Pak. J. Bot., 43(2): 885-894, 2011.

TAGETES ERECTUS L. – A POTENTIAL RESOLUTION FOR MANAGEMENT OF *PARTHENIUM HYSTEROPHORUS* L.

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Abstract

The present study provides an insight of use of *Tagetes erectus* as it contains herbicidal constituents for the management of *Parthenium* weed. Herbicidal effects of aqueous shoot, root, flower and soil extracts of allelopathic ornamental plant viz. *T. erectus* L., was evaluated against germination and growth of noxious alien weed *Parthenium hysterophorus* L. Aqueous extracts of 2, 4, 6, 8 and 10% (on fresh weight bases) obtained from aerial parts and rhizospheric soil of *T. erectus* inhibited germination and seedling growth of *P. hysterophorus* in bioassays conducted in Petri plates. In foliar spray bioassay, aqueous extracts of aerial plant parts of 10% w/v (on dry weight bases) concentrations were sprayed on one- and two-weeks old pot grown *Parthenium* seedlings. Two subsequent sprays were carried out at 5 days intervals each. These extracts on pot plants resulted in reduced shoot and root length and biomass. In residue incorporation bioassay, crushed shoots of *T. erectus* were incorporated in the soil at 1, 2, 3 and 4% w/w bases. *Parthenium* seeds were sown one week after residue incorporation and plants were harvested 40 days after sowing. Incorporation of 1–4% residues significantly reduced germination by 25-88%. Residues at all the concentrations significantly suppressed plant biomass by 90-97%.

Introduction

Parthenium hysterophorus is an invasive alien weed in Pakistan. It is native to tropical America and has become widespread in North America, South America, the Caribbean, and many parts of Africa, Australia and Asia (Navie *et al*., 1996; Javaid *et al*., 2006). The weed has been spreading in Pakistan for about last 20 years. It has now become a major wasteland weed and rapidly replacing the native flora in rain fed areas of the province Punjab and is also spreading in North Western Frontier Province and Kashmir (Javaid & Anjum, 2005). Fast growth rate, high reproductive potential, adaptive nature and interference by allelopathy (Kohli & Rani, 1994) are the major contributing factors for rapid spread and successful establishment of this weed in any ecosystem.

Allelopathy is so far an untapped resource for weed control in crops yet it shows considerable promise in weed management. Chemical weed control has been proved to be efficient and economical in controlling weeds, but weeds can and do develop resistance to pesticides/herbicides being used to control them, making them less effective (Tranel & Wright, 2002; De Prado & Franco, 2004). Therefore, the development of biopesticides has been focused as a vital pest control strategy in recent years. One source of potential new herbicides is natural products produced by plants. Many plant species are known to have herbicidal effects on other plant species (Marcías *et al*., 2004; Vasilakoglou *et al*., 2005; Dhima *et al*., 2006; Javaid *et al*., 2008). *Tagetes erectus* (marigold) is a commonly used ornamental plant, but its attractive blooms are not the only benefit of planting this crop. Marigolds release a chemical substance with a pungent odor that has been proven scientifically useful for inhibiting attacks from root-knot nematodes, vine weevils and various other insects, fungi, bacteria and viruses. Marigolds have been seeded between beds of solanaceous plants in India for hundreds of years for nematode and insect pest management (Khan *et al*., 1971). A chemical released by marigold roots called α-terthienyl has drawn much attention for its nematicidal characteristics. Essential oil of marigold was found to have a 100% inhibitory effect against Gram-positive bacteria and a 95% inhibitory effect against fungi (Hethelyi *et al*., 1986). Thiophenes, one of several compound classes found in marigold, show significant antiviral capabilities (Soule, 1993).

The present research work was, therefore, designed to study i) the effect of aqueous extract of different parts of *T. erectus* on germination and seedling growth of *P. hysterophorus* and ii) the effect of extract spray and residual incorporation of *T. erectus* on growth and yield of pot grown *P. hysterophorus* plants. This information is a prerequisite for the development of biological weed control methods.

Materials and Methods

Selection of plant material: *T. erectus*, commonly cultivated in Punjab, Pakistan, was selected in the present study. Plant materials (root, shoot, flower) and rhizospheric soil of this plant was collected from the nursery of University of the Punjab, Lahore, Pakistan in December, 2008. Materials were dried to constant weight in an electric oven at 40°C. The dried materials were cut into and threshed to small pieces. These materials were stored in polythene bags.

Extract preparation: The chopped materials were soaked in appropriate quantities of distilled water to 10% w/v extracts. Materials were left for 48 hours at 25°C. Afterwards, extracts were filtered through muslin cloth followed by Whatman filter paper No. 1 and appropriate quantities of distilled water were added to stock solutions to get 2, 4, 6, 8 & 10% (w/v) concentrations of different extracts. Likewise, for the preparation of rhizospheric soil suspension, 10 g of soil was soaked in distilled water to make 10% w/v soil suspension and after 48 hours the dilutions were made as described above. In order to make control for soil suspension, 10 g of non-rhizospheric soil was added to sterilized distilled water to make the final volume 100 mL.

Laboratory bioassays: The effect of different concentrations of 2–10% of extracts was studied on germination and early seedling growth of *Parthenium*. Ten seeds of *Parthenium* were placed in a 9 cm diameter Petri plate lined with Whatman No. 1 filter papers moistened with 3 mL of respective concentration of each extract. The control treatments received the same quantities of distilled water. Each treatment was replicated thrice. Plates were incubated at 25°C under 12 h light periods daily. After 7 days, seed germination, seedling root/shoot length and fresh biomass were determined.

Foliar spray bioassays: *Parthenium* seeds were sown in pots of 15 cm diameter and 15 cm deep each containing 600 g of soil. Initially 10 seeds were sown in each pot which were thinned to 5 uniform seedlings at the time of harvest. Aqueous extracts of 10% (w/v) of threshed shoot, root and flower materials of test plant were prepared by soaking the materials in sterilized distilled water for 48 hours followed by filtration through muslin cloth and filter paper. The freshly prepared extracts were sprayed on the surface of 1-week and 2-week old *Parthenium* plants with a hand sprayer. Two subsequent sprays were similarly carried out with 5 days intervals each. Control plants were similarly sprayed with water. Plants were harvested 40 days after sowing. Data regarding length and fresh biomass of both root and shoot were recorded.

Residue incorporation pot trials: Crushed shoot materials of the test plant was thoroughly mixed in pot soil at 1, 2, 3 and 4% (w/w) on dry weight bases. Each pot was of 15 cm diameter, 15 cm deep and contained 600 g dry soil. After mixing the materials pots were irrigated with tap water and left for 7 days for decomposition of materials and release of allelochemicals. After that *Parthenium* seeds were sown in each pot at 10 seeds per pot. Pots were placed in open sunlight. Pots were irrigated with tap water daily to keep the soil moisture level at field capacity. Plants were harvested 4 weeks after sowing and data regarding shoot and root length and biomass were recorded.

Statistical analysis: Data regarding germination, root length, shoot length and plant fresh and dry weight were subjected to analysis of variance (ANOVA) followed by Duncan's Multiple Range Test to delineate mean differences (Steel & Torrie, 1980) using computer software SPSS and COSTAT.

Results

Laboratory bioassays: Analysis of variance shows that the effect of plant extract type (E) was insignificant while that of extract concentration (C) was highly significant ($p \leq 0.001$) for germination of *Parthenium* seeds. Similarly, the interactive effects of E×C were also insignificant for germination (Table 1). All the concentrations of all aqueous extract types significantly reduced the germination. Particularly, the higher concentrations of 8 and 10% significantly suppressed seed germination (Fig. 1A).

Analysis of variance reveals that the effect of E and C as well as their interaction was significant for shoot length (Table 1). Shoot length was significantly reduced by all the concentrations of all aqueous extracts. Different concentrations of flower and root extracts reduced shoot length by 37–53 and 47–53%, respectively. In contrast to that, shoot extract of *T. erectus* exhibited comparatively less reduction in shoot length (26-47%) (Fig. 1B). Soil suspension extract of different concentrations also markedly reduced the shoot length. Effect of 10% extract concentration was maximum as 50% reduction in shoot length was evidenced (Fig. 1B).

The effect of E as well as its interaction i.e., E×C was insignificant for root length whereas the employed concentrations had significant ($p \leq 0.001$) effect on root length (Table 1). Root length was found to be more sensitive to extracts as compared to the shoot length. All the extract concentrations of all extract types significantly reduced the root length. Shoot extracts were more toxic than the root extracts. Different concentrations of shoot and root extracts reduced the root length by 12–66% and 07–56% while the flower and soil extracts reduced root length up to 19–63% and 40–68%, respectively (Fig. 1C).

Table 1. Analysis of variance for the effect of different concentrations of aqueous shoot, root, flower and rhizospheric soil extracts of *Tagetes erectus* on germination and seedling growth of *Parthenium*.

Trait	df	Mean squares			
		Germination	Shoot length	Root length	Plant fresh wt.
Treatments	23	1038^{**}	32.56^{**}	318^{**}	5.10^{**}
Extract type (E)	3	94^{ns}	46^{**}	172^{ns}	2.18^{*}
Concentration (C)	5	4617^{**}	115^{**}	1183^{**}	20.42^{**}
E × C	15	34^{ns}	2.53^{*}	58^{ns}	0.58^{ns}
Error	48	47	0.98	92	0.42
Total	**72**				

*, **, Significant at $p \leq 0.01$ and 0.001, respectively; ns: Non-significant.

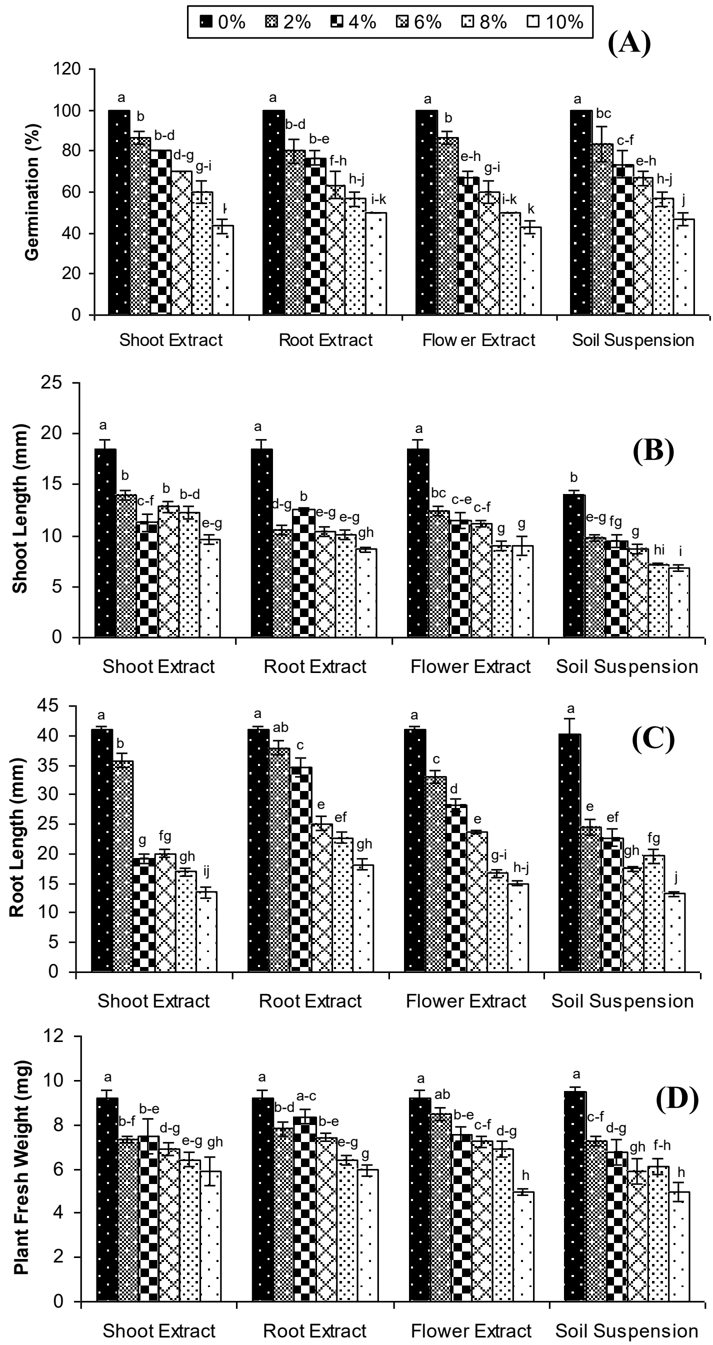

Fig. 1. Effect of different concentrations of plant parts of *Tagetes erectus* on germination and seedling growth of *Parthenium* in laboratory bioassays.
Vertical bars show standard errors of means of three replicates. Values with different letters at their top show significant difference (p≤0.05) as determined by Duncan's Multiple Range Test.

The effect of E and C was significant for plant fresh weight while that of E×C was insignificant (Table 1). The highest concentration of all extract types significantly reduced plant biomass up to 40% (Fig. 1D).

Foliar spray bioassays: Data regarding the effect of foliar spray of aqueous shoot, root and flower extracts of *T. erectus* on shoot and root growth of one- and two-weeks old *Parthenium* plants is presented in Fig. 2 and 3. All the shoot, root and flower extracts significantly suppressed shoot as well as root length of one- and two-week old *Parthenium* plants (Fig. 2 A&B). All the employed extract types significantly reduced the shoot and root fresh as well as dry biomass of *Parthenium* (Fig. 2C-F). Both one- and two-weeks old plants were susceptible to foliar spray of the extracts, however, the treatment to one-week old plants was found to be more effective as compared to two-week old plants for the control of this weed (Fig. 3).

Residue incorporation pot trials: Data regarding the effect of 1-4% leaf residual incorporation on germination and plant growth is presented in Figs. 4 & 5. All the residue incorporation treatments had significant and pronounced effect on germination and growth of the test plant. The germination of *Parthenium* was suppressed by 25–88%. All the concentrations of residue incorporation suppressed the shoot length. Maximum inhibitory effect was noticed by 4% residual treatment where about 68% suppression in shoot length was recorded (Fig. 4B). Effect of different concentrations of residue incorporation on root length was variable. Lower concentrations of 1 and 2% markedly reduced the root length by 41 and 54%, respectively. In contrast to that, higher concentration of 3% residue incorporation enhanced the root length a bit as compared to lower concentrations but this was still reduced as compared to control by 47% (Fig. 4C). All the concentrations of 1–4% residue incorporation exhibited significant reduction in plant biomass (Fig. 4D-G). However, the higher concentrations of 4% significantly reduced the plant fresh and dry biomass by 90-97%, respectively.

Discussion

All aqueous extracts of *T. erectus* were found to be highly toxic to germinating *Parthenium* as all extracts significantly reduced the germination of *Parthenium* seeds. Effect of different extracts of test allelopathic plant species on shoot and root length and seedling biomass of *Parthenium* was also significant in laboratory bioassays. The inhibitory potential of the extracts was increased by increase in concentration. Likewise various studies to evaluate the herbicidal potential of allelopathic grasses (Anjum *et al.,* 2005; Javaid *et al*., 2005) and trees (Shafique *et al.,* 2005) against *Parthenium*, carried out by our research group, have provided very encouraging results.

All the applied extracts significantly suppressed the seedling growth of the test weed in foliar spray pot trials. One-week old plants were found to be more susceptible as compared to two-week old plants which were comparatively less effective. *T. erectus* is known to have Thiophenes, one of several compound classes found in marigold, show significant antimicrobial capabilities (Soule, 1993) which might be a cause of growth inhibition of *Parthenium*. Likewise, Marigold roots release the chemical alpha-terthienyl, one of the most toxic naturally occurring compounds found to date (Gommers & Bakker, 1988). This compound is nematicidal, insecticidal, antiviral and cytotoxic (Arnason *et al.,* 1989; Marles *et al.,* 1992).The presence of alpha-terthienyl inhibits the hatching of nematode eggs (Siddiqui & Alam, 1988). The reduction in the growth rate of *Parthenium* could be attributed to the presence of such compounds in different extracts. Recently Ko *et al*., (2005) have reported the inhibitory effects of husk extracts of seven rice varieties

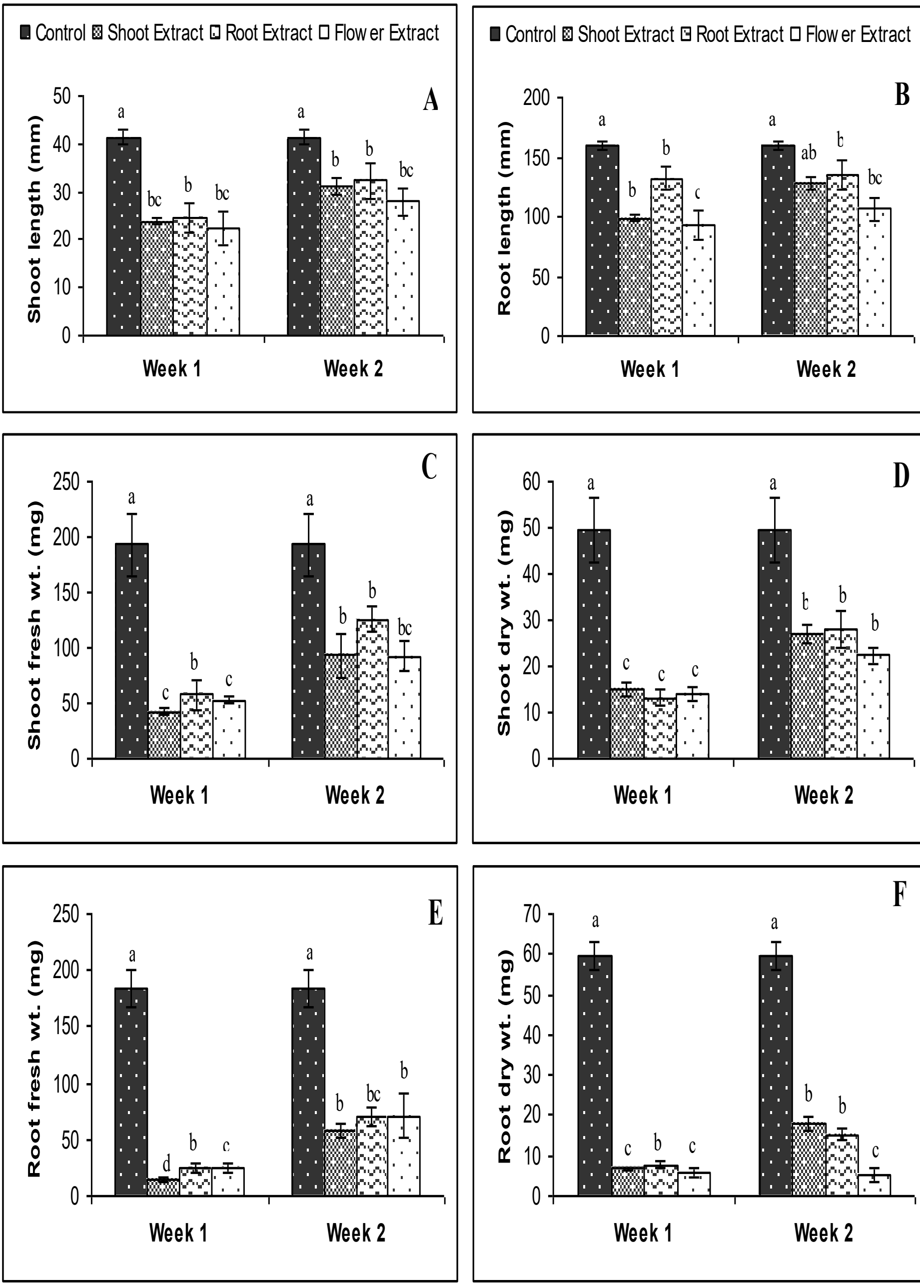

Fig. 2. Effect of foliar spray of aqueous shoot, root and flower extracts of *Tagetes erectus* on shoot and root growth of parthenium.

Vertical bars show standard error of means of three replicates. Values with different letters show significant difference ($p \leq 0.05$) as determined by Duncan's Multiple Range Test.

1-week old and 2-weeks means that foliar spray was started after one and two weeks of germination, respectively.

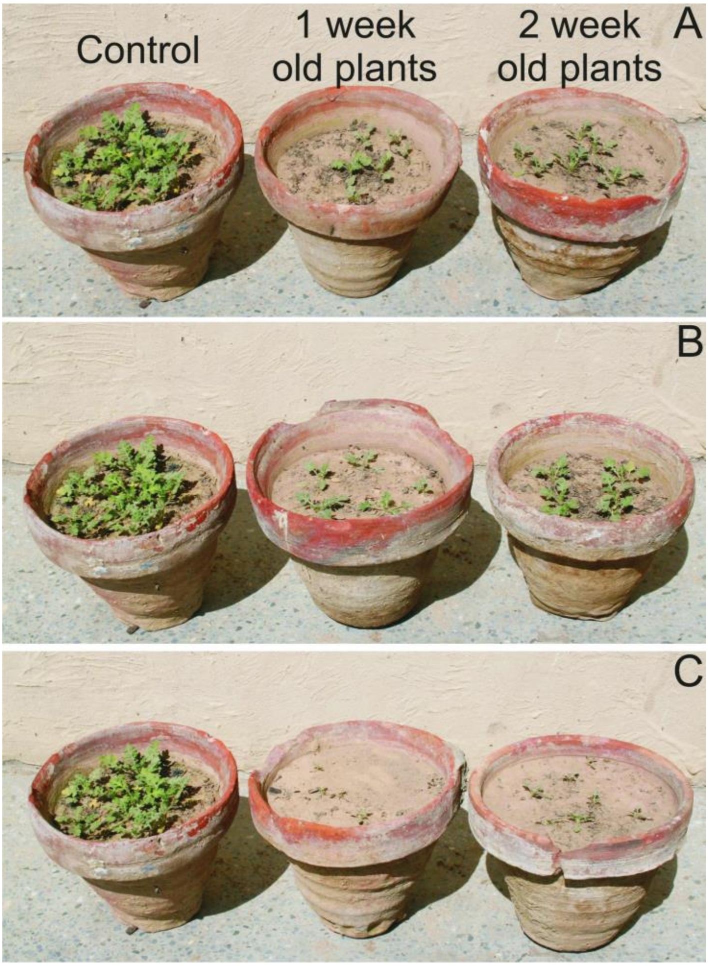

Fig. 3. Effect of foliar spray of 10% aqueous shoot, root and flower extracts of *Tagetes erectus* on growth of parthenium in pot trials.

on growth of barnyard grass (*Echinochloa crusgalli* (L.) Beauv.). Similar adverse effects of water extracts of different *Brassica* spp., on germination and growth of cut leaf ground-cherry weed (*Physalis angulata* L.) have been reported by Uremis *et al.* (2005).

All the residue incorporation treatments (1-4%) had significant and pronounced effect on germination and growth of the test plant by suppressing about 25–88% of germination. Abdul-Rehman & Habib (1989) found that decomposing crop residues of alfalfa (*Medicago sativa* L.) reduced the germination of blady grass (*Imperata cylindrica* (L.) Beauv.) by 52%. Recently Javaid *et al*. (2008) exploited the allelopathic properties of rice for *Parthenium* management. All residue incorporation treatments (0.5-1.5%) significantly declined the seedling biomass of target weed.

The present study concludes that *T. erectus* extracts have significant herbicidal effects on the germination and growth of *Parthenium*. Crop residues could be spread on wastelands, resulting in the leaching of allelochemicals that would reduce the seed germination and consequently the population of *Parthenium*.

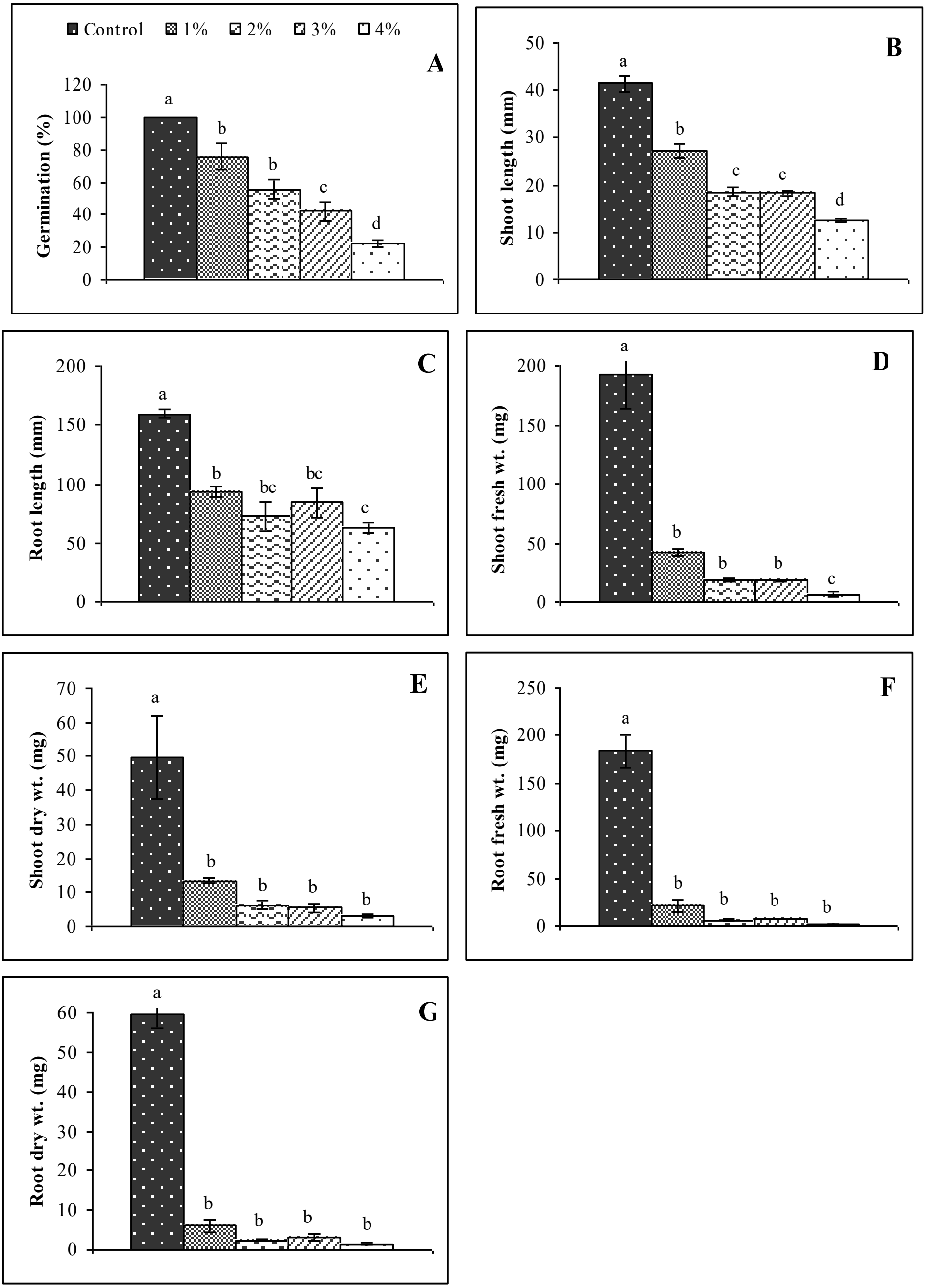

Fig. 4. Effect of leaf residue (LR) incorporation of *Tagetes erectus* on germination and plant growth of parthenium in pot trials.
Vertical bars show standard errors of means of three replicates. Values with different letters at their top show significant difference ($p \leq 0.05$) as determined by Duncan's Multiple Range Test.

Fig. 5. Effect of leaf residue (LR) incorporation of *Tagetes erectus* on growth of Parthenium in pot trials.

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(Received for publication 20 April 2009)