Pennisetum glaucum AQUEOUS EXTRACT SUPPRESSES GROWTH OF SOME WEED SPECIES

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ABSTRACT

A laboratory study was conducted to investigate the allelopathic effects of aqueous extract of Pennisetum glaucum on different noxious weed species i.e., signal grass (Brachiaria reptans), common lambsquarters (Chenopodium album), field bindweed (Convolvulus arvensis), broadleaf dock (Rumex dentatus), jungle rice (Echinochloa colona), slender amaranth (Amaranthus viridis), snake cucumber (Cucumis melo var. agrestis) and milk thistle (Sonchus asper). Five different concentrations (25, 30, 35, 40, 45 g/L) of pearl millet aqueous extract along with control (distill water) were used to decipher its efficacy on aforementioned weed species. Various parameters were studied including germination (%), root and shoot length, root and shoot weight and plant fresh weight. The study revealed very strong phytotoxic effects of millet aqueous extract on all the studied parameters when applied at 45 g L^{-1}, whereas use of 25 g L^{-1} aqueous extract was found less effective compared with control showing some stimulation in plant growth. Milk thistle (Sonchus asper) and snake cucumber (Cucumis melo) were most susceptible, whereas signal grass (Brachiaria reptans) was resistant to aqueous extract of pearl millet. The data indicated that aqueous extract of pearl millet has inhibitory effects on weeds growth at higher concentrations (45 g L^{-1}). Further research is suggested to fine tune the efficacy of pearl millet extract for their commercial utilization in weed management.

Keywords: Allelopathy; pearl millet; aqueous extracts; weed species

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INTRODUCTION

Pearl millet (*Pennisetum glaucum* [L.] R.Br.) is the 3rd important cereal in livestock feed in Pakistan. It is a major contributor in the feeding of rural cattle and poultry. In countries such as USA, pearl millet is sown for forage purpose in summer, whereas the grain is used as raw material for bird feed industry and wildlife (Obeng *et al*., 2012). Millet is the major source of energy and protein for millions of people in Africa. It has many nutritious and medical functions (Yang *et al*., 2012) and is a drought resistant crop (Adekunle, 2012). Pearl millet produces the largest number of seeds and it is the crop most commonly used for human consumption and animal feed (Mariac *et al*., 2006; ICRISAT, 2007). Radhouane (2014) reported pearl millet as an allelopathic plant, while Autochthonous genotype (KS) of pearl millet has strong allelopathic effects and can be used as bio-agent for weeds control (Radhouane, 2012). It has been reported that aqueous extracts of pearl millet can decrease the shoot length of weeds (Cheema *et al*., 2002). Weed control with different chemicals is basic option; however, their continuous application for a longer time can cause environmental degradation, animals and human health issues as well as herbicide resistance in certain weed species (Marwat *et al*., 2011). Allelochemicals produced by millet have negative impact on plants resulting in reduction of plant growth of neighboring species (Khan *et al.*, 2008). Allelopathy is an interference mechanism by which plants release chemicals which affect other plants (Cheema *et al*., 2003). Generally, allelochemicals are inhibitors of root, stem, leaves and overall plant growth. Several compounds proved inhibitors for germination (Al-Zahrani, 2011). In most cases, the adverse effects of allelopathic result in mortality or a growth arrest. Incorporating allelopathy into natural and agricultural management systems may reduce the use of herbicides, insecticides, pesticides, reducing environment/soil pollution. Considering importance of allelopathy and the observed phytotoxic effects of pearl millet seeds on some plants, the present research was conducted to find out possible allelopathic potential of pearl millet for the suppression of some weed species.

MATERIALS AND METHODS

The experiment was carried out in Postgraduate Lab, Department of Agronomy, Gomal University, Dera Ismail Khan, Pakistan in 2018. The test weed species included Signal grass (*Brachiaria reptans*), Common lambsquarters (*Chenopodium album*), Field bindweed (*Convolvulus arvensis*), Broadleaf dock (*Rumex dentatus*), Jungle rice (*Echinochloa colona*), Slender amaranth (*Amaranthus viridis*), Snake cucumber (*Cucumis melo* var. *agrestis*) and Milk thistle (*Sonchus asper*). A two factors experiment was laid out in a completely randomized design with three repeats. Six concentrations of pearl millet aqueous extract (factor-A) were tested on growth and development of aforementioned weeds (factor-B). The detail of experimental treatment is given in Table-1. Solution was prepared by grinding dried leaves of pearl millet and mixing in 1 liter distilled water, each at the rate of 25, 30, 35, 40 and 45 g separately for 3 days at room temperature, while in control, distilled water was used for comparison. The aqueous extract was filtered thereafter and stored separately for each concentration in different bottles. Before sowing, seeds of respective weeds were soaked in extract for 3 hours. After that, 90 g sandy loam soil was collected in plastic glasses and 10 seeds of each weed species were sown in individual glass accordingly as per respective extract concentration. After 3 days of sowing, 15 mL extract was applied to each treatment with an interval of 2 days, except control where only distilled water was used. All the treatments were kept in growth chamber maintained at 27°C. Experimental data on germination (%), root and shoot length (cm), fresh root and shoot weight (g) and plant fresh weight (g) of different weed species were recorded 21 days after

sowing and were subjected to statistical analysis, followed by means comparison through LSD test using "Statistix 8.1" computer software.

RESULTS AND DISCUSSION

Germination (%)

Data presented in Table-2 elucidated that various concentrations of extract significantly reduced germination of different weeds as compared to control. The tested weeds also exhibited significant results amongst each other. As regards concentrations, a declining trend in germination of weeds was found from control to higher concentrations of extract used. Maximum reduction in germination (7.5 & 8.5%) was noted in Snake cucumber (*Cucumis melo* var. *agrestis*) and Milk thistle (*Sonchus asper*) respectively by the application of extract @ 45 g L^{-1}. This might be due to sensitivity embryo of Snake cucumber and Milk thistle towards allelochemicals present in extract than other weed species. Basharat *et al.* (2017) also observed suppressed germination of weeds with the application of pearl millet extract. Similar results were also reported by Hussain and Shah (2017). The study revealed that all the tested weeds showed highest germination in control treatment where no extract was used.

Root length (cm)

The study revealed that root length of different weeds was significantly influenced with multiple concentrations of pearl millet aqueous extract (Table-3). It was noted that higher concentration of extract greatly reduced root length of weed species. Maximum inhibition (0.89 & 0.93 cm) was recorded in Milk thistle (*Sonchus asper*) and Jungle rice (*Echinichloa colona*) respectively with the application of 45 g L^{-1} extract each. The study also expressed that lower concentration (25 g L^{-1}) of extract had stimulatory effects on root elongation of Signal grass (*Brachiaria reptants*), Bitter dock (*Rumex dentatus*) and Jungle rice (*Echonochloa colona*) showing 6.83, 6.00 & 4.33 cm root length, while the control (distilled water only) treatment had 6.20, 5.90 & 3.90 cm, respectively root length of aforesaid three weed species. A gradual decrease in root growth of almost all the weed species was observed, as the concentration of extract increased. Similar observations were also registered by Gulzar and Siddique (2014) who reported that increasing *Pennisetum glaucum* aqueous extract concentrations reduced root length.

Shoot length (cm)

Shoot length was significantly affected by variable concentration of pearl millet aqueous extract, different weed species as well as their interaction (Table-4). Data analysis showed that highest concentration (45 g L^{-1}) of pearl millet extract reduced shoot length at maximum (3.27, 3.50 & 3.70 cm) of Milk thistle (*Sonchus asper*), Snake cucumber (*Cucumis melo* var. *agrestis*) and Slender amaranth (*Amaranthus viridis*), respectively. These three treatment combinations were also statistically similar to each other. However, longest shoot growth of each tested weed species was recorded in control treatment where only distilled water was used. Maximum but statistically similar shoot length (11.92 & 11.67 cm) was recorded in Signal grass (*Brachiaria reptans*) in control (distilled water only) and in extract using 25 g L^{-1}, respectively. It was also found that shoot length in most of the treatment combinations was statistically at par. However, extract of pearl millet affected the growth of plumule and embryo of most of the tested weeds. The inhibition in shoot growth of different weed species might be due to application of aqueous extract at various concentration and presence of phytochemicals present therein. Gulzar and Siddiqui (2014) reported that higher concentration of aqueous extract was more effective in controlling weed growth. Hussain and Shah (2017) and Shinwari *et al*. (2017) also reported that mostly plant physiological processes are disturbed due to allelochemicals.

Root weight (g)

Root weight of various weed species tested against different concentrations of pearl millet aqueous extract showed significant variations (Table-5). A declining trend in root weight of different weeds was observed, as the concentrations of extract increased. Different weed species also showed variable results for their root weight. The lowest root weight (0.02 g) was recorded with highest concentration of extract (45 g L^{-1}) applied to Milk thistle (*Sonchus asper*). It was followed by the same concentration of extract when applied to Snake cucumber (*Cucumis melo* var. *agrestis*) and D_4 (40 g L^{-1}) applied to Milk thistle (*Sonchus asper*) showing root weight of 0.03 g each. It was also observed that all the tested weed species showed their highest root weight in control (distilled water only) treatment which means that application of aqueous extract had inhibitory effects on growth of different weeds. Maximum root weight (0.17 g) was obtained by Signal weed (*Brachiaria reptans*) when grown in distilled water (control). It was followed by Lamb's quarters (*Chenopodium album*) showing 0.16 g root weight and was also grown in distilled water (control). These findings are supported by Saxena *et al*. (1996) who depicted that higher concentration of millet extract reduced the root length and thereby weight due to phytotoxic effects, as well as different root systems in different weed species.

Shoot weight (g)

Data showed significant variations by using different concentration of pearl millet extract and different weed species, however, the two factors were non-significantly interacted with each other (Table-6). Data analysis showed almost similar trend for shoot weight as that of root weight. Application of 40 g L^{-1} extract gave lowest shoot weight (0.29 g) which might be due to high phytotoxic effects of *Pennisetum glaucum* aqueous extract. It was followed by 0.33 g shoot weight recorded in highest concentration (40 g L^{-1}) of extract, while both the treatments were statistically akin. Maximum shoot weight (0.60 g) was noted in control (distilled water only) followed by 25 g L^{-1} application of extract showing 0.52 g shoot weight. As regards different weed species, the lowest weight of shoots (0.33 g) was produced by Milk thistle (*Sonchus asper*). This might be due to shortest shoot length which resulted in lower weight. It was followed by statistically similar shoot weight (0.36 g) produced by Snake cucumber (*Cucumis melo* var. *agrestis*). Signal grass (*Brachiaria reptans*) had maximum shoot weight (0.51 g), which was statistically similar with Lamb's quarters (*Chenopodium murale*) and Field bindweed (*Convolvulus arvensis*) showing 0.50 & 0.48 g shoot weight, respectively. The study further revealed that multiple concentrations of aqueous extract non-significantly interacted with different weed species. However, application of 45 g L^{-1} extract to Milk thistle (*Sonchus asper*) showed lowest shoot weight (0.21 g), while Signal grass (*Brachiaria reptans*) had maximum shoot weight (0.61 g) when grown under control (distilled water) treatment. This might be due to allelochemicals present in aqueous extract, which affected water absorption of plants by reducing imbibition in seeds and seedling. Inhibition in root and shoot weight by higher concentration of pearl millet aqueous extract was also reported by Saxena *et al*. (1996).

Fresh weight (g plant^{-1})

Data analysis revealed that plant weight had significant response to different concentrations of *Pennisetum glaucum* aqueous extract and different weed species, while interactions were not significant (Table-7). It is pertinent from the data that application of 25 g L^{-1} extract showed some stimulatory effects on the fresh plant weight of different weeds. Moreover, the use of 30 g L^{-1} extract also showed similar effects as compared to control (distilled water). The lowest plant weight (0.78 g) was observed in D_4 (40 g L^{-1}) which was followed by statistically similar weight (0.79 g plant^{-1}) recorded in D_5 (45 g L^{-1}). Maximum plant weight (1.12 g) was

achieved in D_1 (25 g L^{-1}) which was followed by D_2 (30 g L^{-1}) showing 0.97 g fresh plant weight. The data indicated that lower concentrations of Pearl millet extract had stimulatory effects due to increase permeability and absorption of cell, which might cause growth promotion in weight of plants. As regards different weed species, maximum plant weight (1.20 & 1.12 g) was recorded by Signal grass (*Brachiaria reptans*) and Lamb's quarters (*Chenopodium album*), respectively. This might be due to higher root/shoot weight of these weed species. The lowest plant fresh weight (0.68 g) was given by Milk thistle (*Sonchus asper*) which might be due high phytotoxic effects of extract, hence, the growth was stunted and the plant could not gain weight. The two factors were non-significantly interacted with each other. However, lowest plant weight of all the tested weed species was recorded by the application of highest concentration (45 g L^{-1}) of aqueous extract except lambquarters (*Chenopodium album*) and Field bindweed (*Convolvulus arvensis*). Shinwari *et al*. (2017) described the phyto-diversity for allelopathic activity and some crops having allelochemicals suppressed the plant weight of neighboring weeds.

CONCLUSION

This study concluded that aqueous extract of Pearl millet has strong allelopathic effect on weeds germination and other related traits. Application of 45 g L^{-1} extract to different weed species strongly inhibited their growth and showed lowest levels of root and shoot length, root and shoot weight and plant fresh weight. Hence, Pearl millet aqueous extract may be used in higher concentrations as a biological agent for controlling different weeds for reduced weed-crop competition and enhanced productivity.

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Table-1. Details of experimental treatments

Factor-A (concentration of aqueous extract of pearl millet)		**Factor-B (weed species)**		
		Common Name		**Local Name**
D_0	Control (distilled water)	W_1	Signal grass (*Brachiaria reptans*)	Bandri
D_1	25 g L^{-1}	W_2	Lamb's quarter (*Chenopodium album*)	Bathu
D_2	30 g L^{-1}	W_3	Field bindweed (*Convolvulus arvensis*)	Lehli
D_3	35 g L^{-1}	W_4	Broadleaf dock (*Rumex dentatus*)	Jangli Palak
D_4	40 g L^{-1}	W_5	Jungle rice (*Echinochloa colona*)	Swanki
D_5	45 g L^{-1}	W_6	Slender amaranth (*Amaranthus viridis*)	Jangli Cholai
		W_7	Snake cucumber (*Cucumis melo*)	Chibber
		W_8	Milk thistle (*Sonchus asper*)	Dodhak

Table-2. Effect of pearl millet aqueous extract on germination (%) of different weed species

Weed Species	**Concentrations of Pearl millet Aqueous Extract**						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	70.2 b-f	52.3 k	62.1 e-i	45.0 kl	40.0 lm	30.3 nop	49.97 b
Chenopodium album	65.0 d-h	63.2 e-i	60.2 g-j	58.0 hij	32.3 mn	20.5 qr	49.87 b
Convolvulus arvensis	67.0 c-g	64.4 d-h	60.3 g-j	62.0 f-i	30.5 no	30.2 nop	52.40 b
Rumex dentatus	75.2 abc	75.0 abc	70.2 b-f	60.0 g-j	58.4 hij	22.6 pq	52.40 b
Echinochloa colona	80.5 a	74.2 abc	70.3 b-f	72.0 bcd	62.3 e-i	8.5 st	61.30 a
Amaranthus viridis	72.2 a-d	70.3 b-f	70.4 b-e	42.0 l	30.2 nop	16.2 qrs	50.20 b
Cucumis melo	76.3 ab	72.2 a-d	60.5 g-j	40.1 lm	15.6 qrs	7.5 t	45.37 c
Sonchus asper	72.4 a-d	40.2 lm	55.6 ij	32.5 mn	22.8 opq	12.6 rst	39.28 d
Mean	72.35 a	63.98 ab	63.70 ab	51.45 b	36.51 c	18.55 d	-

$LSD_{0.05}$ for Concentrations = 13.05 Weed species = 3.32 Interaction = 8.41

Table-3. Effect of pearl millet aqueous extract on root length (cm) of different weed species.

Weed Species	Concentrations of Pearl millet Aqueous Extract						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	6.20ab	6.83a	6.00 abc	4.67 def	3.53 g-j	2.73j-o	4.99 a
Chenopodium album	5.90 abs	6.00 abc	5.00 cde	4.00 e-h	3.17 h-m	2.66 j-o	4.46 b
Convolvulus arvensis	5.40 bcd	5.00 cde	4.00 e-h	3.00 h-n	2.30 l-p	1.93n-s	3.61 c
Rumex dentatus	3.90 f-i	4.33 d-e	3.00 h-n	2.33 k-p	1.93 n-s	1.86o-s	2.89 d
Echinochloa colona	3.20 h-m	4.00 e-h	3.00 h-n	2.00 n-r	1.30 p-s	0.93 rs	2.41 e
Amaranthus viridis	3.60 f-j	3.50 g-j	2.67 j-o	1.80 o-s	1.37 p-s	1.13 qrs	2.35 f
Cucumis melo	3.40 g-k	3.33 g-l	2.67 j-o	1.77 o-s	1.33 p-s	1.13 qrs	2.27 g
Sonchus asper	3.00 h-n	2.83 i-o	2.13 m-q	1.37 p-s	1.10 qrs	0.89 s	1.89 f
Mean	4.33 a	4.48 a	3.56 b	2.62 c	2.01 d	1.66 d	-

$LSD_{0.05}$ for Concentrations = 0.58 Weed species = 0.25 Interaction = 1.08

Table-4. Effect of pearl millet aqueous extract on shoot length (cm) of different weed species.

Weed Species	Concentrations of Pearl millet Aqueous Extract						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	11.92 a	11.67 ab	10.67 bcd	9.67 def	9.23 e-h	8.77 f-j	10.32 a
Chenopodium album	11.00 abc	10.17 cde	9.50 efg	9.00 f-i	8.57 g-j	8.27 h-l	9.42 b
Convolvulus arvensis	9.50 efg	9.00 f-i	8.33 h-k	8.00 i-m	7.90 j-m	7.77 j-m	8.42 c
Rumex dentatus	9.00 f-i	8.00 i-m	7.33 k-n	6.67 n-q	6.23 o-r	5.77 qrs	7.16 d
Echinochloa colona	8.27 h-l	7.93 j-m	7.10 m-p	6.10 pqr	5.43 rst	4.80 s-v	6.60 e
Amaranthus viridis	8.00 i-m	7.27 lmn	6.60 n-q	5.33 r-u	4.53 t-w	3.70 wxy	5.90 f
Cucumis melo	7.50 k-n	7.10 m-p	6.17 pqr	5.00 s-v	4.10 v-y	3.50 xy	5.56 g
Sonchus asper	7.20 mno	6.20 o-r	5.37 r-u	4.40 u-x	3.77 wxy	3.27 y	5.02 h
Mean	9.04 a	8.42 a	7.63 b	6.77 c	6.22 cd	5.73 d	

$LSD_{0.05}$ for Concentrations = 0.67 Weed species = 0.23 Interaction = 1.02

Table-5. Effect of pearl millet aqueous extract on root weight (g) of different weed species.

Weed Species	Concentrations of Pearl millet Aqueous Extract						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	0.17 a	0.13 d	0.12 e	0.11 f	0.10 g	0.09 h	0.11 a
Chenopodium album	0.16 b	0.12 e	0.11 f	0.09 h	0.08 i	0.07 j	0.10 b
Convolvulus arvensis	0.15 c	0.12 e	0.10 g	0.09 h	0.08 i	0.07 j	0.09 c
Rumex dentatus	0.15 c	0.11 f	0.09 h	0.08 i	0.07 j	0.06 k	0.08 d
Echinochloa colona	0.12 e	0.10 g	0.08 i	0.07 j	0.06 k	0.05 l	0.07 e
Amaranthus viridis	0.10 g	0.09 h	0.07 j	0.06 k	0.05 l	0.04 m	0.06 f
Cucumis melo	0.11 f	0.08 i	0.07 j	0.05 l	0.04 m	0.03 n	0.06 f
Sonchus asper	0.09 h	0.07 j	0.06 k	0.05 l	0.03 n	0.02 o	0.05 g
Mean	0.13 a	0.10 b	0.09 c	0.08 d	0.06 e	0.06 e	-

$LSD_{0.05}$ for Concentrations = 0.006 Weed species = 0.003 Interaction = 0.007

Table-6. Effect of pearl millet aqueous extract on shoot weight (g) of different weed species.

Weed Species	Concentrations of Pearl millet Aqueous Extract						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	0.75 ^{NS}	0.62	0.53	0.45	0.41	0.37	0.51 a
Chenopodium album	0.65	0.61	0.53	0.47	0.39	0.35	0.50 ab
Convolvulus arvensis	0.64	0.59	0.51	0.45	0.37	0.33	0.48 b
Rumex dentatus	0.60	0.55	0.48	0.41	0.34	0.30	0.45 c
Echinochloa colona	0.60	0.51	0.43	0.37	0.31	0.28	0.42 d
Amaranthus viridis	0.58	0.47	0.40	0.35	0.29	0.25	0.39 e
Cucumis melo	0.51	0.44	0.38	0.33	0.27	0.24	0.36 f
Sonchus asper	0.52	0.40	0.34	0.28	0.25	0.21	0.33 g
Mean	0.60 a	0.52 b	0.45 c	0.39 d	0.33 e	0.29 e	

$LSD_{0.05}$ for Concentration = 0.04 Weed species = 0.02 Interaction = non-significant

Table-7. Effect of pearl millet aqueous extract on fresh weight (g plant^{-1}) of different weed species.

Weed Species	Concentrations of Pearl millet Aqueous Extract						
	D_0 control	**D_1 25 g L^{-1}**	**D_2 30 g L^{-1}**	**D_3 35 g L^{-1}**	**D_4 40 g L^{-1}**	**D_5 45 g L^{-1}**	**Mean**
Brachiaria reptans	1.2 ^{NS}	1.40	1.23	1.16	1.11	1.08	1.20 a
Chenopodium album	1.00	1.25	1.09	1.02	0.96	1.26	1.12 b
Convolvulus arvensis	0.92	1.17	1.01	0.93	0.87	0.84	0.96 c
Rumex dentatus	0.85	1.13	1.00	0.91	0.84	0.81	0.92 cd
Echinochloa colona	0.80	1.09	0.96	0.84	0.75	0.71	0.86 d
Amaranthus viridis	0.72	1.03	0.89	0.73	0.62	0.57	0.76 e
Cucumis melo	0.73	0.97	0.84	0.70	0.62	0.56	0.74 ef
Sonchus asper	0.70	0.93	0.77	0.60	0.52	0.56	0.68 f
Mean	0.87 bc	1.12 a	0.97 b	0.86 bc	0.78 c	0.79 c	-

$LSD_{0.05}$ for Concentrations = 0.15 Weed species = 0.07 Interaction = Non-significant