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Article

ALLELOPATHIC EFFECTS OF INVASIVE *Prosopis juliflora* ON GRASS SPECIES OF POTOHAR PLATEAU, PAKISTAN

Efeitos Alelopáticos da Planta Invasiva ***Prosopis juliflora*** *em Gramíneas do Planalto de Potohar, Paquistão*

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ABSTRACT - The present study was conducted to investigate the allelopathic effects of *Prosopis juliflora* (Sw.) DC. (Mesquite) on various growth parameters of three promising grass species (*Cenchrus ciliaris, Panicum antidotale* and *Panicum maximum*) on the Potohar Plateau, Pakistan, under nursery conditions. The experiment was carried out under a completely randomized design with two factors and three replicates. Different concentrations of the foliage aqueous extract of *P. juliflora* were prepared and their effect was studied on root length, shoot length, fresh and dry biomass of tested grass species. All grass species showed a concentration dependent inhibition. However, among all grasses, *C. ciliaris* was affected most severely whereas *P. antidotale* was the least affected grass species. This indicates an adverse effect of mesquite leaf on grass growth which is directly proportional to the increase in the extraction level of the mesquite leaf. These outcomes suggest that mesquite foliage contains allelochemicals that had inhibitory effect on grass growth.

Keywords: allelopathy, *Cenchrus ciliaris*, *Panicum antidotale*, *Panicum maximum*, growth.

RESUMO - O presente estudo foi realizado para investigar os efeitos alelopáticos de ***Prosopis juliflora*** *(Sw.) DC. (algaroba) sobre vários parâmetros de crescimento de três espécies promissoras de gramíneas (****Cenchrus ciliaris****,* ***Panicum antidotale*** *e* ***Panicum máximo****) do Planalto de Potohar, no Paquistão, mantidas em viveiro. O experimento foi conduzido sob delineamento inteiramente casualizado, com dois fatores e três repetições. Diferentes concentrações do extrato aquoso de* ***P. juliflora*** *foram preparadas, e seu efeito foi investigado em relação a comprimento radicular, comprimento da parte aérea e biomassa fresca e seca das espécies de gramíneas testadas. Todas as espécies de gramíneas mostraram inibição, cujo nível foi dependente da concentração. No entanto, entre todas as gramíneas,* ***C. ciliaris*** *foi afetada de forma mais severa, enquanto* ***P. antidotale*** *foi a espécie menos afetada. Isso indica que o efeito adverso das folhas de algaroba no crescimento das gramíneas é diretamente proporcional ao aumento no nível de extração da folha dessa árvore. Os resultados sugerem que as folhas de algaroba contêm aleloquímicos que exerceram efeito inibitório no crescimento das gramíneas.*

Palavras-chave: alelopatia, *Cenchrus ciliaris*, *Panicum antidotale*, *Panicum maximum*, crescimento.

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INTRODUCTION

Allelopathy is the beneficial or destructive impact of phytotoxic chemicals released by plants that cause an injurious effect on the growth and development of nearby plants or microorganisms. These allelochemicals are found in all

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plant organs i.e. flowers, fruits, leaves, roots, stems, seeds and rhizomes (Putnam and Tang, 1986). The amount and emanation pathway of allelochemicals varies from species to species (Friedman, 1995). Multiple crop and weed species have allelopathic action on the growth and germination of other plant species (Farooq et al., 2013).

Research and advancement in understanding allelopathy are crucial for the development of forestry, agriculture and the global environment, because allelopathy primarily deals with native and exotic invasive weeds (Resai and Khajeddin, 2008). Allelopathic crops are reported to hinder agricultural practices and bring about ecological degradation on a regular basis. It has been found that allelopathic plants can be potentially used as natural herbicides as they are more biodegradable than traditional herbicides and also have undesirable effects on non-target species (Saberi et al., 2011).

The total area of Pakistan is 87.98 million hectares and almost 58 percent of the country's land is under rangelands (Mohammad, 1989). Potohar plateau is bounded by the Jhelum and Indus rivers and it has an area of 1.82 million hectares. Because of its uneven topographic features, livestock grazing is a common practice. Dhaman grass (*C. ciliaris*), Green Panic grass (*P. antidotale*), and Blue Panic grass (*P. maximum*) are the highly palatable grasses of this region. Mesquite (*P. juliflora*) is an invasive plant of the Potohar region and affects grasses as well as other associated crop species by way of direct competition for nutrient resources, moisture and through its allelopathic effect of declining growth of the other associated plants (Khalid, 2000). Mesquite is the major invader of the rangelands of Pakistan, including the Potohar area. Hence, the effect of Mesquite on the growth of grasses needs to be investigated in order to devise strategies to minimize its adverse impact on other flora of the rangeland ecosystem. Therefore, present research has been planned to investigate the allelopathic effect of Mesquite foliage on growth of three promising grass species (Dhaman, Blue and Green Panic) under nursery conditions.

MATERIALS AND METHODS

Mesquite leaves were collected from the Potohar region. Leaf extracts of Mesquite were prepared with the following concentrations.

T1 = Tap water stored at room temperature (Control).

T2 = 500 g *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours.

T3 = 500 g *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour.

T4 = 1 kg *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours.

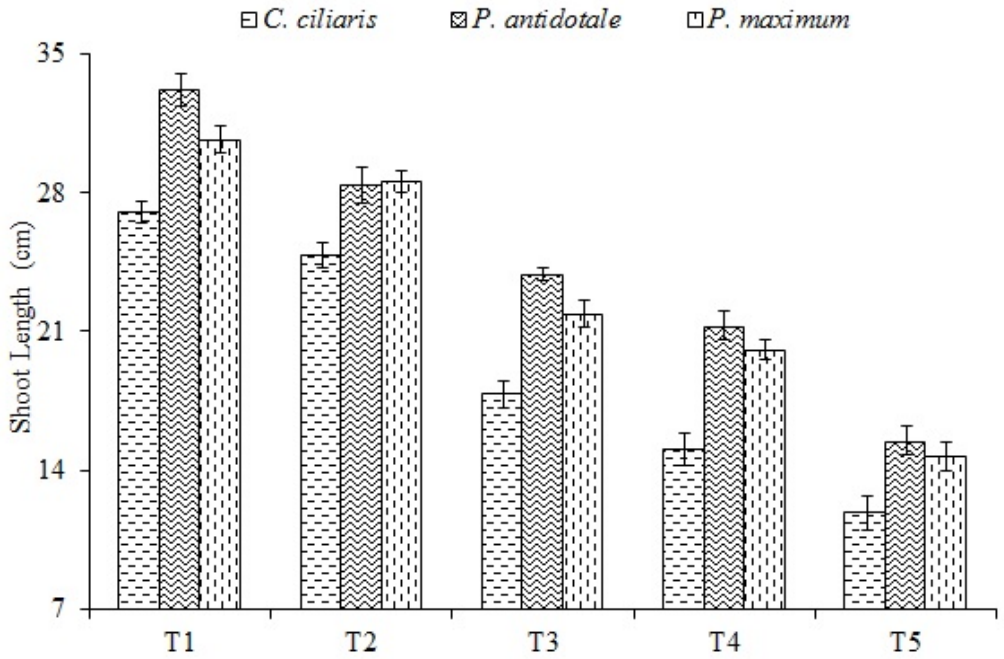
T5 = 1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour.

The experiment was carried out under a completely randomized design (CRD) with two factors and three replications. Each treatment consisted of ten plants. Tufts were transplanted in the polythene tubes in proper growth medium (soil, fine sand and farm yard manure in a 1:1:2 ratio). The plants were watered with the application of the respective extracts (treatments) during the study period. The experiment lasted for twelve weeks. Data were collected on shoot length, root length, shoot fresh weight, shoot dry weight, root fresh weight and root dry weight. Shoot and root length was measured with the help of a scale and then averaged. Shoots and roots of different plants were harvested and fresh biomass (g) was recorded. The roots and shoots were oven dried at 70 ^{o}C for 48 hours until stable weight was achieved. The data was subjected to statistical analysis by using the statistical software package MSTATC, following Steel et al., (1997). The Least Significant Difference (LSD) Test was applied at 5% significance level of probability to compare the means.

RESULTS AND DISCUSSION

The present findings demonstrate negative allelopathic effects of mesquite extracts on root length, shoot length and biomass of *C. ciliaris*, *P. antidotale* and *P. maximum*.

Shoot and root length: The data showed that mesquite leaf significantly affected shoot and root length of the grass species (Figures 1 and 2). At all test concentrations of mesquite leaf extracts inhibit shoot and root length in a concentration dependent way i.e. T5<T4<T3<T2<T1 ($p \leq 0.05$). The data indicates that *C. ciliaris* shows minimum shoot and root length whereas maximum shoot and root length was recorded in *P. antidotale* at T5 (1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).



The bars indicate standard error (± SE) of the mean (n = 3). All means are significantly different at $p \leq 0.05$. (T1 = Tap water stored at room temperature (Control); T2 = 500 g *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T3 = 500 g *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour; T4 = 1 kg *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T5 = 1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).

Figure 1 - Effect of mesquite foliage extract on shoot length (cm) of promising grasses of the Potohar Plateau.

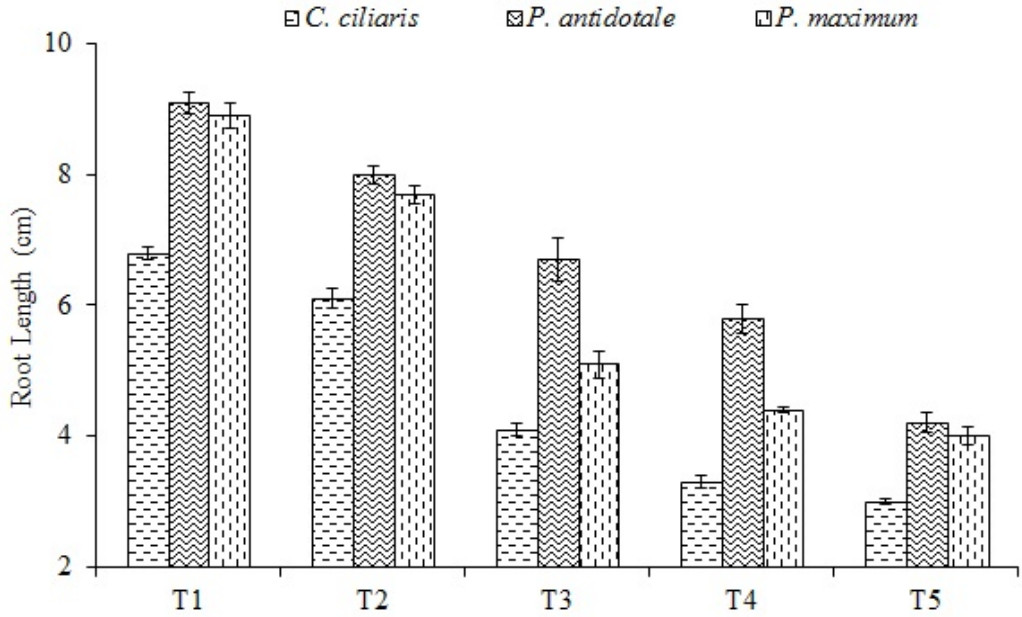


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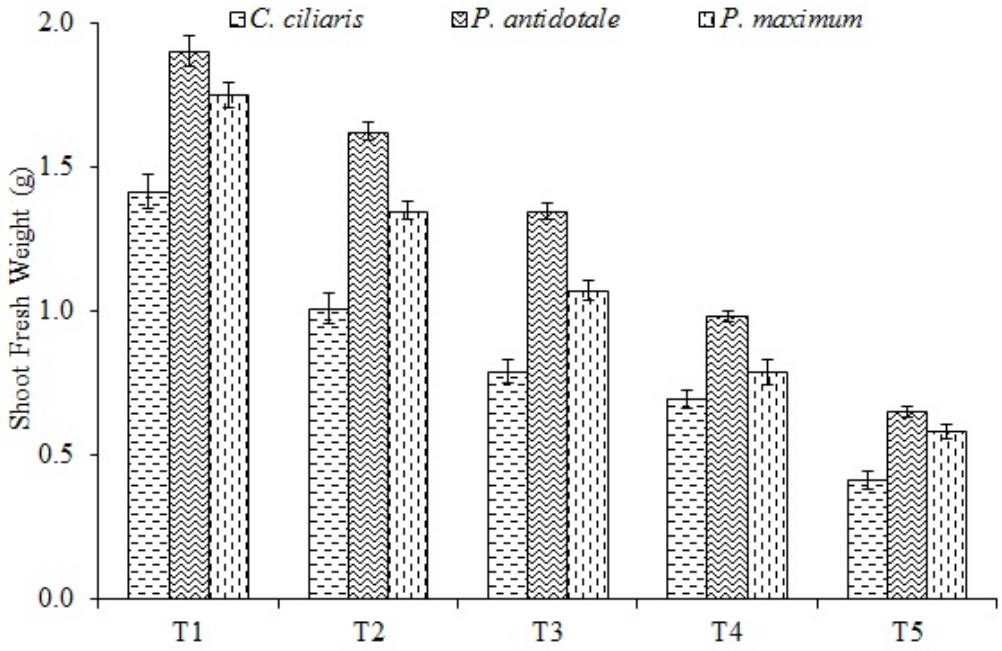
Figure 2 - Effect of mesquite foliage extract on root length (cm) of promising grasses of the Potohar Plateau.

This effect of mesquite foliage might be due to the presence of chemicals that interfere with production and/or transport of plant hormones, *viz.*, cytokinins and auxins required for cell division and cell elongation. Bhatt et al. (1994) reported similar results for the extracts of *Parthenium hysterophorus* and *Xanthium strumarium*. The inhibitory effect of the mesquite foliage on shoot length of the tested grasses may be due to the presence of allelochemicals, including tannins, wax, flavonoids and phenolic acids. Similar findings were also reported by Siddiqui et al. (2009) during their study on the effects of leaf extracts on various agricultural crops. Therefore, the adverse effects of mesquite extracts on shoot and root length and other parameters might be due to allelochemicals.

Shoot and root biomass: The effect of mesquite foliage on the growth of the study grasses shows a reduction in fresh and dry biomass of the roots and shoots.

Shoot and root fresh weight: A significant reduction in the fresh weight of shoot of different grasses were observed with increased concentration of mesquite foliage (Figure 3). There was a concentration dependent decrease in shoot fresh weight. The data revealed that shoot fresh weight of all the grasses differed significantly from one another ($p \leq 0.05$). Mesquite leaf extracts also significantly reduced the root fresh weight of the tested grasses (Figure 4). More reduction in root fresh weight was found in *C. ciliaris* whereas less reduction was recorded in *P. antidotale*. All grasses showed a concentration dependent reduction in root fresh weight. Minimum shoot and root fresh weight was recorded in *C. ciliaris* whereas maximum shoot and root fresh weight was recorded in *P. antidotale* at T5 (1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).



The bars indicate standard error (± SE) of mean (n = 3). All means are significantly different at $p \leq 0.05$. (T1 = Tap water stored at room temperature (Control); T2 = 500 g *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T3 = 500 g *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour; T4 = 1 kg *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T5 = 1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).

Figure 3 - Effect of mesquite foliage extract on shoot fresh weight (g) of promising grasses of the Potohar Plateau.

The decreased root and shoot fresh weight might be due to the decrease in root and shoot length of the grasses. Similar results were reported by Khan et al. (2008), who recorded decreased fresh weight in wheat varieties after application of *Eucalyptus* extract at different concentrations. The present study also indicated that the aqueous extract of mesquite foliage significantly reduced the shoot and root fresh weight of the grasses.

Shoot and root dry weight: Dry matter production is one of the deciding factors to determine crop vigor and is a function of root and shoot dry matter. Leaf extracts of mesquite significantly reduced the shoot and root dry weight of the tested grasses (Figures 5 and 6). The data indicate

a concentration dependent reduction in shoot dry weight of the grasses. Minimum shoot and root dry weight was recorded in *C. ciliaris* followed by *P. maximum* and *P. antidotale* at T5 (1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).

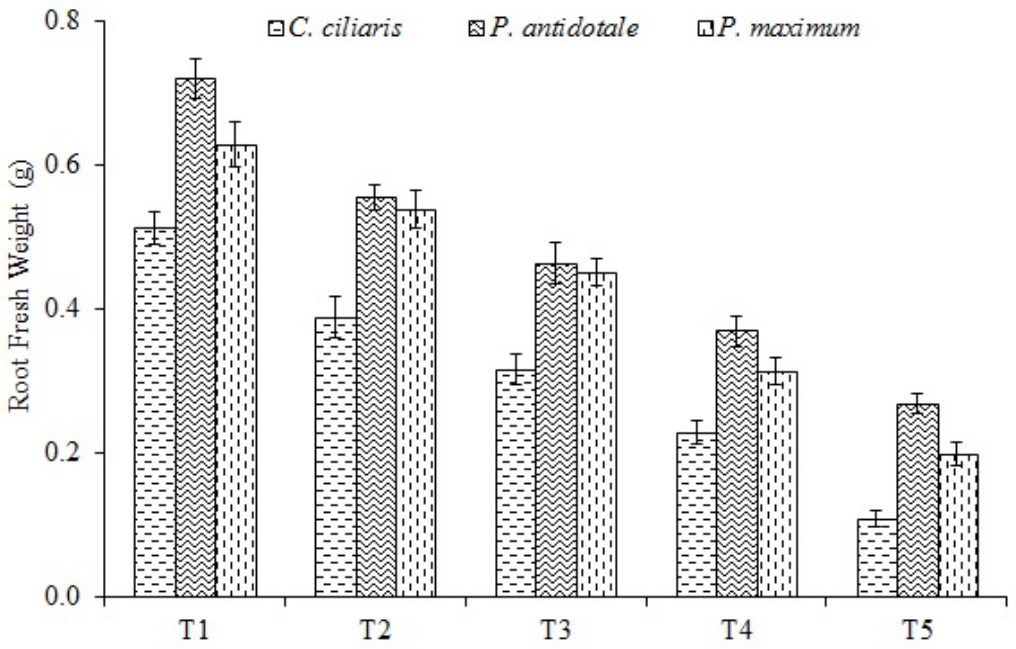


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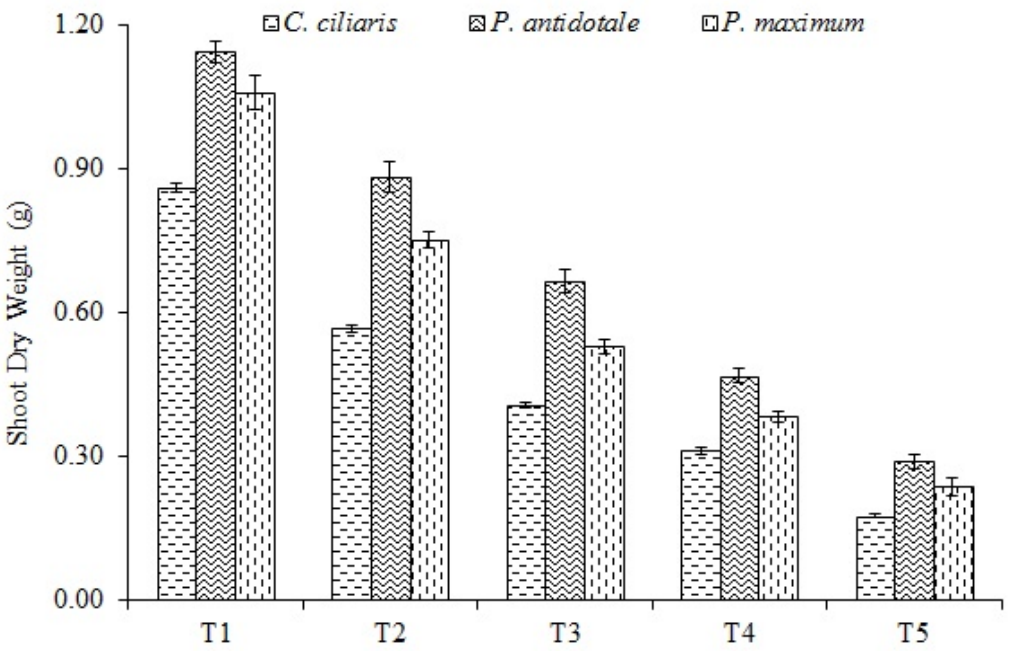
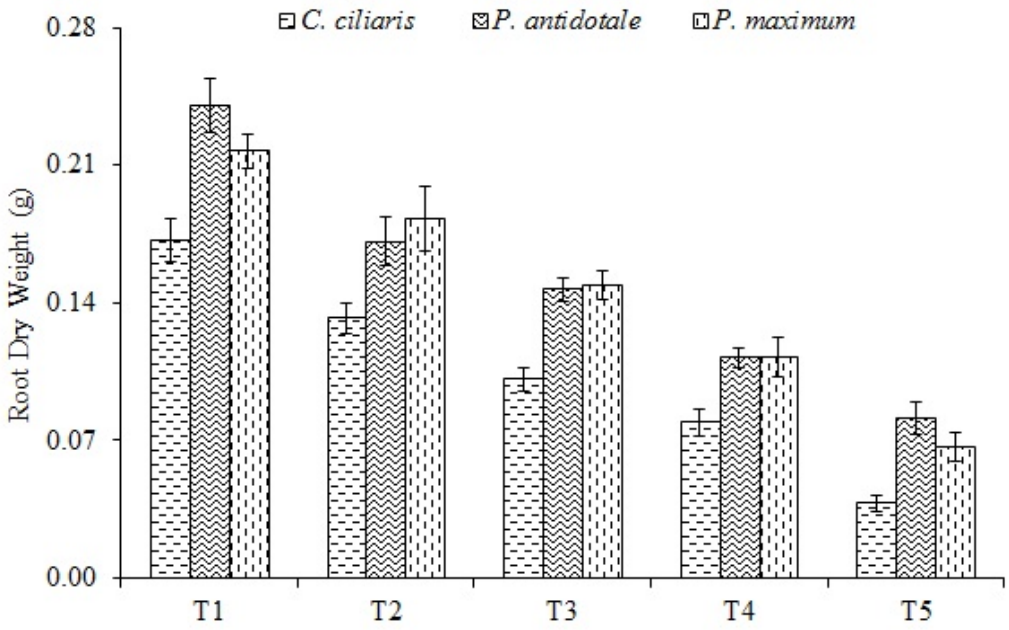
Figure 4 - Effect of mesquite foliage extract on root fresh weight (g) of promising grasses of the Potohar Plateau.



The bars indicate standard error (± SE) of the mean (n = 3). All means are significantly different at p≤0.05. (T1 = Tap water stored at room temperature (Control); T2 = 500 g *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T3 = 500 g *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour; T4 = 1 kg *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T5 = 1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).

Figure 5 - Effect of mesquite foliage extract on shoot dry weight (g) of promising grasses of the Potohar Plateau.



The bars indicate standard error (± SE) of mean (n = 3). All means are significantly different at p≤0.05. (T1 = Tap water stored at room temperature (Control); T2 = 500 g *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T3 = 500 g *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour; T4 = 1 kg *P. juliflora* leaves soaked in 10 liters of tap water for 72 hours; T5 = 1 kg *P. juliflora* leaves boiled in 10 liters of tap water for 1 hour).

Figure 6 - Effect of mesquite foliage extract on root dry weight (g) of promising grasses of the Potohar Plateau.

Significant variation in shoot dry weight among the experimental grasses after application of different mesquite foliage solutions revealed that the interaction was also significant. The decrease in dry matter content may be attributed to the decrease in seedling length and seedling vigor index. Similar results were found by Obaid and Qasem (2005), who reported an inhibitory effect of *Amaranthus gracilis*, *Convolvulus arvensis*, *Lactuca serriola* and *Portulaca oleracea* on seedling growth and dry matter of vegetable crops. Jalageri et al. (2010) also reported a significant decline in the shoot biomass as a result of different weed residues. *Eucalyptus camaldulensis*, *Prosopis juliflora* and *Acacia nilotica* significantly affected seedling growth of several crops and weed species (Khan et al., 2004). The reduction in root growth was probably due to water soluble toxins. Similar findings have been reported by Patel et al. (2002), who noted that growth was adversely affected by *Eucalyptus* trees.

Mesquite is a problematic invasive plant which has successfully outcompeted the native plants of rangelands of the Potohar Plateau, Pakistan. *C. ciliaris*, *P. antidotale* and *P. maximum* are nutritious and palatable species and are the major source of forage for the livestock in the area. There was a significant inhibition of shoot and root length, fresh and dry biomass by all concentrations of leaf extracts. However, *P. antidotale* appears to be least affected grass species. The adverse effect of mesquite aqueous extracts revealed that any concentration of its water-soluble toxins in soil can result in reduced growth and reduced plant biomass. In order to reduce the rate of invasion, *P. juliflora* should be removed mechanically by uprooting. Monitoring movement of livestock should control dissemination of seeds. This may play an important role in preventing further invasion of new areas. Moreover, irrigation channels also play a substantial role in transferring the seeds to nearby areas including farming lands. Thus, removal of *P. juliflora* adjacent to irrigation channels may reduce dispersal of seeds by water bodies and, as a consequence, decline the invasion rate.

REFERENCES

Bhatt BP, Chauhan DS, Todaria P. Effect of weed leachates on germination and radicle extension of some food crops. Indian J Plant Physiol. 1994;36:170-7.

Farooq M, Bajwa AA, Cheema SA, Cheema ZA. Application of allelopathy in crop production. Int J Agric Biol. 2013;15:1367-78.

Friedman J. Allelopathy, autotoxicity and germination. In: Kigel J, Galili G. editors. Seed development and germination. New York: Marcel Dekker; 1995. p.599-628.

Jalageri BR, Channappagoudar BB, Surwenshi A, Nakul HT. Allelopathic effects of prominent weed species on cereals, pulses and oilseed crops. Res J Agric Sci. 2010;1:107-12.

Khalid S. *Parthenium hysterophorus* L. A new introduction to Pakistan. Pak J Biol Sci. 2000;3(5):846-7.

Khan EA, Khan MA, Ahmad HK, Khan FU. Allelopathic effects of Eucalyptus leaf extracts on germination and growth of cotton (*Gossypium hirsutum*). Pak J Weed Sci Res. 2004;10(3-4):145-50.

Khan MA, Hussain I, Khan EA. Allelopathic effects of eucalyptus (*Eucalyptus camaldulensis* L.) on germination and seedling growth of wheat (*Triticum aestivum* L.). Pak J Weed Sci Res. 2008;14(1-2):9-18.

Mohammad N. Rangeland management in Pakistan. Kathmandu, Nepal: The International Center for Integrated Mountain Development (ICIMOD); 1989.

Obaid KA, Qasem JR. Allelopathic activity of common weed species on vegetable crops grown in Jordan. Allelop J. 2005;15(2):221-36.

Patel B, Achariya B, Bupripata NP. Allelopathic effects of Eucalyptus leaves on seed germination and seedling growth of winter wheat. In: Proceedings Indian Society Allelopathy. 2002. p.115-9.

Putnam AR, Tang C. The science of allelopathy. New York: Wiley; 1986.

Resai M, Khajeddin SJ. Allelopathic effects of *Onobrychis* on *Scariola orientalis* and *Agropyron elongatum.* Iran J Rangeland. 2008;4(1):386-400. (In Persian).

Saberi M, Shahriari AR, Tarnian F, Jafari M, Safari H. Influence of seed priming on germination and seedling range species under allelopathic components. Front Agric China. 2011;5(3):310-21.

Siddiqui MH, Mohammad F, Khan MN. Morphological and physio-biochemical characterization of *Brassica juncea* L. Czern. & Coss. genotypes under salt stress. J Plant Int. 2009;4:67-80.

Steel RGD, Torrie JH, Dickey DA. Principles and procedures of statistics: A biometrical approach. 3rd ed. New York: McGraw Hill Book; 1997. p.400-28.