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ALLELOPATHIC EFFECTS OF WEEDS ON WHEAT (*TRITICUM AESTIVUM* L.) GERMINATION AND GROWTH

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Abstract

Three weed species viz., *Asphodelus tenuifolius* Cav., *Euphorbia hirta* L., and *Fumaria indica* (Haussk.) Pugsley were used in the form of powder with different ratios/quantity as treatments of 10, 25, 50 and 100g and mixed with uniform amount of soil (500g). Wheat seeds were grown and it was observed that 10 and 25g powder/500g soil of *Asphodelus tenuifolius* considerably increased the germination and rate of germination of wheat, while the powder of other two species reduced this phenomenon in the test species at the concentration of 25, 50 and 100g/500g soil. All the weeds powder treatments showed remarkable varied effects on the plant height and their weights (fresh, dry shoot and root weight) of the test plant. The powder of *Fumaria indica* and *Asphodelus tenuifolius* significantly reduced, while the *Euphorbia hirta* showed non-significant effects on the wheat plant height. Soil containing *Euphorbia hirta* powder showed the significant reduction in the fresh and dry shoot weight of wheat plant.

Introduction

Pakistan is an agricultural country with its economy being greatly dependent upon agriculture. Wheat is the major cereal grain crop of the world including Pakistan. In Pakistan, greater part of the population is living in the rural areas and their chief source of income depends generally on agriculture and agricultural products. The uses of pure seed, suitable l and preparation, balanced fertilizers and suitable irrigation along with weed control, play important role for higher wheat yield. The notion of weeds as unwanted plants was born when man started to grow intentionally plants for food. Agricultural researches have found that weeds cause 17-25% losses in wheat annually due to their competitive and allelopathic nature (Shah, 2006; Shad, 1987). According to the International Allelopathy Society, any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influence the growth and development of any biological system is termed as allelopathy (Anon, 1996). In Allelopathy, competitions of the plants have negative effects when two or more organisms attempt to directly use the same resources. A large number of allelechemicals, which are released by plants are stimulatory or have inhibitory effects with the interactions of weeds and crops (Burhan & Shaukat, 2000; Rebaz *et al.*, 2001; Shaukat *et al*., 2002). Therefore, a better weed management is required, where allelopathy can play an effective role in the crop field system. Muzik (1970) has reported that crop losses due to weeds are greater than insects, pests and plant diseases. It was estimated that in wheat yields losses ranged from 20 to 40% due to interaction with weeds (Ahmed & Shaikh, 2003). There are about 30 different weed species generally found in fields of wheat in Sindh and of which 12 to sixteen weed species are widely distributed causing losses up to economic threshold level (Ahmed & Shaikh, 2003).

In spite of modern weed control technology, weeds continue to cause annual losses of about 10% in agricultural production in the world. The annual economic loss caused by weeds in agricultural production is estimated at more than 18.2 billion dollars, with about 12 billion dollar of this amount attributed to the production losses caused by weeds. Another 3-6 billion dollar is spent on cultural ecological and biological weed control methods (Alam, 1991). The growers are paying very little attention to the weed control or using the eradication practice, hence suffering 15 to 25 percent wheat grain loss (Tunio, 2001). Bearing these considerations in mind, the present investigation was conducted to explore any allelopathic potential of three common weeds which were found associated with wheat crop.

Materials and Methods

Dry plant materials of three weeds (*Asphodelus tenuifolius, Euphorbia hirta* and *Fumaria indica*) were collected, washed, dried and then ground in a Wiley Mill and weighed out in the ratios of 10, 25, 50 and 100g each of the three weed species. For each weed species five replicates with five treatments and including controls were used. The powder of each weed with the above quantity was mixed thoroughly with 500g soil (sandy loam) separately and then sufficient quantity of water was added to all the plastic bags and kept for one week in the glass house to develop any possible microbial activity. Sufficient quantity of healthy seeds of wheat were sterilized with 3% sodium hypochlorite solution and then thoroughly washed with the sterile distilled water several times.

Ten healthy seeds of wheat were sown in all the treated (control, 10, 25, 50 and100g) plastic bags. Each treatment was replicated five times. The numbers of seeds germinated were counted daily in each treatment, till the completion of germination period. Speed of germination index "S" was also calculated as described by Khandakar & Bradbeer (1983).

$$S= [N1/1+N2/2+N3/3 \ldots\ldots] \times 100/1$$

where N1, N2, N3 ………Nn=proportion of seeds which germinate on day 1, 2, 3 ……… n following set up of the experiment. S varies from 100 (if all seeds were germinated on the first day following set up) to 0 (if no seeds have germinated by the end of the experiment). This calculation has an advantage over the percent germination, because it is usually more sensitive as an indicator of allelopahtic effects (Wardle *et al*., 1991). To asses the growth of wheat plants carefully, the plants were thinned and only three healthy plants were retained in each bag. After one month of growth the plant height was measured in centimeters from the base of plant up to the tip of the longest shoot. Further details observations have been provided in Jabeen & Ahmed (2009).

Statistical analysis: The data collected for germination percentage of wheat (*Triticum aestivum)* was subjected to analysis of variance (ANOVA) with the repeated measures design. In this design, Wilks'Lambda, Pillar's Trace, Hotelling-Lawlely Trace and Roy's Greatest Root were available. In the vast majority of cases, the observed significance levels for these statistical analyses will be the same. The Repeated Measures Design was performed using Statistical Package for Social Sciences (SPSS) Version 10, (Nie *et al.*, 2009). The other data sets of growth, fresh and dry weights were subjected to one way ANOVA. As a post- hoc test, Duncan's multiple range procedure was employed (Duncan, 1955).

Results and Discussion

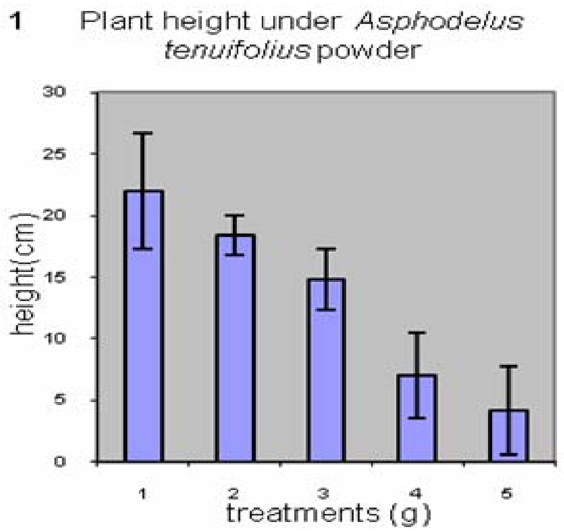
***Asphodelus tenuifolius*:** Table 1 showed that in 10g and 25g weed powder, percentage germination was markedly increased as compared to controls. This showed that weed powder with low concentration affected positively and might contained some kind of promoters. Similarly, the speed of germination index "S" was distinctly higher in 25g treatment (54.2) as compared to control (28.9) and also in other three treatments**.** Hussain *et al*., (2007) have also obtained similar results for *Echinocloa colonum,* while soil incorporation of *Senna* caused promotory effect on germination of the weed up to the extent of 15% over the control.

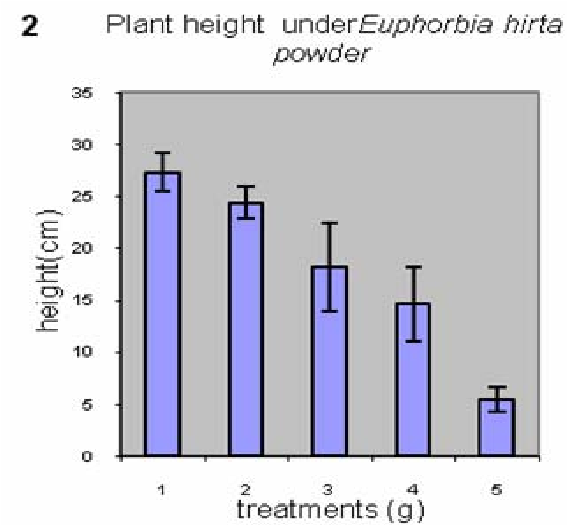
Table 1. Effect of different concentrations of three different weeds on germination, growth, shoots and roots fresh and dry weight of wheat (*Triticum aestivum*).

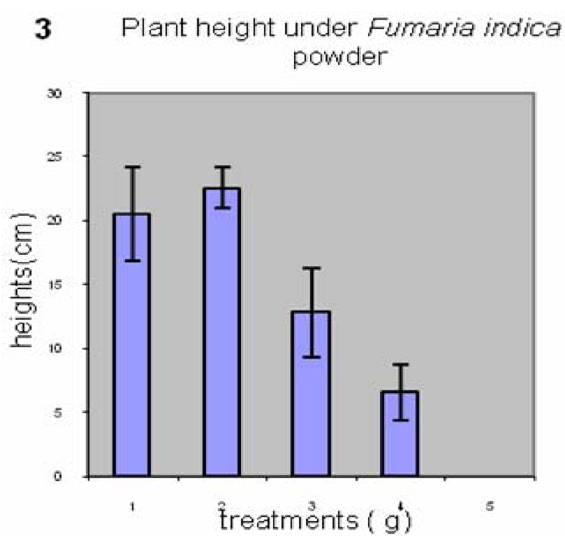
Treatments	(%) germination	Speed of germination	Plant height (g)	Fresh shoot weight (cm)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
	a. ***Asphodelus tenuifolius***						
Control	58	28.9	22 ± 4.67a	1.32 ± 0.47a	0.56 ± 0.18b	0.44 ± 0.26a	0.19 ± 0.10b
10g	80	28.5	18.44 ± 1.59a	0.85 ± 0.17ab	0.31 ± 0.06b	0.35 ± 0.13b	0.13 ± 0.04b
25g	88	54.2	14.84 ± 2.44a	0.51 ± 0.19b	0.16 ± 0.64c	0.21 ± 0.08ab	0.07 ± 0.03ab
50g	34	15	7.01 ± 3.46b	0.17 ± 0.16bc	0.06 ± 0.05bc	0.21 ± 0.20ab	0.05 ± 0.05ab
100g	26	4.6	4.18 ± 3.59b	0.08 ± 0.08bc	0.02 ± 0.02bc	0.04 ± 0.04ab	0.009 ± 0.009ba
	b. ***Euphorbia hirta***						
Control	76	31.4	27.29 ± 1.83a	1.75 ± 0.08a	0.71 ± 0.13b	0.75 ± 0.32a	0.25 ± 0.10b
10g	70	31.1	24.37 ± 1.54a	1.30 ± 0.22c	0.55 ± 0.09b	0.49 ± 0.09ab	0.14 ± 0.04b
25g	46	11.2	18.17 ± 4.19b	0.97 ± 0.34bc	0.32 ± 0.10d	0.54 ± 0.22ab	0.14 ± 0.07ab
50g	54	18.8	14.57 ± 3.65b	0.57 ± 0.20bc	0.22 ± 0.09d	0.31 ± 0.14ab	0.06 ± 0.02ab
100g	20	2.9	5.43 ± 1.13c	0.22 ± 0.06d	0.07 ± 0.02e	0.08 ± 0.02ab	0.03 ± 0.01ab
	c. ***Fumaria indica***						
Control	66	22.4	20.5 ± 3.68a	1.11 ± 0.30a	0.41 ± 0.10b	0.41 ± 0.15a	0.09 ± 0.03b
10g	54	15.6	22.59 ± 1.62a	1.39 ± 0.35a	0.48 ± 0.11b	0.54 ± 0.14a	0.11 ± 0.02b
25g	56	10.7	12.82 ± 3.48b	0.78 ± 0.35ab	0.22 ± 0.10c	0.46 ± 0.22a	0.07 ± 0.03b
50g	32	3.1	6.57 ± 2.12c	0.37 ± 0.15abc	0.09 ± 0.04d	0.18 ± 0.07a	0.03 ± 0.01c
100g	4	0.66	-	-	-	-	-

Legend: Number followed by same letters in the treatments rows is non-significantly different according to Duncan's Multiple Range Test at p<0.05 level
± Standard error, cm = Centimeter, g = Gram
1a = *Asphodelus tenuifolius*, 1b = *Euphorbia hirta*, 1c= *Fumaria indica*

Plant height was adversely affected as the ratio of weed powder increased (Fig. 1). The maximum plant height was recorded in control (22 ±4.67), while a significant reduction of wheat plant height was observed in 100g weed powder treatment (4.18±3.59). ($p<0.001$), Similarly, the reduced plant height of wheat seedling was recorded in the interaction with *Asphodelus tenuifolius* by Jabeen *et al* (2011). Shoot, root fresh and dry weight decreased gradually as the concentration of powder was increased as shown in Figs. 4 and 5. It was generally found that allelochemicals released from plant leachates exhibit stimulation at low concentration and inhibition at high concentration (Lovett *et al*., 1989). Our studied also accorded with this conjecture. Statisticals analysis by General Linear Model (GLM) with Repeated Measures Design showed significant differences among the treatments for plant height during the eight weeks growth period i.e. F=50.189 ($p<0.001$), (Pillai's trace = 0.790, Wilk's lambda= 0.210; $p<0.001$) (Table 2).







Figs. 1-3. Effect of different concentrations of three different weeds powder on plant height of wheat (*Triticum aestivum* L.)
Legend: cms = Centimeter, g = Gram

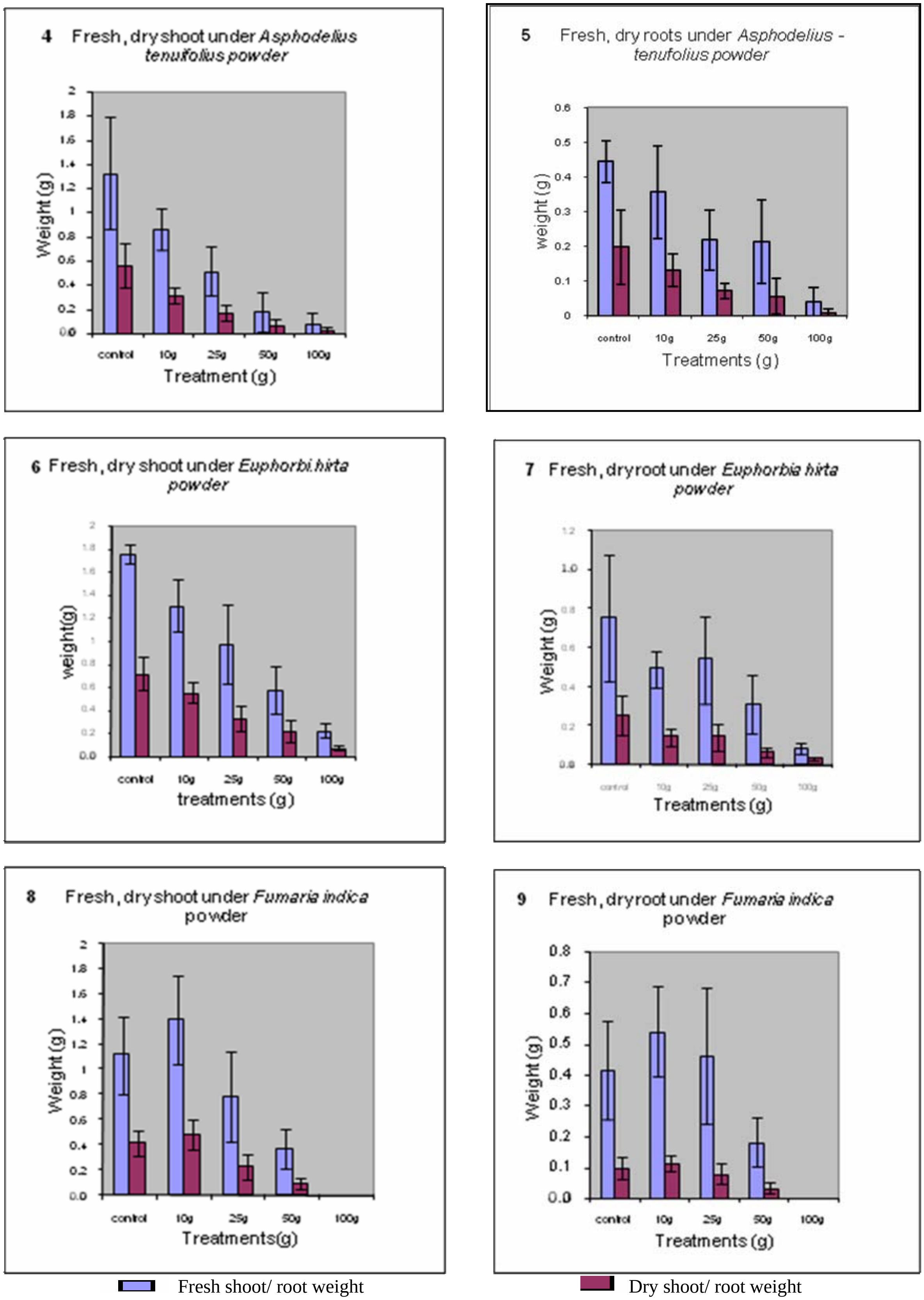
***Euphorbia hirta*:** Percentage of germination (76%) and speed of germination index was highest in control (31.4) as compared to other treatments (Table 1). It showed that the reduction of germination in the treatments may be due to the allelopathic effects on seed germination of wheat plant. Similar results were also found by Hussain (1983) and according to him, the weed species with high percentage of density and frequency might exert competitive and allelopathic stress to reduce growth and yield of associated crops.

Fig. 2 showed the maximum wheat plant height in control (27.29 ±1.83) and as the quantity of weed powder increased the reductions in plant height were also occurred. The pattern of reduction in fresh and dry shoot and root weight of these treatments was shown in Figs. 6, 7. It was clearly indicated that the fresh and dry shoot/ root weight decreased with the increasing concentrations of weed powder. According to Shaukat *et al.,* (2002), the toxicity progressively increased with the increasing amount of weed material which reduced the fresh and dry weight of test species.

Statistical analysis by GLM with repeated measures design also showed significant differences among the treatments for plant height of eight weeks growth i.e. F= 94.626 (Pillai's trace= 0.858, Wilk's lambda= 0.142, p< 0.001) (Table 2).

***Fumaria indica*:** Like previous trial (Table 1), it has indicated the maximum percentage germination and speed of germination index in control (66%, index "S"=22.4).While both values were considerably decreased with increasing weed powder concentrations.

Fig. 3 showed that the maximum plant height (22.59 ±1.62) was recorded in 10g weed powder though, it was not significantly differ from the control. The reductions of plant height (6.57 ±2.12 and 12.82 ±3.45) were observed in 25g and 50g weed powder, respectively. In treatment 4 (soil containing 100g weed powder), the plant growth was drastically reduced as seen in Fig. 3 and Table 1). It may be anticipated that in low quantity/ ratio the decomposing material of this weed powder promoted the growth, due to the presence of organic matter while, at higher quantity its allelopathic chemicals were toxic to wheat growth (Fig. 3 and Table 1). Fresh and dry shoot/root weight of wheat did not show any significant difference with respect to control, expect fresh/ dry weight of shoot and dry weight of root in 50g weed powder. However, in 100g weed powder no wheat plant survived at all. Jabeen & Ahmed (2009) have also reported similar results working on possible allelopathic effects of three different weeds on germination and growth of maize (*Zea mays*) cultivars. According to them, the low amount of weed powder increased the amount of organic matter in soil, resulting in the better growth than the control, while higher amount of allelopathic chemical in the soil generally reduced the growth due to toxic chemicals present in weeds. Wardle *et* al (1993) have also reported that small quantity of weed played an important role to increase crop growth.



Figs. 4-9. Effect of different concentrations of three different weeds powder on shoots, roots fresh and dry weight of wheat (*Triticum aestivum* L.).

Table 2. Generalized Linear Model: Effect of different concentrations of three weeds powder on plant height of wheat (*Triticum aestivum* L.)

	Effect	Value	F	Hypothesis df	Error df	Significant
	Asphodelus tenuifolius					
Height cm	Pillaia' Trace	0.790	50.189	3.000	40.000	<0.001
	Willks'Lambda	0.210	50.189	3.000	40.000	<0.001
	Euphorbia hirta					
Height cm	Pillaia' Trace	0.858	94.626	3.000	47.000	<.001
	Willks'Lambda	0.142	94.626	3.000	47.000	<.001
	Fumaria indica					
Height cm	Pillaia' Trace	0.360	9.371	3.000	50.000	<0.001
	Willks'Lambda	0.640	9.371	3.000	50.000	<0.001

The present study showed that in general, all these weeds species in small quantity showed no significant inhibition with respect to controls and in some cases normally enhanced growth. However, in higher amount its allelopathic effects reduced or completely ceased the plant growth. Therefore, it was suggested that at the time of seed sowing, the amount of these weeds should be controlled properly. In addition, the present investigation has suggested that these three weed species produced allelochemicals which reduced germination as well as the subsequent growth of wheat plant.

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