough to stop its advance in the country. It can only be managed effectively by developing an integrated approach involving many options in combination, like minimal use of effective herbicides, development of effective, environmentally-friendly new herbicides using allelochemicals of allelopathic trees, the introduction and development of biological control agents and adapting existing cultural practices.

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