Pak. J. Bot., 39(7): 2611-2618, 2007.

CAUSES OF RAPID SPREAD OF *PARTHENIUM HYSTEROPHORUS* L. IN PAKISTAN AND POSSIBLE CONTROL MEASURES – A REVIEW

ARSHAD JAVAID*, SOBIYA SHAFIQUE AND SHAZIA SHAFIQUE

Institute of Mycology and Plant Pathology,
University of the Punjab, Quaid-e-Azam Campus Lahore, Pakistan
**Corresponding author's e-mail: arshadjpk@yahoo.com*

Abstract

Parthenium hysterophorus L., an annual herb native to the subtropics of North and South America, has achieved major weed status in Pakistan during the last 15-20 years. This weed is rapidly spreading in rain fed districts of northern Punjab while in southern Punjab this weed is either absent or less frequent. It is growing luxuriantly in forests, grasslands, wastelands, around the agricultural fields and sometimes in less competitive field crops, and is rapidly replacing the local flora. Highly adaptive nature to adverse environmental conditions, fast growing rate, high productive potential, absence of natural enemies, and interference by resource depletion and allelopathy are the major causes of its establishment in a variety of ecosystems. The weed can be successfully controlled by herbicide Buctril Super at a very low dosage of 0.67 ml L^{-1} of water. The allelopathic grasses like *Desmostachya bipinnata* and *Imperata cylindrica* restrict the spread of this weed. Various studies conducted in our laboratory by using aqueous extracts of allelopathic grasses, trees and crops have revealed that allelochemicals have great herbicidal potential against this noxious weed. In a recent survey, we found beetle *Zygogramma biocorata* Pallister causing defoliation of this weed. It can be used as a successful biological agent for the control of this noxious alien weed.

Introduction

Parthenium hysterophorus L., is an aggressive weed of family Asteracea. It is native to the subtropics of North and South America but now has invaded Asia, Africa and Australia during the last 50 years. Since then the weed has not only naturalized itself in many countries but has spread at an alarming rate. *Parthenium* posses a serious health risk, particularly to the urban populations as it moves into new areas and consolidates established ones. The chemical analysis has indicated that all the plant parts including trichomes and pollens contain toxins called sesquiterpene lactones. The major components of toxin being 'Parthenin' and other phenolic acids such as caffeic acid, vanillic acid, anisic acid, chlorogenic acid and parahydroxy benzoic acid are lethal to human beings and animals (Oudhia, 1998). In addition to health hazards a lot of available data also highlights its impact on agriculture as well as natural ecosystems (Chippendale & Panetta, 1994; Evans, 1997). There are reports of total habitat change in native Australian grasslands, open woodlands, river banks and floodplains due to *Parthenium* invasion (McFayden, 1992; Chippendale & Panetta, 1994). Similar invasions of national wildlife parks have also been reported in southern India (Evans, 1997).

Parthenium introduced accidentally in India in 1955 through the imported food grains and at present has occupied almost all parts of India (Ramaswami, 1997). The weed has been rapidly spreading in Pakistan for the last 15-20 years. It has now become a major wasteland weed and is rapidly replacing the native flora in rainfed areas of the Punjab province and is also spreading in North Western Frontier Province and Kashmir.

The weed grows luxuriously around the agricultural fields and is also found in some less competitive crops like watermelon (Javaid & Anjum, 2005; Javaid *et al*., 2006a). However, in India and Australia it has also become a major problematic weed both in agricultural and wastelands (Evans, 1997). In Pakistan weed failed to establish in agricultural fields possibly because of wetland rice cultivation in rainfed areas of northern Punjab, and due to low rainfall and salinity in southern Punjab (Javaid & Anjum, 2005).

Causes of rapid spread of *Parthenium*

High reproductive potential: *Parthenium* weed is an extremely prolific seed producer, with up to 25,000 seeds per plant (Navie *et al*., 1996) and with an enormous seed bank, estimated at 200,000 seeds m^{-1} in abandoned fields (Joshi, 1991). Furthermore, seeds can germinate any time of year given suitable moisture levels. The seeds of *Parthenium* remain viable for a long time and can thrive under very harsh environmental conditions (Williams & Groves, 1980). Non dormancy and extreme light weight of its seeds armed with pappus are the characteristics which help its extensive spread and establishment (Ramaswami, 1997).

Fast growth rate: It is a very fast maturing annual. Generally plants commence flowering when they are 4 to 8 weeks old and may flower for several months. Under unfavourable conditions such as under drought stress the weed can germinate, grow, mature and set seeds in four weeks. The weed also has a very high regenerative potential (Dagar *et al.*, 1976). The weed is highly adaptive to adverse environmental conditions, and is a successful invader of any open land. It soon establishes its own colony at the cost of other vegetation.

Allelopathic potential: *Parthenium* inhibits the germination and growth of other plants by allelopathy. Srivastava *et al.*, (1985) discovered that aqueous extracts of leaves and inflorescence inhibited the germination and growth of barely, wheat and peas. Kumari *et al.*, (1985) showed that cell survival and chlorophyll content were markedly reduced when *Parthenium* extracts were directly sprayed on crop plants. Recently Singh *et al.,* (2005) reported the phytotoxic effects of *Parthenium* residues on *Brassica campestris, B. oleracea* and *B. rapa*. Similar adverse impact of *Parthenium* residues have been reported by Batish *et al.,* (2002) on growth of *Cicer arietinum* and *Raphanus sativus.* Various allelochemicals such as water soluble phenolics including caffeic, ferulic, vanicillic, anisic and fumaric acids and sesquiterpene lactones including parthenin and coronopilin, have been identified from the weed (Kanchan, 1975; Jarvis *et al*., 1985; Picman & Picman, 1984).

Unpalatable to animals: In a recent study we found that buffalos, cows and sheep do not eat *Parthenium* while goats can (Javaid & Anjum, 2005). Earlier investigations in India had revealed serious health hazards to livestock in *Parthenium*-invaded areas. In artificial feeding tests buffalo bull calves accepted the weed, alone or in mixture with green fodder, with severe consequences. The majority developed severe dermatitis and toxic symptoms and died within 8-30 days. Lesions were found subsequently in the gastrointestinal tract, liver and kidneys (Narasimhan *et al.,* 1977). Changes in blood chemistry and inhibition of liver dehydrogenases, as well as degenerative changes in both the liver and kidneys have been reported in buffalo and sheep (Ahmad *et al*., 1988; Rajkumar *et al.,* 1988). The milk of livestock may also be tainted by parthenin (Towers & Rao, 1992).

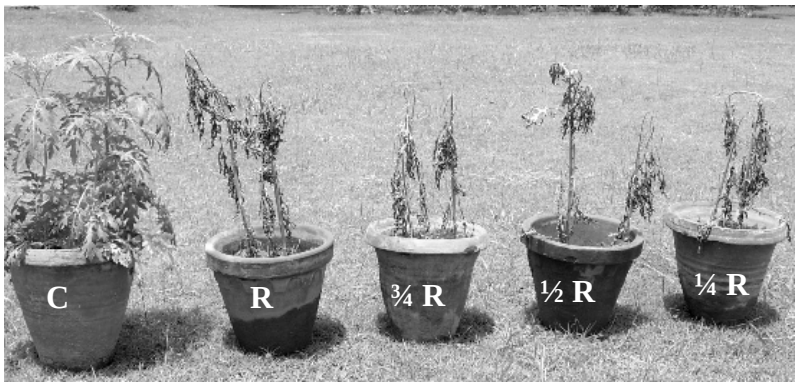

Fig. 1. Effect of different concentrations of Buctril Super on *Parthenium hysterophorus* after 5 week growth stage. C: Control, R: Recommended dose.

Control measures of *Parthenium*

Chemical management: Recently we conducted a pot experiment to evaluate the herbicidal potential of two herbicides viz., Chwastox and Buctril Super against *Parthenium.* The recommended doses (R) of Chwastox (4 ml L^{-1}) and Buctril Super (2.5 ml L^{-1}) as well as dilutions @ ¾ R, ½ R and ¼ R were sprayed on pot grown *P. hysterophorus* plants after 2, 5 and 10 weeks of sowing corresponding to early vegetative, pre-flowering and maturity stages, respectively. All the employed dosages of Buctril Super killed the target weed at all the three growth stages within 2 days of spray (Fig. 1). Chwastox, however, was found to be a slow active herbicide in this case and effective control was delayed up to 7 days. Earlier Kanchan & Jayachandra (1977) found that bromocil, diuron and terbacil @ 1.5 kg ha^{-1} were very effective against *Parthenium.* Similarly Dhanraj & Mitra (1976) have reported that diquat @ 0.5 kg ha^{-1} in 500 L spray can effectively control *Parthenium* at all growth stages. Mishra & Bhan (1994) have recommended the sulphonyl urea herbicides like chlorimuron ethyl and metasulfuron methyl to control *Parthenium* in non-cropped areas. Spraying of 2 kg, 2, 4-D sodium salt or 2L MCPA in 400 L of water controlled the growth of *Parthenium* seedlings. Likewise, MSMA @ 1L 100 ml^{-1} of water successfully controlled fully grown *Parthenium* (Mahaderappa, 1996). Several well known herbicides such as paraquat, trifluralin, diphenamid, napropamide, acetanilides, alachlor, metolachlor and propachlor have shown to be ineffective against *Parthenium* weed (Labrada, 1990; Njoroge, 1991).

Although herbicidal approach seems a very viable option to control *Parthenium* however, in our view this approach alone is not justifiable as herbicidal effect does not last long and ends only with one germination. Moreover, herbicide residues in soil and water cause environmental pollution and health problems. Furthermore, chemical treatment can kill the existing plants but can not prevent the entry of seeds getting deposited from outside. The remnant seeds of the invaded land as well as newly deposited seeds are always ready for germination with slight moisture becoming available to them. In addition, since *Parthenium* is more a waste land weed, there will be hardly any body to invest on chemical treatment for temporary relief. Nevertheless, only in very limited situations, chemical control of *Parthenium* is justifiable for quick relief.

Furthermore, development of newer group of herbicides with attributes of economically cheap, persistent but having less residual effects are imperative.

Management through allelopathic plants: Increasing public concern on environmental issues requires alternative weed management systems which are less pesticide dependant or based on naturally occurring compounds (Singh *et al.*, 2003). Allelopathy as an ecological approach and allelochemicals as biological herbicides have been a challenge to current approaches (Inderjit & Duke, 2003). Recently some studies carried out by our research have shown very encouraging results regarding the use of allelopathic plants in *Parthenium* management. Javaid *et al.*, (2005) and Anjum *et al.*, (2005) showed that the allelopathic grasses *Imperata cylindrica* (L). Beauv. and *Desmostachya bipinnata* Stapf significantly reduced the distribution of *Parthenium* and aqueous extracts of these grasses had a significantly negative impact on germination and growth of the target weed. Later on Javaid & Anjum (2006) reported similar negative impact of aqueous extracts of other allelopathic grasses viz., *Dicanthium annulatum* Stapf., *Cenchrus pennisetiformis* Hochest, *Sorghum halepense* Pers., on germination and seedling growth of *Parthenium.* Shafique *et al.,* (2005) demonstrated that aqueous leaf extracts of allelopathic trees viz., *Azadirachta indica* (L.) A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L. and *Syzygium cumini* (L.) Skeels, have the potential to decline germination and seedling growth of *Parthenium.* The weed can be managed by spreading the residues of the test allelopathic plants on wastelands. Allelochemicals will release into the environment as rain leachates or by decomposition of the residues and will reduce the seed germination of noxious target weed.

Biological management: There is not any earlier report of biological control of *Parthenium* in Pakistan. Recently we found larvae of a beetle *Zygogramma bicolorata* Pallister feeding on leaves and causing defoliation of *Parthenium.* Studies have shown that *Z. bicolorata* can be used as a potential biological agent to control *Parthenium.* The beetle was first introduced to Australia from Mexico in 1980 (McFadyen & McClay, 1981) and subsequently was introduced to India in 1984 (Jayanth, 1987). Probably the beetle came Pakistan from India. There are many other arthropods like a seed feeding weevil *Smicronyx lutulentus* Dietz (Curculionidae), a stem-galling moth *Epiblema strenuana* Walker (Tortricidae), a leaf mining moth *Bucculatrix parthenica* Bradley (Lyonetiidae), a sap-feeding plant hopper *Stobaera concinna* Stal (Delphacidae), a stem-boring curculionid weevil *Listronotus setosipennis* Hustache (Wild *et al*., 1992; Evans, 1997) that can be introduced in Pakistan as potential biological control agents of *Parthenium.* Furthermore a rust fungus *Puccinia abrupta* Diet. & Holw. Var. *partheniicola* (Jackson) Parmelee from Mexico is also known to severely damage the *Parthenium* (Evans, 1987). Recently Javaid *et al.,* (2006b) have reported the attack of a mealy bug species and causing sever damage to *Parthenium* plants of all ages. The attacked plants first showed symptoms of die-back and ultimately dried to death.

Cultural management: Some researchers have advocated growing competitive crops such as *Cenchrus ciliaris, Clitorea terneata* and *Digitaria milanjiana,* to suppress *Parthenium* (O,Donnell & Adkins, 2005). However, as the *Parthenium* is mainly a wasteland weed, the scope of this practice is limited to only certain situations.

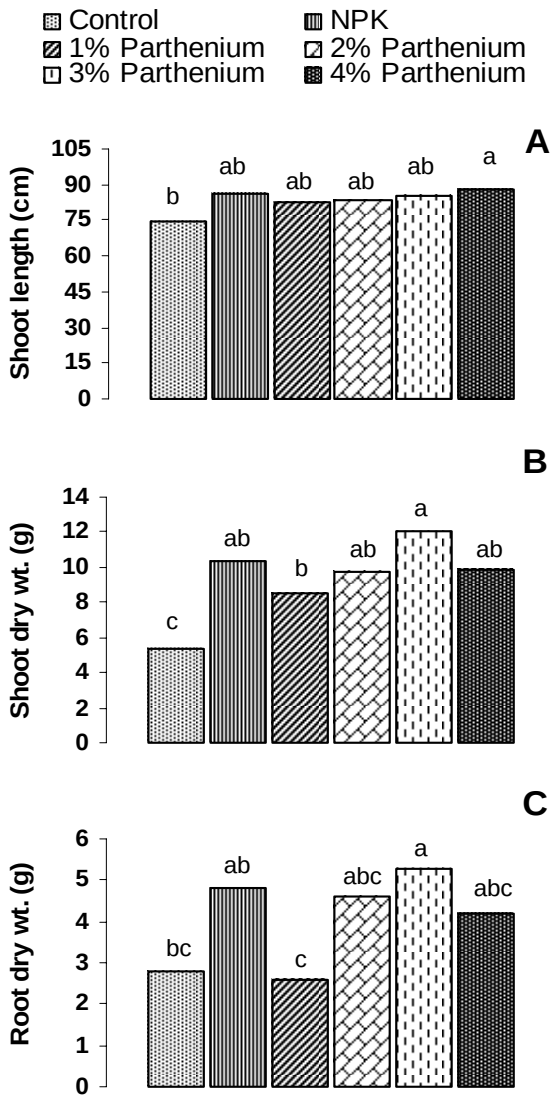

Fig. 2. Effect of NPK fertilizers and *Parthenium* green manure on growth of maize. Values with different letters show significant difference (p=0.05) as determined by Duncan's Multiple Range Test.

Management by utilization: One of the most effective methods to manage the *Parthenium* is the large scale utilization of this weed. The weed has been well documented for its insecticidal (Gajendran & Gopalan, 1982), nematicidal (Bala *et al.*, 1986) and herbicidal (Pandey *et al.*, 1993) properties. The weed is also used for oxalic acid and biogas production (Gunaseelan, 1987; Bhan *et al.*, 1997).

Parthenium can be managed by using it as green manure. It is able to extract nutrients even from nutrient deficient soils. It has very high level of nitrogen (3%), phosphorus (0.2%), potassium (4.5%) and other macro and micro-nutrients. It can be

used as a green manure for field crops. We conducted a pot experiment where 1, 2, 3 and 4% *Parthenium* fresh shoot material was mixed in soil and studied its effect on maize growth. For comparison we also included a treatment of recommended NPK fertilizers. A 4% *Parthenium* treatment gave maize biomass production equivalent to that of recommended NPK fertilizers (Fig. 2). In another experiment we also obtained similar effect of *Parthenium* green manure on growth and yield of wheat. However, effect of *Parthenium* green manure on growth, nodulation and yield of a leguminous crop *Vigna radiate* (L.) Wilczek did not prove beneficial.

Legal Management: Laws and acts for the control of *Parthenium* at national level should be approved by the legislators. Administration of federal as well as provincial government, in collaboration with the scientists, should give a wide publicity through radio, T.V. video, posters and seminars to bring awareness and educate the people for the implementation of the laws and acts.

From the past researches, it is clear that *Parthenium* can only be managed effectively by developing integrated approach involving many options in combination like little use of very effective herbicides, biological control agents and cultural practices.

References

Ahmad, M.N., P.R. Rao and A.S. Moorthy. 1988. A study on changes in blood blood chemistry in *Parthenium* toxicity in buffalo calves. *Cheirion*., 17: 57-60.

Anjum, T, R. Bajwa and A. Javaid. 2005. Biological Control of *Parthenium* I: Effect of *Imperata cylindrica* on distribution, germination and seedling growth of *Parthenium hysterophorus* L. *Int. J. Agric. Biol.*, 6 (3): in press

Bala, S.K., P. Bhattacharya, K.S. Mukerjee and N.C. Sukul. 1986. Nematicidal properties of the plants *Xanthium strumarium* and *Parthenium hysterophorus. Envorn. Ecol.,* 4: 139-141.

Batish, D.R., H.P. Singh, J.K. Pandher, V. Arora and R.K. Kohli. 2002. Phytotoxic effect of *Parthenium* residues on the selected soil properties and growth of chickpea and radish. *Weed Biol. Manag*., 2: 73-78.

Bhan, V.M., S. Kumar and M.S. Raghuwanshi. 1997. Future strategies for effective *Parthenium* management. *In: Proc. First Int. Conf. on Parthenium Management*. pp. 90-95.

Chippendale, J.F. and F.D. Panetta. 1994. The cost of *Parthenium* weed to the Queensland cattle industry. *Plant Prot. Q.*, 9: 73-76.

Dagar, J.C., A.N. Rao and L.P. Mall. 1976. Regeneration of *Parthenium hysterophorus. Geobios*,3: 202-203.

Dhanraj, R. E. and M. K. Mitra. 1976. Control of *Parthenium hysterophorus* L. with diquat. PANS. 22: 269-272.

Evans, H.C. 1997. *Parthenium hysterophorus:* a review of its weed status and the possibilities for biological control. *Biocont.News Inform.*, 18: 89-98.

Evans, H.C.1987. Fungal pathogens of some subtropical and tropical weeds and the possibilities for biological control. *Biocont.News Inform*., 8: 7-30.

Gajendran, G. and M. Gopalan. 1982. Notes on the antifeedant activity of *Parthenium hysterophorus* L. on *Spodoptera litura*. *Ind. J. Agric Sci.,* 52: 203-205.

Gunaseelan, V.N. 1987. *Parthenium* as an additive with cattle manure in biogas production. *Biol wastes*, 21: 195-203.

Inderjit and S.O. Duke. 2003. Ecophysiological aspects of allelopathy. *Planta*, 217: 529-539.

Jarvis, B.B., N.B. Pena, M.M. Rao and N.B. Mandava. 1985. Allelopathic agents from *Parthenium hysterophorus* and *Baccharis megapotamica. In*: The Chemistry of Allelopathy. Washington DC, USA; American Chemical Society, pp. 149-159.

Javaid, A. and T. Anjum. 2005. *Parthenium hysterophorus* L. – a noxious alien weed. *Pak. J. Weed Sci. Res.,* 11 (3-4): 171-177.

Javaid, A. and T. Anjum. 2006. Biological Control of *Parthenium* III: Control of *Parthenium hysterophorus* L. by aqueous extracts of allelopathic grasses. *Pak. J. Bot*., 38 (1) in press

Javaid, A., S. Shafique and S. Shafique. 2006a. *Parthenium* weed – an emerging threat to plant biodiversity in Pakistan. *Int. J. Biol. Biotech.*,3(3): 619-622.

Javaid, A., S. Shafique, R. Bajwa, S. Shafique. 2006b. Biological control of noxious alien weed *Parthenium hysterophorus* L. in Pakistan. *Int. J. Biol. Biotech.*,3(4): 721-724.

Javaid, A., T. Anjum and R. Bajwa. 2005. Biological Control of *Parthenium* II: Allelopathic effect of *Desmostachya bipinnata* on distribution and early seedling growth of *Parthenium hysterophorus* L. *Int. J. Biol. Biotech.,* 2(2): 459-463.

Jayanth, K.P. 1987. Introduction and establishment of *Zygogramma bicolorata* on *Parthenium hysterophorus* in Bangalore, India. *Curr. Sci.,* 56: 310-311.

Joshi, S. 1991. Interference effect of C*assia uniflora* Mill. on *Parthenium hysterophorus* L. *Plant Soil,* 132: 213-218.

Kanchan, S.D. and Jayachandra. 1977. Post-emergent chemical control of congress grass. *Pesticides*, 11: 55-56.

Kanchan, S.D.1975. Growth inhibitors from *Parthenium hysterophorus* L. *Curr. Sci*., 44: 358-359.

Kumari, A., R.K. Kohli and D.B. Saxena. 1985. Allelopathic effects of *Parthenium hysterophorus* leachates and extracts on *Brassica campestris* L. *Annals Biol.,* 1: 189-196.

Labrada, R.1990. El manejo de malezas en areas de hortalizas y frijol en Cuba. *X Congreso ALAM, LA Habana, Abril 1-14,* Vol. II: 1-16.

Mahaderappa, M. 1996. *Parthenium*, Prasaranga, University of Mysore, Mysore, p.66.

McClay, A.S., W.A. Palmer, F.D. Bennett, and K.R. Pullen. 1995. Phytopagous arthropods associated with *Parthenium hysterophorus* in North America. *Environ. Entomol.,* 24: 796-809.

McFadyen, R.E. 1992. Biological control against *Parthenium* weed in Australia. *Crop Prot.,* 11: 400-407.

McFadyen, R.E. and A.R. McClay. 1981. Two new insets for the biological control of *Parthenium* weed in Queensland. In: *Sixth Australian Weed Conference*, (Eds.): B.J. Wilson and J.D. Swarbrick. pp. 145-149.

Mishra, J.S. and V.M. Bhan. 1994. Efficacy of sulphonyl urea herbicides against *Parthenium hysterophorus. Weed News,* 1: 16.

Narasimhan, T.R., M. Ananth, A. Mangala and P.V.S. Rao. 1977. Toxicity of *Parthenium hysterophorus* L. *Curr. Sci.,* 46: 15-16.

Navie, S.C., R.E. McFayden, F.D. Panetta and S.W. Adkins. 1996. The biology of Australian weeds. 27. *Parthenium hysterophorus* L. *Plant Prot. Q.,* 11: 76-88.

Njoroge, J.M. 1991. Tolerance of *Bidens pilosa* L., and *Parthenium hysterophorus* L. to paraquate (Gramoxone) in Kenya. *Kenya Coffee,* 56: 999-1001.

O,Donnell, C. and S.W. Adkins. 2005. Management of *Parthenium* weed through competitive displacement with beneficial plants. *Weed Biol. Manag*., 5:77-79.

Oudhia, P. 1998. *Parthenium:* A curse for the biodiversity of Chhattisgarh plain. *In: Abstract National Research Seminar on Biochemical changes. An impact on Environment,* R.D. Govt. P.G. College, Mandla (M.P.) 30-31 July p.26.

Pandey, D.K., L.P. Kauraw and V.M. Bhan. 1993. Inhibitory effect of *Parthenium hysterophorus* residue on growth of water hyacinth (*Eichhornia crassipes*). *J. Chem. Ecol.,* 19: 2651-2662.

Picman, J. and A.K. Picman. 1984. Autotoxicity in *Parthenium hysterophorus* and its possible role in germination. *Biochem. Systemat. Ecol.,* 12: 287-292.

Rajkumar, E.D.M., N.V.N. Kumar, N.V.H. Haran and N.V.S, Ram. 1988. Antagonistic effect of *Parthenium hysterophorus* on succinate dehydrogenase of sheep liver. *J. Environ. Biol.,* 9: 231-237.

Ramaswami, P.P. 1997. Potential uses of *Parthenium. In: Proc. First Int. Conf. on Parthenium Management*, pp. 77-80.

Singh, H.P., D.R. Batish and R. K. Kohli. 2003. Allelopathic interactions and allelochemicals: New possibilities for sustainable weed management. *Cri. Rev. Plant Sci.*, 22: 239-311.

Singh, H.P., D.R. Batish, J.K. Pandher and R.K. Kohli. 2005. Phytotoxic effects of *Parthenium hysterophorus* residues on three *Brssica* species. *Weed Biol. Manag.*, 5: 105-109.

Srivastava, J.N., J.P. Shukla and R.C. Srivastava. 1985. Effect of *Parthenium hysterophorus* extract on the seed germination and seedling growth of barley, pea and wheat. *Acta Bot. Indica,* 13: 194-197.

Towers, G.H.N. and P.V.S. Rao. 1992. Impact of the *Parthenium hysterophorus* L. on human affairs. In: *Proc. 1st Int. Weed Control Congress*. (Ed.): R.G. Richardson. Melbourne, Australia. pp. 134-138.

Wild, C.H., R.E. McFayden, A.J. Tomley and B.W. Wilson. 1992. The biology and host specificity of the stem-boring weevil *Listonotus setosipennis*, a potential biocontrol agent for *Parthenium hysterophorus. Entomophaga*, 37: 591-598.

Williams, J.D. and R.H. Groves, 1980. The influence of temperature and photoperiod on growth and development of *Parthenium hysterophorus. Weed Res.*, 20: 47-52.

(Received for publication 14 February 2006)