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Allelopathy of 68 Iranian Wheat Genotypes Released between 1939 and 2009

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Abstract: Allelopathic potential of wheat plant and genotypic variation among cultivars has been observed in several studies. In order to recognize and screen allelopathic potential of wheat genotypes against *Amaranthus retroflexus*, *Hordeum spontaneum* and *Avena fatua*, a glasshouse experiment was conducted, using 68 wheat genotypes. Root and shoot water extracts of wheat genotypes were prepared from fourth leaf stage wheat plants. Weeds root length was measured after germination in Petri dishes exposed to wheat extracts. The results showed considerable variation in inhibitory potential of wheat genotypes. Shoot extracts had higher allelopthic effects than root extract. The highest inhibitory effects were observed in the cultivars Rasool, Mahdavi, Navid, Karaj1, Adl1, Gaspard, Gascogen, Bam, Arvand, Baiat and Azadi, but high variation in weed responses were observed. In conclusion, some wheat genotypes had more allelopathic potential so they could be built into weed management programs.

Key words: Allelopathy, genetic variation, water extract, weed management

INTRODUCTION

Wheat (*Triticum aestivum*) is the one of most important crops grown in Iran. If no weed control practice employed, weed infestation reduced wheat grain yield by up to 30% (Labbafy *et al*., 2009). Weed management in modern agriculture is mostly based on synthetic herbicides application (Gressel, 1991), which has resulted in a variety of ecological and environmental problems. Many weeds have become resistant to herbicides and therefore it is difficult to be control (Powles *et al*., 1997). Therfore, alternative weed management practices must be used to reducing these side effects of herbicides in agriculture.

Allelopathy includes releasing biologically active compounds into the environment through root exudation, leaching or volatilization from shoots and decaying plants parts (Rice, 1984). These compounds can inhibits growth of neighboring plants included weeds. Allelopathy has been recognized as natural weed control approach (Rice, 1984). Different crops possess allelochemicals, and their allelopathic effects have been observed on other crops and weed species, which could be utilized for suppressing weeds (Putnam and Defrank, 1979; Rice, 1995).

Genetic variations in allelopathic effect have been found in crops such as, lucerne (*Medicago sativa* L.) (Chung and Miller, 1995), Rice (*Oryza sativa* L.) (Olofsdotter *et al*., 1995; Dilday *et al*., 1994), wheat (Wu *et al*., 2000a), oat (*Avena sativa* L.) (Fay and Duke, 1977), barley (*Hordeum vulgare* L.) (Bertholdsson, 2004; Kremer and Benhammouda 2009), rye (*Secale cereale* L.) (Barnes and Putnam 1986), cucumber (*Cu*large*cumis sativus* L.), pea (*Pisum sativum* L.), maize (*Zea mays* L.) and other crops (Rice, 1984; Wu *et al*., 1999). Wheat seedlings, straw and aqueous extracts of residues have allelopathic effects on some agricultural weeds (Shilling *et al*., 1985; Muminovic, 1991; Wu *et al*., 1998, 2000a, b). Spruell (1984) screened 286 wheat accessions for allelopathic potential against *Bromus japonicus* L. (Japanese brome) and *Chenopodium album* L. (lambsquarter) in the USA. Five accessions produced root exudates that significantly were more inhibitor to the root growth than the commercial strain. Studying inhibitory effects of 38 wheat cultivars on *Lolium multiflorum* Lam. (annual ryegrass) using extract screen bioassay indicated that both germination and root growth of *L. multiflorum* were significantly inhibited by the aqueous shoot extract of wheat cultivars and also the degree of inhibition differed significantly between cultivars (Wu *et al*., 1998).

Rizvi *et al*. (2000) showed that there is a genetic variation of +10 to -30% in the allelopathic potential of wheat cultivars. They found no significant relationship between allelopathic potential and wheat growth. Wu *et al*. (2000b) evaluate 453 wheat accessions from 50 countries by equal compartment-agar method (ECAM) and indicated that inhibition on *L. multiflorum* roots varied from 9.7 to 90.9%. They observed that 63 accessions were strongly allelopathic, inhibiting the root growth of *L. multiflorum* by >81%, while 21 accessions were weakly allelopathic, inhibiting *L. multiflorum* by <45%. Among 26 Australi an wheat accessions Motiul *et al*. (2001) found a 55% mean genetic diversity in allelopathic potential. Hashem and Adkins (1998) also found differential seedling allelopathy on the growth of

Table 1: Winter wheat cultivars tested in the present study

Genotype	Year of release	Genotype	Year of release
Sardari	1939	Navid	1990
Chehelnimgazi	1941	Hirmand	1991
Shahpasand	1942	Gaskojen	1991
Tabasi	1951	Rasool	1992
Azar	1956	Gaspard	1994
Omid	1956	Zarin	1995
Shoale	1957	Darab2	1995
Khalij	1960	Tajan	1995
Roshan	1961	Alamoot	1995
Adl1	1962	Niknejad	1995
Shahi	1967	Atrak	1995
Inia	1968	Mahdavi	1995
Bezostaia	1969	Yavaros	1996
Moghan1	1973	Star	1997
Khazar	1973	Simineh	1997
Arya	1973	Chamran	1997
Arvand	1973	Kavir	1997
Karaj1	1973	Marvdasht	1999
Kara j2	1973	Sayson	2001
Moghan2	1974	Hamon	2002
Naz	1975	Shahryar	2002
Moghan3	1976	Pishtaz	2002
Adl2	1976	Shiraz	2002
Karaj3	1976	Arta	2006
Bayat	1976	Akbari	2006
Alborz	1978	Bam	2006
Azadi	1979	Shiroodi	2006
Turjidum	1979	Bahar	2007
Kaveh	1980	Sistan	2007
Darab	1198	02020	2009
Falat	1981	m79-6	2009
Sabalan	1981	mv-17	2009
Golestan	1986	m84-6	2009
Ghods	1989	m-83-6	2009

Avena fatua L. (wild oat) and *Sisymbrium orientale* L. (Indian hedge mustard) in 17 accessions of *Triticum speltoides* L. Aqueous extracts of wheat straw also, were allelopathic to the germination and growth of a number of weed species (Steinsiek *et al*., 1982).

Today some weeds (such as *Avena fatua*) develop resistant accessions to wheat selective herbicides; on the other hand there was no selective herbicide for some newly arising weeds such as *Hordeum spontaneum* K. Koch (wild barley). Therefore the objective of this study were a) evaluation of genetic diversity in Iranian wheat accession released during past 70 years, b) evaluate the effects of wheat seedling allelopathy on broad leaved and grass weeds and c) evaluate the susceptibility of different weeds to wheat seedling allelopathy.

MATERIALS AND METHODS

The experiment was conducted in 2010 at laboratory of Islamic Azad University of Arsanjan. 68 wheat genotypes were selected among wheat genotypes released during years 1940 to 2009 and were obtained from Karaj Seed and Plant Improvement Institute (Table 1). Wheat and weed seeds (*Hordeum spontaneum*, *Avena fatua* and Amaranthus retroflexus) were surface sterilized by soaking in 1% sodium hypochloride for 20 min, then rinsed with distilled water for several times to remove excess of chemical. Wheat cultivars were grown in the glasshouse and pulled out of the pots at the stage of fourth leaf. The plants were gently washed with distilled water, dried between two paper towels and separated into roots and shoots. Each component was dried in an oven at 50ºC for 48 h and chopped to 1 cm pieces.

The dried material of each plant was ground in grinder and soaked in distilled water for 24 h at room temperature (28±4) at the ratio of 1:20 (1 g plant material per 20 mL water). Each extract was filtered through a Whatman #42 filter paper. The sterilized filtrate was designated as full strength (100%) then used to prepare 25, 50 and 100% concentration by diluting with distilled water. The extract stored at <5ºC before and during its use in the experiment.

Extracts of wheat genotypes were tested for phytotoxicity on seed germination and radicle growth of *H. spontaneum*, *A. fatua* and *A. retroflexus*). Ten seeds were placed in each petri dish containing agar as medium of germination for *H. spontaneum* and *A. fatua* and twenty-five seeds for *A. retroflexus*. The seeds were incubated at 30º in the light for 5-7 days. Number of germinating seeds was recorded, and the lengths of the

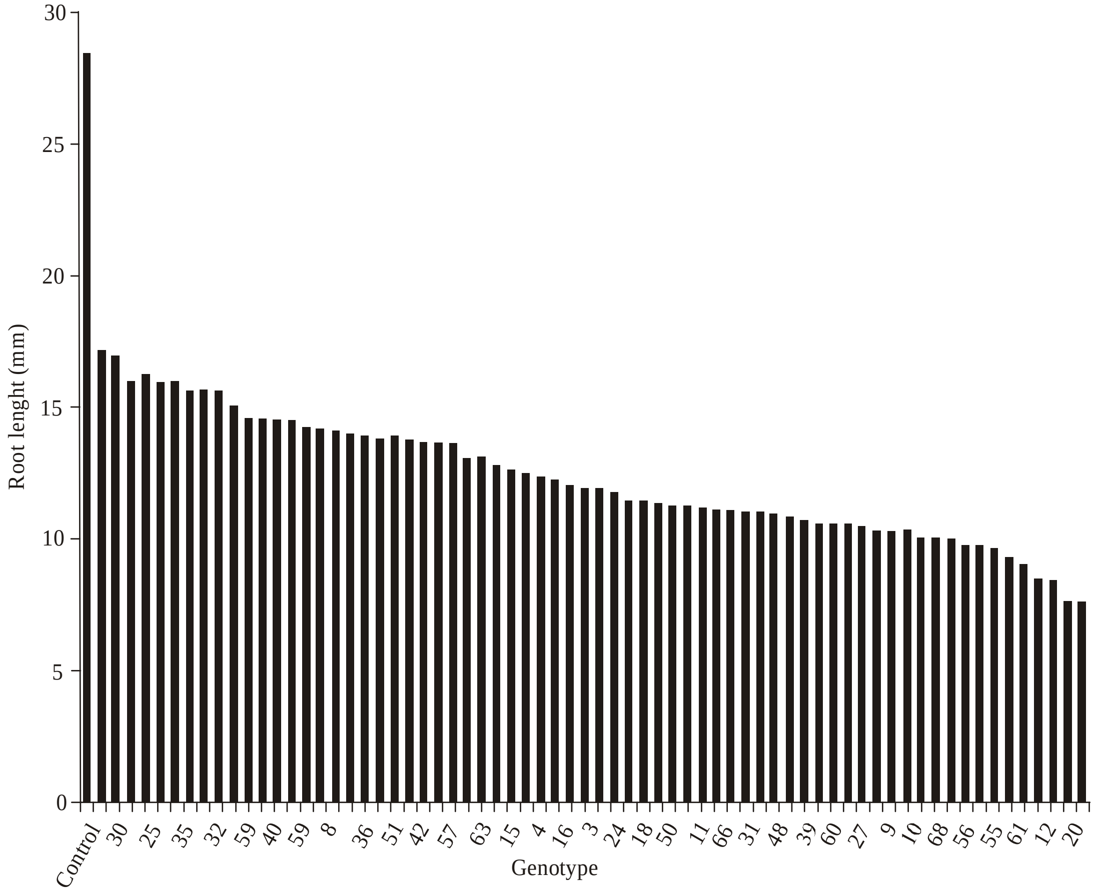

Fig. 1: Effect of wheat shoot extract on pigweed root growth (LSD = 3.4)

roots of 10 randomly selected germinating seeds were measured. Seeds were considered germinated when the radicle extended through the seed coat.

The experimental design was a factorial based on complete randomized design with four replications. The treatments consisted of 68 wheat genotypes and four concentrations of extract (0, 25, 50 and 100% concentration). All experimental data were subjected to analysis of variance by using Genstat (version 11). Least Significant Difference (LSD) test at the 5% level of probability used for mean separation.

RESULTS AND DISCUSSION

Wheat extracts effects on *Amaranthus retroflexus:* Shoot extract of different wheat genotypes significantly reduced *A. retroflexus* root length and there were considerable differences between genotypes (Fig. 1). *Amaranthus retroflexus* root length reduced from 43 to 75% in comparison with control by using extract of different genotypes. The most reduction was observed in Sayson, Gaspard, Gaskojen, Bam and Darab1 (more than 70% reduction in comparison with control) while, Bahar, Kavir, Ghods, Tabasi and Atrak showed the lowest root growth reduction.

Wheat root extract also differed significantly in reducing *A.* retroflexus root length. The inhibitory effects of wheat genotypes varied from 0 to 43% reduction of *A. retroflexus* root length (data not shown). The most reduction was observed with root extract of Gaspard, Karaj2, Gaskojen, Pishtaz and Navid which reducing 43, 43, 29, 28 and 28% in comparison to control respectively. The lowest root length reduction (less than 3%) was observed by extract of Akbari, Inia, Arya, Star and 2020.

Allelopathic activities among these genotypes were found to have normal distribution. Among 68 genotypes, 5 wheat genotypes were strongly allelopathic and reduced *A. retroflexus* root growth more than 70%. Also, 31 genotypes reduced root length 60-70%. Weak allelopathic genotypes (9 wheat genotypes) reduced *A. retroflexus* root length by 40-50%. Twenty-three wheat genotypes were intermediate and reduced root length by 50-60%.

Wheat extracts effects on *Avena fatua:* Shoot extract of wheat genotypes have significant effects on *A. fatua* root growth. All of wheat genotypes reduced *A. fatua* root

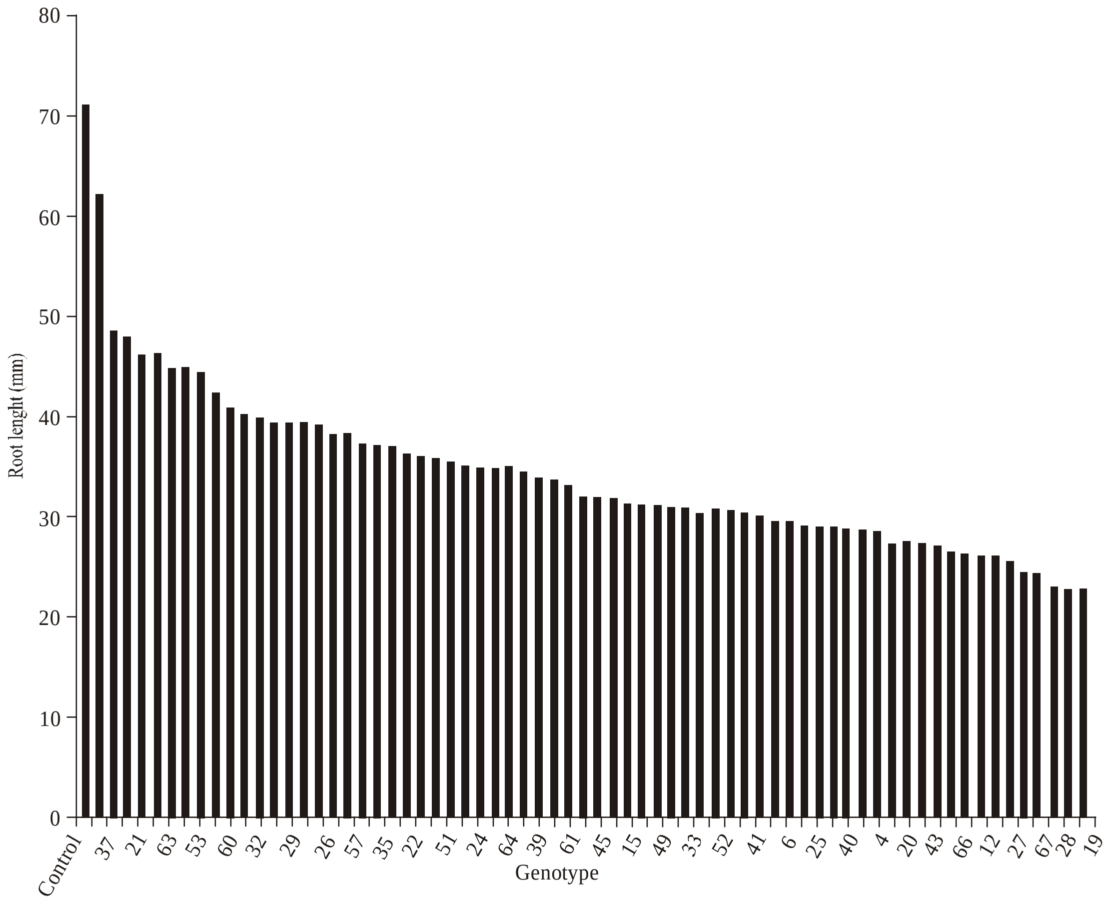

Fig. 2: Effect of wheatshoot extract on wild oat root growth (LSD = 4.12)

length in comparison to control and the range of reduction was between 11-67% (Fig. 2). The highest inhibitory effects observed in Gaskojen, Bayat, Karaj1, Navid and Rasool which reduced *A. fatua* root length by 67, 67, 66, 65 and 64% in comparison to control, respectively. The lowest reduction was found using shoot extract of Niknejad which only reduced 11% root length also, Atrak, Yavarus, Akbari and Shiroodi reduced root length between 31 to 34%.

Root extract of all wheat genotypes reduced A. fatua root growth in comparison to control (data not shown). This reduction varies from 6 to 54%. Root extract of Navid, Rasool, Mahdavi, Gaskojen, and Adl1 genotypes showed the highest allopathic effect which reduced *A. fatua* root length by 54, 53, 52, 52 and 42% respectively. The lowest reduction observed using root extract of Alamoot, Inia Moghan3, Azar and Tabasi.

Most of wheat genotypes (30 from 68 genotypes) were intermediate in inhibitory against *A. fatua* which reduced root length between 50-60%. Fourteen genotypes were strongly allelopathic, causing root length reduction by 60-70%. One genotype showed weak allelopathic and reduced less than 20% *A. fatua* root length.

Wheat extracts effects on *Hordeum spontaneum*: There were significant differences between wheat genotypes shoot extract in reduction *H. spontaneum* root growth (Fig. 3). Wheat genotypes reduce *H. spontaneum* root length from 21 to 69% in comparison to control. The highest reduction belonged to Mahdavi, Azadi, Gaspard, Arvand and Adl1 shoot extract while, the lowest reduction observed using Inia, Ghods, Tajan, Shahryar and Alborz extract. Root extract also causes a reduction between 2 to 65% in *H. spontaneum* root length (data not shown). The highest reduction observed using root extract of Mahdavi, Rasool, Arvand, Navid and Gaskogen that reduced root length by 40-60%.

Among 68 wheat genotypes, 44 genotypes caused more than 50% reduction in *H. spontaneum* root length. Ten genotypes showed strong allelopathy and reduced H *spontaneum* root length by 60-70% while, 5 genotypes showed weak allelopathy and caused less than 40% reduction.

The results showed that there was a significant variation between wheat genotypes allelopathy from both shoot and root extract. Variation among Iranian wheat genotypes also, have shown in other experiments.

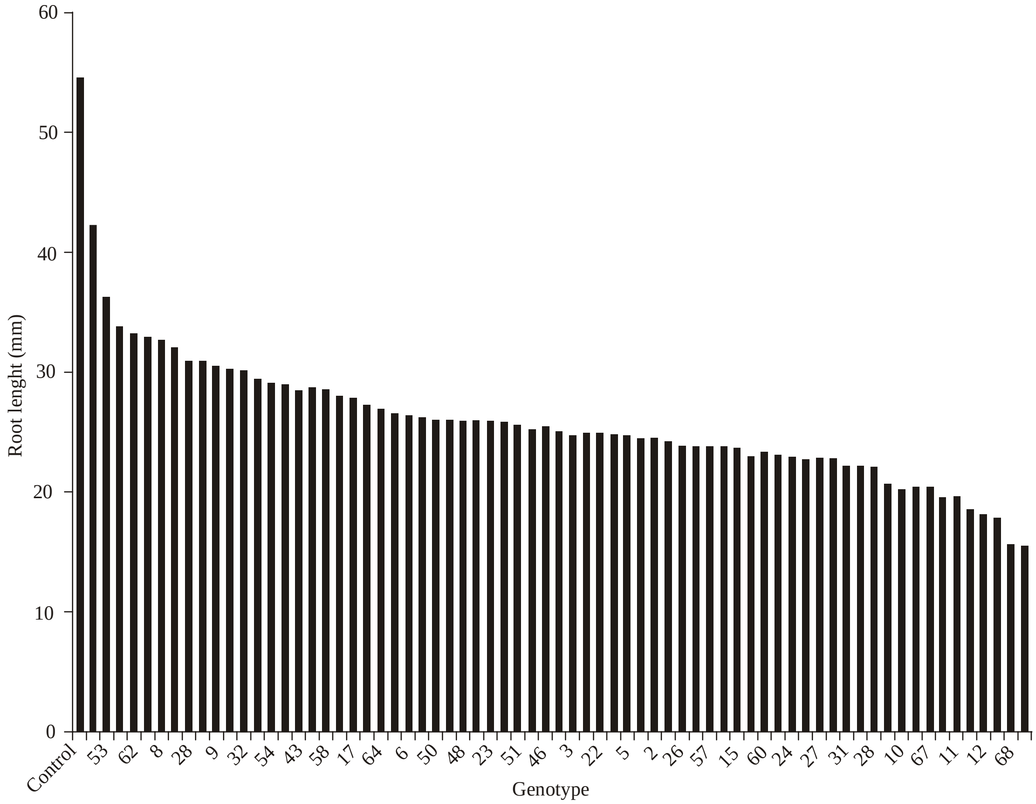

Fig. 2: Effect of wheat shoot extract on wild barley root growth (LSD = 3.78)

Kiarostami *et al*. (2007) showed that there was a significant difference in allelopathic potential of 10 Iranian wheat genotypes (Atrak, Star, Dez, Pishtaz, Chamran, Darab2, Shiroodi, Marvdasht and Tajan) and observed that highest allelopathic was related to Chamran and Pishtaz genotypes extract. Labbafy *et al*. (2009) also found a variation in allelopathic potential of four Iranian wheat genotypes (Roshan, Niknejad, Tabasi and Shiraz). Among these genotypes, Roshan had the highest allelopathic potential on rye, compared to other wheat cultivars.

The inhibitory effects of these wheat genotypes vary with recipient species. For example shoot extract of Sayson, Bam and Darab1 showed high allelopathy against A. retroflexus but not about *A. fatua* and *H. spontaneum*. In contrast, in *A. fatua* shoot extract of Navid, Rasool and Karaj1 showed high allelopathy but not in *A. retroflexus* and *H. spontaneum*. The same results were observed for *H. spontaneum*. This means that wheat allelochemicals possess selectivity to some extent. Wheat shoot extract had the higher inhibitory on *A. retroflexus* root growth than other two weeds but, root extract of wheat showed the lower inhibitory on *A. retroflexus* in comparison to *H. spontaneum* and *A. fatua* (Fig. 4). Actually, different allelochemicals existing in different wheat genotypes (Wu *et al*., 2000c, 2001). Wu *et al*. (2000b) showed that plant

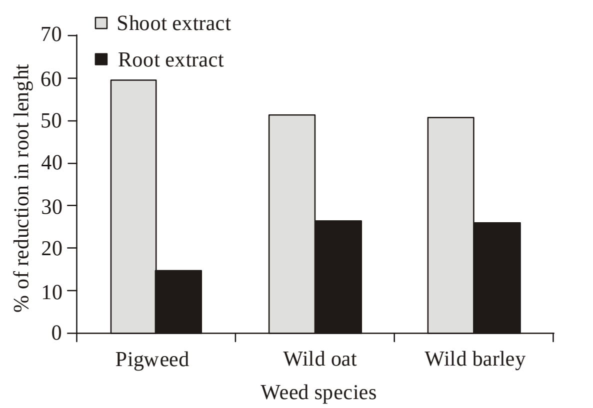

Fig. 4: Comparison allelopathic effects of root and shoot extract of wheat genotypes on different weed species

tissues (shoots and roots) of strongly allelopathic accessions generally contained higher amounts of allelochemicals than those of poorly allelopathic ones. On the other hand some genotypes like Gaspard and Gaskojen in all three weeds showed high potential of allelopathy.

There are also differences between shoot and root extract of different genotypes for weed growth inhibition

(Fig. 4). Shoot extract had more inhibitory effects on all three weed species. It showed that different allelochemical or higher percentages of same allelochemical exist in shoot tissue in comparison to root. However Wu *et al*. (2000c) showed that similar allelochemicals are presented in shoot and root of Australian wheat genotypes. It has been observed that leaf extracts of wheat is the most phytotoxic plant part extracts in both germination and radicle tests (Oueslati, 2003; Guenzi *et al*., 1967). Leaf extracts of *Artemisia princeps* var. '*orientalis*' also decreased seedling elongation of receptor plants more than root and stem extracts (Kil and Yun, 1992).

CONCLUSION

Generally, the results showed that there are substantial variations in allelopathic potential of wheat genotypes. The genotypes with high allelopathic potential may be candidates for a genetic analysis of the allelopathic effects of wheat and may be beneficial breeding lines in practical utilization of allelopathy. Further research is needed to determine the genetic control of crop allelopathic activity. Additional field screening is always advisable to substantiate laboratory results.

REFERENCES

Barnes, J.P. and A.R. Putnam, 1986. Evidence for allelopathy by residues and aqueous extracts of rye (Secale cereale). Weed Sci., 34: 384-390.

Bertholdsson, N.O., 2004. Variation in allelopathic activity over one hundred years of barley selection and breeding. Weed Res.,44: 78-86.

Chung, I.M. and D.A. Miller, 1995. Effect of alfalfa plant and soil extracts on germination and growth of alfalfa. Agron J., 87: 762-767.

Dilday, R.H., J. Lin and W. Yan, 1994. Identification of allelopathy in the USDA-ARS rice germplasm collection. Aust. J. Exp. Agric., 34: 901-910.

Fay, P.K. and W.B. Duke, 1977. An assessment of allelopathic poten tial in Avena germplasm. Weed Sci., 25: 224-228.

Gressel, J., 1991. Why Get Resistance? It can be Prevented or Delayed. In: Casey, J.C., G.W. Cussans, R.K. Atkin, (Eds.), Herbicide Resistance in Weeds and Crops. Butterworth and Heinmann, Oxford, U.K., pp: 1-26.

Guenzi, W.D., T.M. Mc-Calla and F.A. Norstadt, 1967. Presence and persistence of phytotoxic subtances in wheat, oat, corn and sorghum residues. Agron J., 59: 163-165.

Hashem, A. and S.W. Adkins, 1998. Allelopathic effects of Triticum speltoides on two important weeds of wheat. Plant Prot. Quar., 13: 33-35.

Kiarostami, K., M. Ilkhanizadeh and A. Kazemnejad, 2007. Study on allelopathic potential of wheat (*Triticum aestivum*) against Hordeum spontaneum and Lolium rigidum. Iran J. Biol. (in Persian), 20: 207-214.

Kil, B.S. and K.W. Yun, 1992. Allelopathic effects of water extracts of *Artemisia princeps* var, orientalis on selected plant species. J. Chem. Ecol., 18: 39-51.

Kremer, R.J. and M. Benhammouda, 2009. Allelopathic plants. 19. Barley (*Hordeum vulgare* L.). Allelopathy J., 24: 225-242.

Labbafy, M.R., F. Maighany, A. Hejazy, H. Khalaj, A.M. Baghestany and A. Mehrafarin, 2009. Study of Allelopathic Interaction of Wheat (*Triticum aestivum* L) and Rye (*Secale cereal* L.) Using Equal-Compartment-Agar Method. Asian J Agric. Sci., 1(2): 25-28.

Motiul, Q., D. Grant, B. Russell, W. Steven and W. Sutherland, 2001. Allelopathy, DIMBOA production and genetic variability in accessions of Triticum speltoides. J. Chem. Ecol., 27: 747-760.

Muminovic, S., 1991. Allelopathic influence of straw of crops on the germination, height and weight of weeds. Radovi Poljoprivrednog Fakulteta Univerziteta u Sarajevu, 39: 29-37.

Olofsdotter, M., D. Navarez and K. Moody, 1995. Allelopathic potential in rice (*Oryza sativa* L.) germplasm. Ann. Appl. Bio., 127: 543-560.

Oueslati, O., 2003. Allelopathy in two durum wheat (*Triticum aestivum* L.) varieties. Agric. Ecosys. Environ., 96: 161-163.

Powles, S.B., C. Preston, I.B. Brian and A.R. Justum, 1997. Herbicide resistance: Impact and management. Adv. Agro., 58: 57-93.

Putnam, A.R. and J. Defrank, 1979. Use of cover crops to inhibit weeds. Proc. IX Int. Cong. Plant Prot., pp: 580-582.

Rice, E.L., 1984. Allelopathy. 2nd Edn., Academic Press, London.

Rice, E.L., 1995. Biological Control of Weeds and Plant Diseases: Advances in Applied Allelopathy. University Oklahoma Press, Norman.

Rizvi, S.J.H., V. Rizvi, M. Tahir, M.H. Rahimian, P. Shimi and A. Atri, 2000. Genetic variation in allelopathic activity of wheat (*Triticum aestivum* L.) genotypes. Wheat Inf. Ser., 91: 25-29.

Shilling, D.G., R.A. Liebl and A.D. Worsham, 1985. Rye (*Secale cereale* L.) and Wheat (*Triticum aestivum* L.) Mulch: the Suppression of Certain Broadleaved Weeds and the Isolation and Identification of Phytotoxins. In: Putnam, A.R. and C.S. Tang, (Eds.), The Science of Allelopathy. John Wiley & Sons Inc., New York, USA, pp: 243-271.

Spruell, J.A., 1984. Allelopathic potential of wheat accessions. Dissertation Abstracts International, B Sciences and Engineering. Ph.D. Thesis, University of Oklahoma, USA, 45: 1102B.

Steinsiek, J.W., L.R. Oliver and F.C. Collins, 1982. Allelopathic potential of wheat (*Triticum aestivum*) straw on selected weed species. Weed Sci., 30: 495-497.

Wu, H., J. Pratley, D. Lemerle, T. Haig and B. Verbeek, 1998. Differential Allelopathic Potential among Wheat Accessions to Ryegrass. In: Michalk, D.L. and J.E. Pratley, (Eds.), Proceedings of 9th Australian Agronomy Conference Wagga, NSW.

Wu, H., J. Pratley, D. Lemerle, T. Haig and B. Verbeek, 1999. Crop cultivars with allelopathic capability. Weed Res., 39: 171-180.

Wu, H., J. Pratley, D. Lemerle and T. Haig, 2000a. Laboratory screening for allelopathic potential of wheat (*Triticum aestivum*) accessions against annual ryegrass (*Lolium rigidum*). Aust. J. Agric. Res., 51: 259-266.

Wu, H., J. Pratley, D. Lemerle and T. Haig, 2000b. Evaluation of seedling allelopathy in 453 wheat (*Triticum aestivum* L.) accessions against annual ryegrass (*Lolium rigidum*) by the equal-compartment-agar method. Aus. J. Agric. Res., 51: 937-944.

Wu, H., T. Haig, J. Pratley, D. Lemerle and M. An, 2000c. Distribution and exudation of allelochemicals in wheat (*Triticum aestivum* L.) J. Chem. Ecol., 26: 2141-2154.

Wu, H., J. Pratley, D. Lemerle, and T. Haig, 2001. Allelopathy in wheat (*Triticum aestivum* L.). Review. Ann. Appl. Biol., 139: 1-9.