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RESPONSE OF WHEAT AND ITS WEEDS TO DIFFERENT ALLEOPATHIC PLANT WATER EXTRACTS

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ABSTRACT

Laboratory based studies were undertaken during November, 2005 in the Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan to assess the allelopathic effect of different aqueous extracts of plants viz. Sorghum (Sorghum bicolor), Sunflower (Helianthus annuus), johnson grass (Sorghum halepense), viz. (Azadirachta indica), eucalyptus (Eucalyptus camaldulensis) and acacia (Acacia nilotica) on wheat and its weeds. Fresh plant parts of these species were dried in shade, chopped, soaked in tap water in ratio 2:10 (w/v) and filtered. Twenty seeds each of Avena fatua, Convolvulus arvensis, Rumex dentatus, Phalaris minor and Triticum aestivum were placed in Petri dishes and laid out in completely randomized design with four replications. Ten ml of each extract was added to each Petri dish. A check, tap water (10 ml) was also included for comparison. Analysis of data taken twenty days after seeding revealed that germination percentage, shoot length, root length and biomass plant $^{-1}$ *were significantly (P<0.001) inhibited by plant extracts as compared to control with the exception that root length showed stimulatory response to Eucalyptus extract. Sunflower extract was the most inhibiting to germination, shoot and root lengths of wheat and to all species of weeds while application of johnson grass extract resulted in significantly minimum biomass plant*$^{-1}$*. Wheat was comparatively more tolerant to the extracts tested.*

Key words: Allelopathy, allelochemicals, aqueous extracts, *Acacia nilotica*, *Halianthus annuus.*

INTRODUCTION

Wheat is the basic component of human diet especially in Indo–Pakistan. It plays an important role in the national economy. A decrease in wheat production severely affects the economy of Pakistan and adds into the miseries of the inhabitants. Average yield of wheat in Pakistan has never crossed 30 – 35 % of its optimum yield potential produced in experimental conditions (Sarwar and Nawaz, 1985).

Among many factors, which adversely influence the crop yield, weed infestation is the devastating one. Weeds affect the crop growth due to competition, allelopathy and by providing habitat for other harmful organisms (allelomediation) [Khan *et al*. 2002].

The annual losses in wheat crop due to weeds on Pakistan and NWFP in monetary terms amount to Rs. 28 and 2 billions respectively (Hassan and Marwat, 2001).

Chemical weed control has been proved to be relatively efficient in controlling weeds (Majid *et al*., 1983; Salarzai*et al*. 1999) and hence currently about two-third, by volume, of the pesticides used worldwide in agricultural production are herbicides (Duke and Lydon, 1993). This indiscriminate use of herbicides for weed control during the short span of fifty years has resulted in serious ecological and environmental problems as resistance, shifts in weed populations that are more closely related to the crops that they infest, minor weeds became dominant, greater environmental pollution and health hazard. Therefore, there is a need for environmentally safe herbicides that are equally or more effective and selective than currently available synthetic herbicides. There is a strong feeling that allelopathic research can be applied to so many current weed problems (Putnam *et al*., 1983; Norwal, 1999).

Allelopathy is derived form the Greek words “allelo” and “pathy” meaning reciprocal sufferings of two organisms. Latter it was defined as any direct or indirect harmful or beneficial effect by one plant on another through production of chemical compounds (allelochemicals) that escape into the environment (Rice, 1984) from plant parts by leaching from above ground parts, stem flow, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems (Ferguson and Rathinasabapathi, 2003). Scientists have consensus that secondary metabolites may function as allelochemicals. Some examples include terpenoids, phenolics, alkaloids, fatty acids, steroids and polyacetylenes (Kohli, 1998). These natural plant products may provide clues to new and safe herbicide chemistry or growth hormone development. Allelopathy occurs in every ecosystem i.e. in forests, grasslands and deserts. Trees often distribute allelochemicals. There are phenomena where wild grasses do not grow beneath trees (Pawar and Chawan, 1999). Inhibition of germination and retardation of seedlings growth are the most common characteristics in the natural world. Putnam (1984) reported that eucalyptus species released volatile compounds such as benzoic, cinnamic and phenolic acids, which inhibited growth of crops and weeds growing near it. Thakur and Bhardwaj (1992) reported that leachates from *E. globulus* leaves significantly reduced maize germination but were ineffective on wheat germination. Qasem (1993) assessed allolopathic effects of 54 weed species on wheat under laboratory and glass house conditions. Weeds substantially varied in their effects. *Ranunculus asiaticus* completely prevented wheat seed germination. Roots on general appeared more sensitive to allelopathic effects than shoots. Duhan and Lakshminarayana, (1995) reported that *A. nilotica* tree bark, extracts inhibited seed germination and seedling growth of *C. tetragonoloba* and *P. glaucum*. Schumann *et al.* (1995) reported that water extracts of *E. grandis* significantly reduced weed establishment. Cheema *et al.* (1997) reported reduction in weed biomass by 33 – 53 % and increase in wheat yield (7 – 14 %) by application of sorghum (*Sorghum bicolor*) and sunflower (*Helianthus annuus*) water extracts. Anjum and Bajwa (2005) reported that sunflower allelochemicals have potential as possible alternatives for achieving sustainable weed management.

Keeping in view, the recognized importance of allelochemicals in biological control of weeds, an experiment was conducted under laboratory conditions with the objectives to screen different plant water extracts for their allelopathic status and to assess their effect on seed germination and seedling growth of wheat and its weeds.

MATERIALS AND METHODS

Laboratory based studies were undertaken during November, 2005 in the Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan to assess the allelopathic effect of different aqueous extracts of plants viz. sorghum (*Sorghum bicolor*), Sunflower (*Helianthus annuus)*, jonhnson grass (*Sorghum helepense*), Neem (*Azadirachta indica)*, Eucalyptus (*Eucalyptus camaldulensis)* and acacia (*Acacia nilotica)* on wheat and its weeds. Fresh plant parts of these species were dried in shade, chopped, soaked in tap water in ratio 2:10 (w/v) and filtered. Twenty seeds each of*Avena fatua*, *Convolvulus arvensis, Rumex dentatus, Phalaris minor* and *Triticum aestivum* were placed in petri dishes and laid out in completely randomized design with four replications. To avoid fungal attack, seeds were treated with fungicide Topsin-M 70 % @ 2 g kg^{-1}. Ten mL of each extract was added to each petri dish. A check, tap water (10 mL) was also included for comparison. After 20 days, data were recorded on seed germination, coleoptile length (mm), root length (mm) and biomass $plant^{-1}$ (mg). The entire data were individually subjected to analysis of variance technique and the means were compared by LSD test using MSTAT software (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Germination percentage

Analysis of the data revealed that different plant water extracts significantly ($p \leq 0.01$) affected germination percentage of wheat and its weeds (Table-1). Maximum (71.50%) seed germination was observed in control (tap water) which was statistically at par with germination percentages recorded for Acacia (68.50), Eucalyptus (68.25) and Neem (68.25) tree extracts. Statistically similar and minimum germination percentages were recorded for Johnson grass (59.50), sunflower (59.50) and sorghum (60.50) extracts. Among species, wheat was the most tolerant to all extracts by exhibiting maximum germination of 91.79 % while *Rumex dentatus* exhibited least germination percentage of 16.25 indicating its higher sensitivity to extracts particularly that of Acacia which completely inhibited its germination. Allelopathic effect of various plant water extracts appeared to be different depending on plant species. Such differences might be related to specific allelopathic compounds being produced in each species (Chon et al. 2003).

The interaction of extract and species revealed that germination of *Phalaris minor* was stimulated by Eucalyptus extract and hence was maximum (98.75 %) which might be due to lower concentration (2:10 w/v) of the extract. Identical results were reported by Anjum and Bajwa (2005) and Nasim *et al*. (2005).

Lovett (1989) also reported that biological activities of receiver plants to allelochemicals are known to be concentration dependent with a response threshold. Responses are, characteristically, stimulation at low concentrations of allelochemicals, and inhibition as the concentration increases.

Shoot length

Statistical analysis of the data showed that different plant water extracts significantly ($p<0.01$) affected shoot length of wheat and its weeds (Table-2). Maximum (94.20 mm) shoot length was recorded for seeds receiving tap water while minimum (71.25 mm) shoot length was observed for sunflower extract. Among species, shoot length was maximum (149.80 mm) for *Avena fatua* followed by wheat (138.10 mm). Minimum (10.89 mm) shoot length was exhibited by *Rumex dentatus* particularly that receiving Eucalyptus extract. Among interaction means, *Avena fatua* receiving tap water produced maximum (177.50 mm) shoot length. This gross morphological effect in shoot length due to different plant water extracts may be the secondary manifestation of primary events, caused by variety of more specific effects acting at the cellular or molecular level in the receiver plants. Moreover, the inhibitory compounds might have reduced the uptake of nutrients which ultimately reduced shoot length (Alsaadawi, 1992). These findings are corroborated by the work of Duhan and Lakshminarayana (1995) who reported that *A. nilotica* tree bark extracts inhibited seed germination and seedling growth of *C. tetragonoloba* and *P. glaucum*. Schumann *et al.* (1995) also reported that water extracts of *E. grandis* significantly reduced weed establishment.

Table-1. Effect of Different Plant Water Extracts on Germination percentage of Wheat and its Weeds.

Extracts	*Avena fatua*	*Convolvulus arvensis*	*Rumex dentatus*	*Phalaris minor*	Wheat	Extract Means

Sorghum	47.50 lm	87.50 def	10.00 p	70.00 l	87.50 def	60.50 b
Sunflower	55.00 jk	60.00 j	15.00 p	85.00 efg	82.50 fg	59.50 b
Johnson grass	75.00 hi	42.50 m	13.75 p	75.00 hi	91.25 cd	59.50 b
Neem	55.00 jk	87.50 def	15.00 p	90.00 cde	93.75 abc	68.25 a
Eucalyptus	45.00 lm	70.00 i	35.00 n	98.75 a	92.50 bcd	68.25 a
Acacia	70.00 i	80.00 gh	00.00 q	95.00 abc	97.50 ab	68.50 a
Control	50.00 kl	90.00 cde	25.00 o	95.00 abc	97.50 ab	71.50 a
Weeds Means	56.79 c	73.93 b	16.25 d	86.96 a	91.79 a	

Means followed by different letters within the same category differ significantly at 5 % level of probability using LSD test.

Table-2. Effect of Different Plant Water Extracts on Shoot Length (mm) of Wheat and its Weeds.

Extracts	***Avena fatua***	***Convolvulus arvensis***	***Rumex dentatus***	***Phalaris minor***	**Wheat**	**Extract Means**
Sorghum	119.75 h	41.75 r	15.50 t	64.50 m	167.00 b	81.70 de
Sunflower	132.75 g	36.50 s	11.50 uv	59.50 n	116.00 i	71.25 f
Johnson grass	168.00 b	51.25 p	12.50 u	68.50 l	98.50 j	79.75 e
Neem	147.00 e	47.25 q	15.25 t	72.00 k	140.50 f	84.40 c
Eucalyptus	162.25 c	57.50 n	9.750 v	72.25 k	132.75 g	86.90 b
Acacia	141.50 f	58.25 n	00.00 w	65.50 m	150.75 d	83.20 cd
Control	177.50 a	54.50 o	11.75 uv	66.25 lm	161.00 c	94.20 a
Weeds Means	149.82 a	49.57 d	10.89 e	66.93 c	138.07 b	

Means followed by different letters with in the same category differ significantly at 5 % level of probability using LSD test.

Root length

The data in Table-3 showed that different plant water extracts significantly ($p \leq 0.01$) affected root length of all the test species (Table-3). Highest (112.80 mm) root length was observed for seeds receiving Eucalyptus extract while lowest (21.35 mm) for those receiving sunflower extract. Among species, wheat was more tolerant to extracts by producing maximum root length of 127.50 mm. Root length of *Rumex dentatus* was minimum (13.93 mm). Interaction of Eucalyptus extract and wheat exhibited a stimulated response and produced maximum root length of 392.80 mm. The roots of plants exposed to allelochemicals became brownish, stunted and void of root hairs. This might be due to rapid inhibiting effect on respiration of root tips, which ultimately reduced elongation. Identical results were reported by Qasim (1993). Concentration of Eucalyptus extract might be lower enough for wheat to exhibit a stimulated response. Identical results were reported by Anjum and Bajwa (2005) and Nasim *et al*. (2005). The studies of Khan et al. (2004; 2005) also reveal differential response of wheat and its weeds to different tree extracts.

Biomass plant $^{-1}$

The analysis of data revealed that biomass plant $^{-1}$ of wheat and all species of weeds was also significantly ($p \leq 0.01$) affected by different plant water extracts (Table-4). Maximum (116.80 mg) biomass plant $^{-1}$ was produced by seeds receiving tap water while minimum (88.80 mg) biomass plant $^{-1}$ was documented for Johnson grass extract. Among species, *Avena fatua* produced maximum (200.50 mg) biomass plant $^{-1}$ followed by wheat with the value of 190.60 mg. Minimum (4.71 mg) biomass plant $^{-1}$ was produced by *Rumex dentatus*. Interaction effect of tap water and wheat resulted in highest (259.80 mg) biomass plant^{-1}. Reduced biomass plant $^{-1}$ of all species when exposed to different plant water extracts might be the result of reduced dry matter accumulation (An *et al.* 1996) and amylase activity in seedlings (Rizvi and Rizvi, 1992).

These findings reveal that most of the growth parameters of all the test species were inhibited when exposed to different plant water extracts. The inhibition is more severe by sunflower extract. Among the test species, wheat was comparatively more tolerant to the allelopathic extracts. It is concluded that all the plant water extracts used in this study exhibit the potential as natural herbicides and hence can be used for weed management in wheat. Further studies are proposed on tank mixing of different plant water extracts for assessment of their synergistic effect on wheat and its weed control.

Table-3. Effect of Different Plant Water Extracts on Root Length (mm) of Wheat and its Weeds.

Extracts	*Avena fatua*	*Convolvulus arvensis*	*Rumex dentatus*	*Phalaris minor*	Wheat	Extract Means
Sorghum	60.75 g	29.50 mn	9.500 qrs	7.500 rs	49.50 hij	31.35 e
Sunflower	57.50 gh	20.75 nop	5.000 rs	5.500 rs	18.00 opq	21.35 f
Johnson grass	82.00 f	36.50 klm	10.50 pqr	24.50 no	45.75 ijk	39.85 e
Neem	106.50 d	42.50 jkl	20.50 nop	18.25 opq	96.50 e	56.85 d
Eucalyptus	74.50 f	49.00 hij	12.50 pqr	35.00 lm	392.80 a	112.75 a
Acacia	104.50 de	62.25 g	00.00 s	37.50 klm	132.75 c	67.40 c
Control	166.00 b	64.50 g	39.50 jklm	54.75 ghi	157.25 b	96.40 b
Weeds Means	93.11 b	43.57 c	13.93 e	26.14 d	127.50 a	

Means followed by different letters within the same category differ significantly at 5 % level of probability using LSD test.

Table-4. Effect of Different Plant Water Extracts on Biomass Plant $^{-1}$ (mg) of Wheat and its Weeds.

Extracts	*Avena fatua*	*Convolvulus arvensis*	*Rumex dentatus*	*Phalaris minor*	Wheat	Extract Means
Sorghum	133.50 j	99.75 n	5.000 tu	9.000 qrs	220.25 c	93.50 c
Sunflower	213.25 d	181.25 g	5.000 tu	10.00 qr	149.50 i	111.80 b
Johnson grass	213.30 d	90.250 o	8.000 rst	10.00 qr	122.50 l	88.80 d
Neem	183.50 g	91.25 o	5.750 stu	10.25 qr	170.75 h	92.30 c
Eucalyptus	228.75 b	107.00 m	4.000 u	10.00 q	221.50 c	114.25 ab
Acacia	231.25 b	130.00 k	0.000 v	20.75 p	190.00 f	114.40 ab
Control	200.00 e	109.50 m	5.250 tu	9.500 qr	259.75 a	116.80 a

Weeds Means	200.50 a	115.57 c	4.714 e	11.36 d	190.61 b

Means followed by different letters with in the same category differ significantly at 5% level of probability using LSD test.

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