Research Article

Allelopathic Effect of Weed Species on Germination and Seedling Traits of Wheat Varieties

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Abstract | Wheat productivity and quality is significantly impaired by weeds' infection which compete for water, nutrients and sunlight. This study was conducted to determine the allelopathic effect of weed species on germination and seedling traits of wheat (*Triticum aestivum* L.). Wheat varieties Amber and TJ83 were subjected to powder of *Chenopodium album*, *Convolvulus arvensis* and *Avena fatua* under three different treatments i.e. 25, 50 and 75g. The effect of these weed powders on seed germination (%), shoot length (cm), root length (cm), shoot fresh weight (g), root fresh weight (g), shoot dry weight (g), root dry weight (g), and seed vigor index of test species was investigated under laboratory conditions. The powder of weed plants produced significantly ($p<0.05$) harmful outcomes on all growth parameters of wheat varieties as compared to the control treatment. The maximum seed germination (82.16a %), shoot length (27.70 cm), root length (14.90 cm), shoot fresh weight (2.19 g), root fresh weight (1.16 g), shoot dry weight (0.54 g), root dry weight (0.27 g), and seed vigor index (3483.5) were recorded in variety Amber under the control (where no allelopathic weed powder was applied). The minimum seed germination (28.16%) was observed in variety TJ83 under the treatment of *Avena fatua* powder (@ 75g kg^{-1} of soil). Shoot length and root length of the studied wheat varieties were also affected in inverse proportion to the concentration of allelopathic weed powder. Shortest shoots (14.46 cm) and roots (3.20 cm) were seen in variety TJ83 at the highest concentration of *Avena fatua* powder (75g kg^{-1} soil). The minimum shoot fresh weight (0.13 g), root fresh weight (0.10 g), shoot dry weight (0.04 g), and root dry weight (0.03 g) were also noticed in variety TJ83 under the highest treatment of *Avena fatua* powder (75g kg^{-1} soil). Similarly, minimum seed vigor index (496.9) was also seen in same variety under the maximum treatment of *Avena fatua*. In respect of the above findings it was concluded that the powder from weed species reduced germination and subsequent plant growth of wheat which hints towards importance of apposite measures within due time against weed species to harvest better crop yield.

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1. Introduction

Wheat (*Triticum aestivum* L.) crop is deeply rooted in human culture and civilization and plays a great role in the global economy as well as food security. It is a major grain crop of Pakistan and a staple food for billions of people world over (Shewry, 2009). It is used to make flour for leavened,

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flat and steamed breads and most of the baked foods; and for fermentation to make beer and alcohol. In Pakistan, about 60 % of the daily diet of a common man is covered by wheat while average utilization per person is about 125 kg per year (Mengal et al., 2015). Wheat is among the cheapest sources of food that provides good amount of calories and protein in the normal human eating routine Kumar et al. (2011).

Pakistan Economic Survey reports clarify that wheat share 9.1 % in agriculture sector, and 1.7 % in overall GDP of Pakistan (GOP, 2018). Wheat was cultivated on an area of about 8,734 thousand hectares during the season 2017-18. The total production of the crop was recorded to be 25.492 million tonnes as compared to 26.674 million tonnes in 2016-17, highlighting a decline of 4.4 percent. The main reasons for decline and variation in total production include: Delayed harvesting of kharif crops and consequently late planting of wheat, unavailability of improved inputs e.g. seed, inefficient fertilizer use, weed infestation, shortage of irrigation water, drought, terminal heat stress, and soil degradation (Ibrahim et al., 2013).

Wheat productivity and quality is significantly impaired by weeds' infection which compete for water, nutrients and sunlight. Weeds are responsible to cause 17-25 % losses in wheat annually due to their competitive and allelopathic nature (Jabeen et al., 2013). Allelochemicals are harmful to crop plants resulting in reduced and delayed germination and decline in seedling growth. Re-plantation problems, poor crop stand and direct interference by certain weeds have been attributed in the part of allelochemicals (Abbas et al., 2014). A large number of allelochemicals, which are released by weed plants, have inhibitory effects towards the crops (Jabeen et al., 2013). It is reported that allelochemicals which are liberated by many plants from leaves, stem, roots, fruit and seeds as residues, exudates and leachates interfere with the growth of other plants (Asgharipour and Armin, 2010).

In Sindh province, about thirty different weed species have been identified in wheat, of which 12 to 16 weed species cause losses up to economic threshold level (Jabeen et al., 2013). Wild oat (*Avena fatua*) is very competitive with wheat and it is reported that 10 wild oat plants m^{-2} can damage wheat production by 20 % (Khan et al., 2012). Moreover, field bind (*Convolvulus arvensis*) weed is also said to be as one of the most harmful weeds in the world which causes 20-70 % losses towards crops yields and gives rise to certain issues during harvesting as well (Peterson et al., 2002). Further, *C. arvensis* reduces the wheat germination by 14 % and yield by 80 % (Yarnia, 2010). Likewise, Lambs quarters (*Chenopodium album*) is also one of the most common weeds of temperate areas (Jhade et al., 2009). It can liberate allelochemicals into the soil; in addition to showing inhibitory influences on the development and growth of surrounding plants (Abdul et al., 2012). It has been proposed that these weeds contain secondary metabolites which interfere the growth of neighboring plants (Dhole et al., 2011).

The present study was designed to evaluate the effect of various allelopathic weed powders on wheat germinability and related traits. Various levels of three common weed species was investigated on two wheat varieties. Hence, this study gives an insight into inhibitory effects of weeds at different concentrations and the role genetic architecture of the varieties could play against the same.

2. Materials and Methods

This experiment was performed at Weed Science and Allelopathy Laboratory, Department of Agronomy, Sindh Agriculture University, Tandojam, during the year 2018. Allelopathic effects of three different weed species were investigated on germination and seedling traits of wheat (*Triticum aestivum* L.). Whole mature weed plants of lamb's quarters (*Chenopodium album*), fieldbind weed (*Convolvulus arvensis*) and wild oat (*Avena fatua*) were up rooted randomly from Agriculture Research institute (ARI), Tandojam. The collected weeds were washed, dried and then ground. After grinding, the weeds were weighed in various ratios of 25, 50 and 75g. The powder of each weed treatment was mixed thoroughly with 1000 g soil (sandy loam) and then sufficient quantity of water was added to all the containers. Healthy seeds of both wheat varieties were sterilized with 3% sodium hypochlorite solution and then thoroughly washed with the sterile distilled water several times. Thirty healthy seeds of both wheat varieties were sown under each treatment (control, 25, 50 and 75g) and kept in room temperature. The number of seeds germinated were counted after 7 days of treatment.

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Table 1: Effect of allelopathic weed powders on wheat.

Allelopathic weed powders	Seed germination (%)	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Seed vigor index
	V I: Amber							
W_1 = Control (untreated)	82.16a	27.70 a	14.90 a	2.19 a	1.16 a	0.54 a	0.27 a	3483.5 a
W_2 = *Chenopodium album* powder: 25g kg^{-1} soil	77.80ab	25.43 b	13.73 b	1.97 ab	0.76 c	0.38 c	0.25 ab	3019.2 b
W_3 = *Chenopodium album* powder: 50g kg^{-1} soil	64.23c	22.46 d	8.90 e	1.62 c	0.62 d	0.30 de	0.23 bc	2014.5 e
W_4 = *Chenopodium album* powder: 75g kg^{-1} soil	44.76e	19.10 gh	6.60 gh	0.58 f	0.49 f	0.24 fg	0.11 f	1151.5 h
W_5 = *Convolvulus arvensis* powder: 25g kg^{-1} soil	63.16c	25.16 b	12.10 c	1.60 cd	0.43 g	0.30 e	0.12 f	2352.5 d
W_6 = *Convolvulus arvensis* powder: 50g kg^{-1} soil	55.30d	19.43 g	8.40 ef	1.12 e	0.37 h	0.18 ij	0.10 fg	1538.2 g
W_7 = *Convolvulus arvensis* powder: 75g kg^{-1} soil	44.46e	18.36 h	5.40 j	0.32 fghi	0.26 ij	0.15 jk	0.07 hi	1056.2 h
W_8 = *Avena fatua* powder: 25g kg^{-1} soil	55.66d	20.53 ef	7.10 g	0.53 fg	0.29 i	0.11 lm	0.22 bcd	1536.8 g
W_9 = *Avena fatua* powder: 50g kg^{-1} soil	46.00e	18.36 h	5.26 j	0.39 fghi	0.19 k	0.08 mno	0.07 hij	1214.3 h
W_{10} = *Avena fatua* powder: 75g kg^{-1} soil	37.93g	15.80 i	4.20 k	0.15 hi	0.15 lm	0.07 no	0.04 jk	758.4 ij
	V II: TJ-83							
W_1 = Control (untreated)	75.03b	25.66 b	13.26 b	1.69 bc	1.11 b	0.48 b	0.21 de	2657.0 c
W_2 = *Chenopodium album* powder: 25g kg^{-1} soil	65.46c	24.20 c	12.10 c	1.61 c	0.66 d	0.34 d	0.20 de	2397.7 cd
W_3 = *Chenopodium album* powder: 50g kg^{-1} soil	55.00d	21.23e	8.06 f	1.25 de	0.56 e	0.28 ef	0.19 e	1632.2 fg
W_4 = *Chenopodium album* powder: 75g kg^{-1} soil	43.13ef	16.70 i	5.73 ij	0.48 fgh	0.39 h	0.20 hi	0.10 fg	982.7 hi
W_5 = *Convolvulus arvensis* powder: 25g kg^{-1} soil	56.53d	20.76 e	10.73 d	1.47 cd	0.35 h	0.23 gh	0.10 fg	1829.4 ef
W_6 = *Convolvulus arvensis* powder: 50g kg^{-1} soil	46.83e	16.70 i	7.00 g	1.02 e	0.28 ij	0.16 ijk	0.08 gh	1107.9 h
W_7 = *Convolvulus arvensis* powder: 75g kg^{-1} soil	38.30fg	14.63 j	3.93 k	0.23 ghi	0.18 kl	0.13 kl	0.04 k	1171.1 h
W_8 = *Avena fatua* powder: 25g kg^{-1} soil	45.63e	19.63 fg	6.06 hi	0.43 fghi	0.24 j	0.10 lmn	0.22 cd	1171.1h
W_9 = *Avena fatua* powder: 50g kg^{-1} soil	35.93g	16.56 i	4.26 k	0.29 fghi	0.14 mn	0.07 no	0.05 ijk	747.0ij
W_{10} = *Avena fatua* powder: 75g kg^{-1} soil	28.16h	14.46 j	3.20 l	0.13 i	0.10 n	0.04 o	0.03 k	496.9 j
LSD	4.91	0.93	0.66		0.04	0.03	0.02	284.75
SDE	2.42	0.46	0.32	0.17	0.02	0.01	0.01	140.66

3. Results and Discussion

The study revealed that allelopathic weed powders from all the weed plants under consideration viz. lamb's quarters (*Chenopodium album*), fieldbind weed (*Convolvulus arvensis*) and wild oat (*Avena fatua*) caused harmful and statistically significant effects on all parameters of the wheat growth as compared to the control (Supplementary Material Table 1-2). Seed Germination (%) is one of the most important indications for number of seedlings expected to ultimately grow. The results of seed germination (%)

of wheat varieties, as effected by various allelopathic weed powders, are shown in Table 1. The statistical analysis indicated that the seed germination (%) of wheat varieties were significantly ($p<0.05$) influenced by allelopathic weed powders. The maximum seed germination (82.16a %), was recorded in Amber variety and in the control where no allelopathic weed powder was applied in the soil. Whereas, minimum seed germination (28.16%) was observed in variety TJ83 under the treatment of *Avena fatua* powder at 75g kg^{-1} of soil. These results were in agreement to the report of Jabeen et al. (2013) which showed that allelopathic weed powders decreased the germination of wheat. Nouri et al. (2012) also reported that exposing the seeds of any plant species to allelochemicals cause drastic decline in seed germination.

Shoot length and root length of the studied wheat varieties were also affected in inverse proportion to the concentration of allelopathic weed powder. The maximum shoot length (27.70 cm) and root length (14.90 cm) were recorded in variety Amber in control, while the shortest shoots (14.46cm) and roots (3.20 cm) were observed in variety TJ83 at the highest concentration of *Avena fatua* powder (75g kg^{-1} soil). Jabeen et al. (2011) observed that on interaction with allelopathic *Asphodelus tenuifolius* powder, height of the wheat seedlings was reduced.

The maximum shoot fresh weight (2.19 g), root fresh weight (1.16 g), shoot dry weight (0.54 g), and root dry weight (0.27 g) was observed in variety Amber under the treatment of control, followed by the treatment having 25g kg^{-1} of *Chenopodium album* powder. The minimum shoot fresh weight (0.13 g), root fresh weight (0.10 g), shoot dry weight (0.04 g), and root dry weight (0.03 g) was found in variety TJ83 under the highest treatment of *Avena fatua* powder (75g kg^{-1} soil). According to Shaukat et al. (2002) the fresh and dry weight of plant species reduces with the increasing quantity of weed material they are exposed to. The conclusions of Ullah et al. (2010) and Hadi et al. (2013) are also similar to our results which proposed that the growth and yield of plant species decrease when the inhibitory effect of weed material is enhanced.

Table 1 Two varieties of wheat *viz.* Amber and TJ-83 were subjected to various concentrations of *Chenopodium album, Convolvulus arvensis* and *Avena fatua* powder. All of the wheat traits were seen to be significantly affected by the allelopathic characters of the weeds.

The maximum seed vigor index (3483.5) was observed in variety Amber under the control, whereas minimum seed vigor index (496.9) was noticed in variety TJ83 under the highest treatment of *Avena fatua* powder (75g kg^{-1} soil). Likewise, Tanveer et al. (2010) and Katoch et al. (2012) have reported that residue of allelopathic weeds in soil have inhibitory effects on the emergence percentage, mean emergence, and the time of emergence index of wheat.

The results of this experiment were in agreement to earlier reports which proposed that alligator weeds produce strong allelopathic effects on field crops including wheat, eggplant and grape (Liu et al., 2007; Zhang et al., 2009). A number of studies have shown that residues from several allelopathic weed species release allelochemicals into the soil, thus affecting the performance of associated and next-season crop plants (Shaukat et al., 2003; Singh et al., 2003). The presence of phenolic compounds such as caffeic acid, chlorogenic acid, 4-hydroxy-3-methoxybenzoic acid, ferulic acid, mcoumaric acid, p-coumaric acid, gallic acid, syringic acid, and vanilic acid in the weeds play critical a role in inhibiting the seed germination and growth of the wheat (Inderjit and Weiner, 2001). Channappagoudar et al. (2005) also stated that phenolic compounds are major phytotoxins which cause inhibition in seed germination and early seedling development, as observed in this study.

Conclusions and Recommendations

Powder of all the three weed species caused harmful effects on wheat germination and growth. It was concluded that higher amount i.e. 75g powder of three weed species lamb's quarters (*Chenopodium album*), fieldbind weed (*Convolvulus arvensis*) and wild oat (*Avena fatua*) produced allelochemicals which decreased germination and consequent wheat plant growth significantly. Overall, the variety Amber was seen to be more resistant to such damage by the weed species.

Author's Contribution

Pushpa, Farheen Deeba Soomro, and Muhammad Tahir Khan: Wrote the manuscript.
Nighat Seema Soomro, Shahla Karim Baloch, and

Mehmooda Buriro: Supervised the research work. Aijaz Ahmed Soomro: did statistical analysis of the data.
Qamar Uddin Jogi, and Muhammad Nawaz Kandhro: Critically reviewed the article and provided technical inputs into the research work.

Supplementary material

There is supplementary material associated with this article. Please view it at: http://dx.doi.org/10.17582/journal.jis/2019/5.2.100.105

Conflict of interest

The authors have declared no conflict of interest.

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