

PARTHENIUM MANAGEMENT THROUGH AQUEOUS EXTRACTS OF *ALSTONIA SCHOLARIS*

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Abstract

Phytotoxic effect of aqueous leaf and bark extracts of *Alstonia scholaris* (L.) R. Br. was investigated against parthenium weed (*Parthenium hysterophorus* L.). In a laboratory bioassay, carried out in 9-cm diameter Petri plates, 2–10% aqueous extracts of fresh leaves significantly reduced germination of parthenium seeds from 30-80%. Seedling growth in terms of root and shoot length, and fresh biomass, was also significantly reduced by all except 2% extract concentration. Bark extracts of same concentrations proved less toxic resulting in an insignificant reduction in germination. Generally, the effect of bark extract on seedling growth was also insignificant. In foliar spray bioassay, three sprays of 50% and 100% w/v (on fresh weight basis) leaf extracts were carried out on 15 days old parthenium plants with 5 days intervals. A significant reduction in root and shoot biomass was recorded due to 100% foliar spray, after 2 week growth of the first spray. The present study concludes that aqueous leaf extract of *A. scholaris* contain potent herbicidal constituents for the management of parthenium weed.

Introduction

Parthenium (*Parthenium hysterophorus* L.) is an aggressive weed of the 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 but has spread at an alarming rate and has become a dominant weed of wastelands/crops in many parts of world and has become a problematic weed (Navie *et al.*, 1996; Evans, 1997). It has become a dominant weed in most of the wastelands and grazing lands in Pakistan (Javaid & Riaz, 2007; Riaz & Javaid, 2010). It has also been reported in some less competitive field crops in Pakistan (Javaid & Anjum, 2005). The weed is characterized with high reproductive potential and fast growth rate, thus becomes dominant in a newly colonized area in a very short time (Kohli & Rani, 1994). Parthenium poses a serious health risk, particularly to the urban populations. 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). The weed is known to cause allergic reactions in people. Symptoms are itching on exposed skin and development of a dermatitis which may spread over the whole body. It also causes asthma (Evans, 1997; Suresh *et al.*, 1994). In addition of health hazards a lot of available data also highlights its impact on agriculture as well as natural ecosystems (Javaid & Anjum, 2005; Javaid *et al.*, 2009; Belz *et al.*, 2007).

Parthenium is reported to be controlled by foliar spray of some chemical herbicides such as bromocil, diuron, terbacil, diquat, chlorimuron ethyl, metasulfuron methyl and buctril super (Mishra & Bhan, 1994; Javaid *et al.*, 2006a, Javaid, 2007). However, control

does not last long enough as expected due to the large amount of seeds deposited in the seed bank and flash germination of the seeds. Furthermore, 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 synthetic chemical approaches (El-Rokiek *et al.*, 2006). Numerous allelochemicals are involved in the allelopathic activities of the allelopathic plants; such as phenolics, terpenoids, alkaloids, coumarins, tannins, flavonoids, steroids and quinines (Xuan *et al.*, 2005). Several compounds extracted from higher plants, such as cineole, benzoxazinones, quinolinic acid and leptospermones, have been applied in agricultural weed control with promising results such as Benzoxazinones and Quinolinic acid by BASF, Germany; Cineole as Cinmethylen by Shell, USA; Letospermones as Triketones by Zeneca (Xuan *et al.*, 2006). Some studies carried out in the recent years reveal that allelopathy can play a major role in controlling the spread and growth of parthenium. Aqueous extracts of allelopathic grasses, allelopathic crops such as rice and dicotyledonous plants such as *Datura metel* significantly suppressed the germination and growth of parthenium weed (Javaid *et al.*, 2005, 2008, 2010; Javaid, 2010; Javaid & Anjum, 2006). Similarly, Shafique *et al.*, (2005) showed that aqueous extracts of allelopathic trees viz., *Azadirachta indica* (L.) A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L., and *Syzygium cumini* (L.) Skeels significantly reduced the germination and early seedling growth of parthenium. The present study was undertaken to investigate the effect of aqueous leaf and bark extracts of *Alstonia scholaris* on germination and seedling growth of parthenium.

Materials and Methods

Germination and early seedling growth bioassays: Fresh leaf and bark materials of *A. scholaris* were thoroughly washed with sterilized water and blended at 10 g 100 mL⁻¹ of distilled water and left for 2 hours at 20°C. These were filtered through a muslin cloth followed by Whatman No. 1 filter paper. This stock solution was further diluted to get 2, 4, 6 and 8% w/v solutions. The extracts were used in the experiments on the same day.

In a laboratory bioassay, the effect of different concentrations of bark and leaf extracts on germination and early seedling growth of parthenium was studied. For this, 10 seeds of parthenium were placed in a 9-cm diameter Petri plate lined with a filter paper, and moistened with 3 mL of different concentrations of leaf and bark extracts. Treatment in a similar manner but with distilled water, served as control. Each treatment was replicated thrice. Petri plates were arranged in a completely randomized design in a growth chamber maintained at 25°C and 8 h light period daily. Germination was recorded daily up to 6 days. After 6 days, the seedling length and fresh biomass were determined.

Foliar spray bioassay: Plastic pots of 7-cm diameter and 6-cm deep were filled with sandy loam soil @130-g soil per pot. Fifteen days old parthenium plants were carefully transplanted to these pots. Aqueous extracts of 100 and 50% (w/v) of fresh leaves of *A. scholaris* was prepared as earlier. These extracts were sprayed on pot grown parthenium plants after 0, 5 and 10 days of transplantation. Plants of control treatment were sprayed with distilled water. Plants were harvested after 2 weeks and data regarding root and shoot dry biomass were determined.

Statistical analysis: The data were subjected to analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (Steel & Torrie, 1980) at $p \leq 0.05$ to compare treatment means.

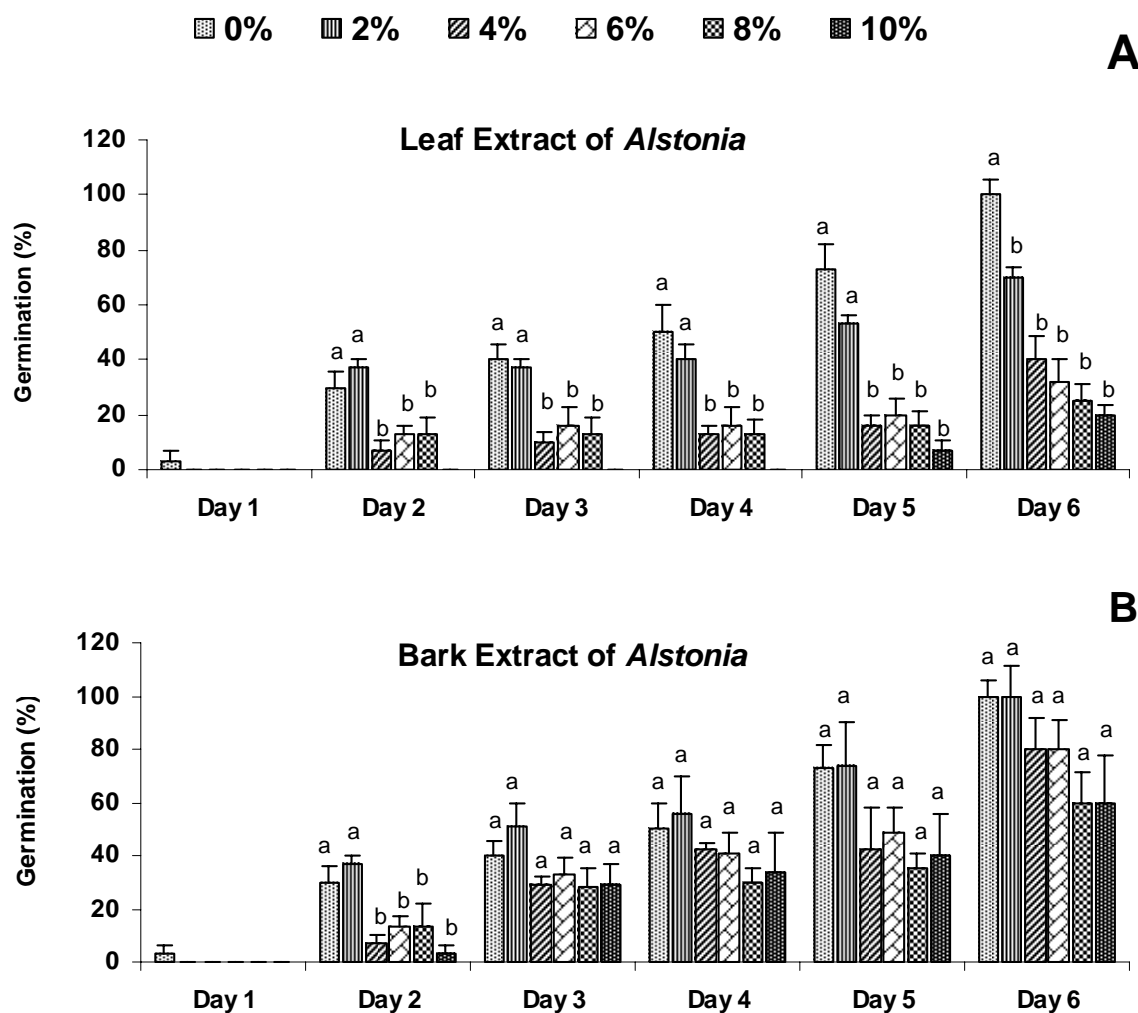


Fig. 1. Effect of leaf and bark extracts of *Alstonia* on germination rate of parthenium.

Vertical bars show standard errors of means of three replicates.

For each day values with different letters show significant difference ($p \leq 0.05$) as determined by Duncan's Multiple Range Test.

Results and Discussion

Effect of leaf extract on germination and early seedling growth: Aqueous leaf extract of *A. scholaris* delayed seed germination as well as reduced the final germination percentage of parthenium. The extract was highly toxic and even the lowest concentration of the extract (2%) significantly reduced the final germination by 30% as compared with control. The increase in extract concentration resulted in a corresponding decrease in germination. The 10% extract reduced the germination by 80% as compared with control (Fig. 1A). These results support the earlier findings that the seedling growth of parthenium can be checked by aqueous extracts of allelopathic plant species. Similar inhibition in germination of parthenium seeds has also been reported due to aqueous leaf extracts of other allelopathic tree species viz., *Azadirachta indica* (L.) A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L., and *Syzygium cumini* (L.) Skeels (Shafique *et al.*, 2005). Our results are also in agreement with the findings of Anjum *et al.*, (2005), Javaid *et al.*, (2005) and Javaid & Anjum (2006) who reported that aqueous extracts of allelopathic grasses viz., *Imperata cylindrica* (L.) Beauv., *Desmostachya bipinnata* Stapf., *Dicanthium annulatum* Stapf., *Cenchrus pennisetiformis* Hochest and *Sorghum halepense* Pers., significantly suppressed the germination of parthenium.

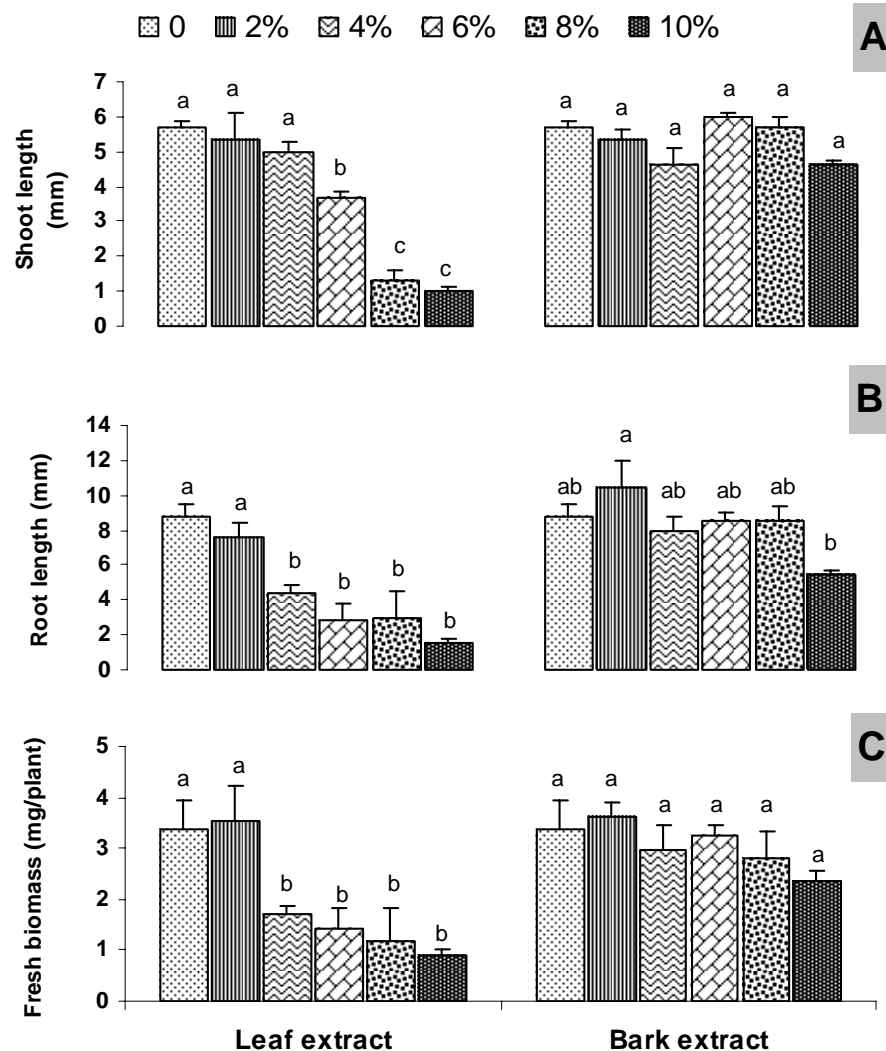


Fig. 2. Effect of aqueous leaf and bark extracts of *Alstonia* on early seedling growth of parthenium in aqueous extract bioassay.

Vertical bars show standard errors

Bars with different letters show significant difference ($p \leq 0.05$) as determined by Duncan's Multiple Range Test.

Leaf extracts of 6% and above exhibited a significant adverse effect on seedling shoot length. Effect of leaf extract on root length and seedling fresh biomass was even more severe where 4% and higher concentrations significantly declined the studied parameters. Increase in extract concentration resulted in a parallel decrease in root and shoot growth (Fig. 2). These results support the earlier findings that the seedlings growth of parthenium can be checked by aqueous extracts of allelopathic plant species (Javaid *et al.*, 2005; Javaid & Anjum, 2005, 2006; Shafique *et al.*, 2005). Leaves of *A. scholaris* contain many indole alkaloids which may be responsible for the herbicidal activity of the aqueous extracts. The leaves of *A. scholaris* collected in Pakistan, India, Philippines, Thailand, Malaysia, and Indonesia showed diverse alkaloidal patterns. In general, the continental trees from Pakistan, India and Thailand contain picrinine-type alkaloids, while those from Indonesia and the Philippines contain alkaloids based on the angustilobine skeleton (Atta-ur-Rahman *et al.*, 1985; Yamauchi *et al.*, 1990; Kam *et al.*, 1997; Salim *et al.*, 2004; Macabeo *et al.*, 2005). Generally, alkaloids are known as potential allelochemicals reducing the germination and growth of susceptible plant species (Whittaker & Fenny, 1971; Harborne, 1977).

Effect of bark extract on germination and early seedling growth: The bark extract proved less inhibitory than leaf extract and exhibited insignificant effect on germination of parthenium seeds (Fig. 2B). Bark extract also failed to exhibit any pronounced adverse effect on seedling root and shoot growth. Effect of all the extract treatments on shoot length and seedling biomass was insignificant. Only the highest concentration of 10% showed a significant adverse impact on seedling root length (Fig. 2). Bark of *A. scholaris* is known to contain several alkaloids, and fatty and resinous substances (Salim *et al.*, 2004). However, in the present study they failed to exhibit their phytotoxic effect against *Parthenium* probably because of their non-specificity towards this noxious weed. The species specificity of phytotoxins has also been demonstrated for other allelopathic plant species (Shaukat *et al.*, 1983; Noor & Khan, 1994). Toxicity is assumed to be associated with the presence of strong electrophilic or nucleophilic systems. Action by such systems on specific positions of proteins or enzymes would alter their configuration and affect their activity (Macias *et al.*, 1992).

Foliar spray bioassay: Foliar spray with both 100 and 50% leaf extracts adversely affected plant growth in parthenium. The adverse effect of foliar spray with 100% extract was significant where 46 and 67% reduction in shoot and root biomass was recorded, respectively (Fig. 3). In a recent study, Javaid *et al.*, (2006b) have reported that foliar spray with aqueous extracts of sunflower (*Helianthus annuus* L.) and sorghum (*Sorghum bicolor* L.) significantly suppressed the growth of parthenium. The present study concludes that aqueous leaf extracts of *A. scholaris* contain inhibitors probably alkaloids, for germination and growth of parthenium. Further studies are required to isolate and identify these inhibitors to be used as a lead for the synthesis of natural herbicides against one of the most noxious weeds of the world.

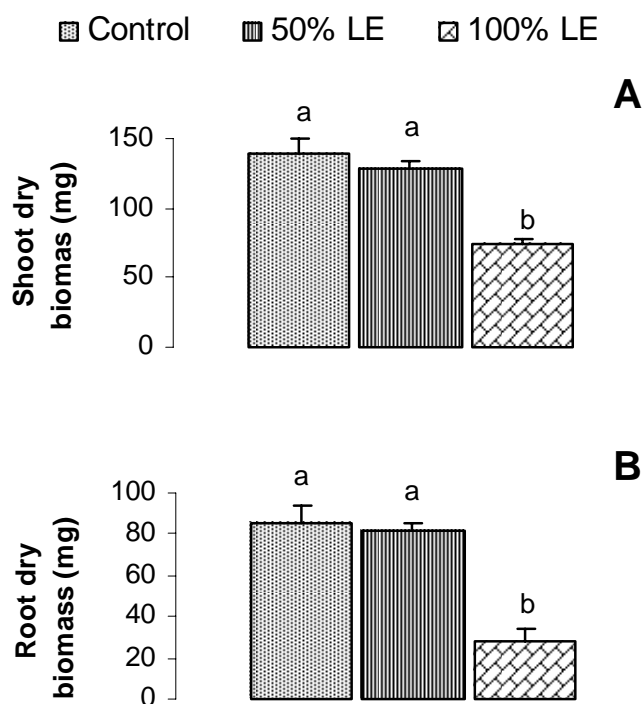


Fig. 3. Effect of foliar spray of *Alstonia* leaf extract (LE) on root and shoot growth of *Parthenium*. Vertical bars show standard error of mean of three replicates. Values with different letters show significant difference ($p \leq 0.05$) as determined by Duncan's Multiple Range Test.

References

- 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.*, 7: 448-450.
- Atta-ur-Rahman, M. Asif, M. Ghazala, J. Fatima and K.A. Alvi. 1985. Scholaricine, an alkaloid from *Alstonia scholaris*. *Phytochemistry*, 24: 2771-2773.
- Belz, R.G., C.F. Reinhardt, L.C. Foxcroft and K. Hurlle. 2007. Residue allelopathy in *Parthenium hysterophorus* L.—Does parthenin play a leading role? *Crop Prot.*, 26: 237-245.
- El-Rokiek, K.G., T.A. El-Sahahawy and F.A. Sharara. 2006. New approach to use rice straw waste for weed control. II: The effect of rice straw extract and fusillade on some weeds infesting soybean. *Int. J. Agric. Biol.*, 8: 269-275.
- Evans, H.C. 1997. *Parthenium hysterophorus*: a review of its weed status and the possibilities for biological control. *Biocontrol/News and Information*, 18: 89-98.
- Harborne, J.B. 1977. *Introduction to Ecological Biochemistry*. Academic Press London. p. 242.
- Javaid, A. 2007. Efficacy of some chemical herbicides against *Parthenium hysterophorus* L. *Pak. J. Weed Sci. Res.*, 13: 93-98.
- Javaid, A. 2010. Herbicidal potential of allelopathic plants and fungi against *Parthenium hysterophorus* – a review. *Allelopathy J.*, 25: 331-344.
- Javaid, A. and T. Anjum. 2005. *Parthenium hysterophorus* L. – a noxious alien weed. *Pak. J. Weed Sci. Res.*, 11: 1-6.
- 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: 459-463.
- Javaid, A. and T. Anjum. 2006. Control of *Parthenium hysterophorus* L. by aqueous extracts of allelopathic grasses. *Pak. J. Bot.*, 38: 139-146.
- Javaid, A., T. Anjum and R. Bajwa. 2006a. Chemical control of *Parthenium hysterophorus* L. *Int. J. Biol. Biotech.*, 3: 387-390.
- Javaid, A., S. Shafique, R. Bajwa and S. Shafique. 2006b. Effect of aqueous extracts of allelopathic crops on germination and growth of *Parthenium hysterophorus* L. *South African J. Bot.*, 72: 608-611.
- Javaid, A. and T. Riaz. 2007. Spread of aggressive alien weed *Parthenium hysterophorus* L., in district Okara, Pakistan. *J Anim. Plant Sci.*, 17: 59-62.
- Javaid, A., S. Shafique, S. Shafique and T. Riaz. 2008. Effect of rice extracts and residue incorporation on *Parthenium hysterophorus* management. *Allelopathy J.*, 22: 353-362.
- Javaid, A., S. Shafique and S. Shafique. 2009. Invasion of noxious alien weed *Parthenium hysterophorus* L., in grazing lands of Lahore, Pakistan. *J. Anim. Plant Sci.*, 19: 149-153.
- Javaid, A., S. Shafique and S. Shafique. 2010. Herbicidal effects of extracts and residue incorporation of *Datura metel* against parthenium weed. *Nat. Prod. Res.*, 24: 1426-1437.
- Kam, T.S., K.T. Nyeoh, K.M. Sim and K. Yoganathan. 1997. Alkaloids from *Alstonia scholaris*. *Phytochemistry*, 45: 1303-1305.
- Kohli, R.K. and D. Rani. 1994. *Parthenium hysterophorus* L., a review. *Res. Bull. (Sci.) Punjab Univ. India* 44: 105-119.
- Macabeo, A.P.G., K. Krohn, D. Gehle, R.W. Read, J.J. Brophy, G.A. Cordell, S.G. Franzblau and A.M. Aguinaldo. 2005. Indole alkaloids from the leaves of Philippine *Alstonia scholaris*. *Phytochemistry*, 66: 1158-1162.
- Macias, F.A., J.C.G. Galindo and G.M. Massanet. 1992. Potential allelopathic activity of several sesquiterpene lactone models. *Phytochemistry*, 31: 1969-1977.
- Mishra, J.S. and V.M. Bhan. 1994. Efficacy of sulphonyl urea herbicides against *Parthenium hysterophorus*. *Weed News*, 1: 16.
- Navie, S.C., R.E. McFadyen, F.D. Panetta and S.W. Adkins. 1996. The biology of Australian weeds 27. *Parthenium hysterophorus* L. *Plant Prot. Quarterly*, 11: 76-88.

- Noor, M. and M.A. Khna. 1994. Allelopathic potential of *Albizia samans*. *Pak. J. Bot.*, 26: 139-147.
- 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.
- Riaz, T. and A. Javaid. 2010. Invasion of invasive parthenium weed in district Hafizabad, Pakistan. *J Anim. Plant Sci.*, 20: 90-93.
- Salim, A.A., M.J. Garson and D.J. Craik. 2004. New indole alkaloids from the bark of *Alstonia scholaris*. *J. Natural Prod.*, 67: 1591-1594.
- Shaukat, S.S., D. Khan and S.T. Ali. 1983. Suppression of herbs by *Inula grantioides* Boiss, in Sind desert, Pakistan. *Pak. J. Bot.*, 15: 43-67.
- Shfique, S., R. Bajwa, A. Javaid and S. Shfique. 2005. Biological control of *Parthenium*. IV. Suppressive ability of aqueous leaf extracts some allelopathic trees against germination and early seedling growth of *Parthenium hysterophorus*. *Pak. J. Weed Sci. Res.*, 11: 75-79.
- Singh, H.P., D.R. Batish and R.K. Kohli. 2003. Allelopathic interactions and allelochemicals: New possibilities for sustainable weed management. *Crit. Rev. Plant Sci.*, 22: 239-311.
- Steel, R.G.D. and J.H. Torrie. 1980. *Principles and Procedures of Statistics*. McGraw Hill Book Co., Inc, New York, USA.
- Suresh, P.V., D. Gupta, D. Behera and S.K. Jindal. 1994. Bronchial provocation with *Parthenium* pollen extract in bronchial asthma. *Indian J. Chest Dis. Allied Sci.*, 36: 104.
- Whittaker, R.H. and P.P. Fenny. 1971. Allelochemicals.: Chemical interactions between species. *Science (NY)*, 171: 575-570.
- Xuan, T.D., S. Tawata, T.D. Khanh and I.M. Chung. 2005. Biological control of weeds and plants pathogens in paddy rice by exploiting plant allelopathy: an overview. *Crop Prot.*, 24: 197-206.
- Xuan, T.D., A.A. elzaawely, F. deba, M. fukuta and S. Tawata. 2006. Mimosine in *Leucaena* as a potent bio-herbicide. *Agron. Sustain. Dev.*, 26: 89-97.
- Yamauchi, T., F. Abe, R.F. Chen, G.I. Nonaka, T. Santisuk and W.G. Padolina. 1990. Alkaloids from the leaves of *Alstonia scholaris* in Taiwan, Thailand, Indonesia and the Philippines. *Phytochemistry*, 29: 3547-3552.

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