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EFFECT OF WILD OATS (*Avena fatua)* DENSITIES AND PROPORTIONS ON YIELD AND YIELD COMPONENTS OF WHEAT

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ABSTRACT

To study the effect of wild oats densities and proportions on yield and yield components of wheat, field trials were conducted at Malakandher Research Farm, NWFP Agricultural University, Peshawar. The experiment was laid out in Randomize Complete Block (RCB) design with split plot arrangement. Four seed rates of wheat viz.100, 130,160 and 190kg ha^{-1} were assigned to main plots, while wild oats densities 0, 5, 10, 15, 20, 25 and 30 seeds m^{-2} were kept into sub-plots. Data were recorded on number of spikes m^{-2}, spike length (cm), grains spike^{-1} , 1000 grain weight (g), tiller wild oat^{-1}, number of seed/ tiller of wild oat and grain yield (kg ha^{-1}) . Statistical analysis of the data showed that most of the parameters were statistically affected by wild oats densities and seed rates. Maximum number of spikes m^{-2} (281.9), spike length (9.33cm), number of grains spike^{-1} (50.0), 1000-grain weight (30.26) and were recorded in wheat monoculture (0 wild oat density plot). Seed rate of 160 kg ha^{-1} had significantly higher spikes m^{-2} (283.4), spike length (8.58cm), 1000-grain weight (30.87g) and grain yield. Thus a seed rate of 160kg ha^{-1} was recommended for suppression of wild oats population in wheat crop. The regression analysis also predicted lowest competition of wild oats in wheat seeded at 160kg ha^{-1}.

Keywords: wheat, oats, density, wild, competition, grain, yield.

INTRODUCTION

Wheat belongs to the family Poaceae, tribe Hordae and genus *Triticum.* Common wheat is hexaploid with 42 chromosomes and botanically known as *Triticum aestivum* L. em Thell. It is an annual self pollinated and photo periodically long day plant. Wheat plant consists of roots, leaves and spikes; wheat has both seminal and adventitious roots. The stem consists of nodes and internodes. Normally the plant produce 2-3 tillers under typical eroded field conditions but individual plant on fertile soil with ample space and space and nutrient may produce as many as 100 tillers (Martin et al, 1976). The plant produces 3-6 nodes per stem. Each node consists of a sheath and a blade with ligules and two auricles at the junction. The wheat ear is known as spike having a zigzag rachis. The wheat ear or head is known as spike. The spike bears 20-30 spikelets at nodes on alternate side of zigzag structure called rachis. Each spikelets consists of two glumes and 2-7 florets. A floret consists of lemma, palea, three stamens and one ovary which after fertilization develop into a grain called caryopsis. The caryopsis of grain has furrow and a hairy tip (Martin *et al.* 1976).Wheat is the most important crop produced in Pakistan. It is a staple and indispensable food article of the people of Pakistan and occupies more land than any other crop.

In Pakistan, wheat production per unit area is still very low than its potential yield, although Pakistan is among the top ten producers of wheat in the world. The average yield of wheat in Pakistan does not go beyond 30-35% of its optimum potential (Sarwar and Nawaz, 1985).

Weeds are one of the major problems in crop production. They compete with crop plants for light, moisture, nutrients and space. Weeds also increase harvesting costs, reduce quality of the produce, clog waterways, and increase fire hazards (Arnon, 1972). Weed competition with wheat could be either broadleaf or grasses. *Avena fatua*, *Phaloris minor* and *Lolium temulentum* are the grassy weeds, which have now become a threat to the nutritional requirement of mankind.

Wild oat (*Avena fatua*) has increased tremendously in the rainfed and irrigated areas of Pakistan as well as elsewhere in the world. It is an annual grass and is difficult to eradicate because the seeds shatter before crop maturation and many of the seeds are plowed into the soil, where they lie dormant for one to many years, and germinate when they are turned up near the surface. The roots are small, numerous and fibrous penetrating into the soil to a depth of several feet. The leaves are flat, with broad base and acute apex. The inflorescence is either equilateral (spreading) or unilateral (one sided) panicle. It is of cosmopolitan distribution in cereals where annual precipitation is between 375 to 750mm. Glumes are lanceolate, ligules up to 6mm long, hairy blades, erect or geniculately ascending. Spikelets pendulous and culms are of 30-150cm height.

Ibrahim *et al.* (1995) conducted four pot experiments in 1992-94 at Giza, Egypt and examined wild oats/wheat competition. Wheat cv. Sakha 69 was grown with wild oats at wheat-wild oats numbers/pot of 6.6+5.6+4.6+3.6+2 or 6+1. At these densities, grain yield per plant was decreased by 58, 54, 43, 16 and 7% in 1993-94, respectively, compared with wheat grown alone. In the 2nd experiment, crop weed competition was markedly decreased when emergence of wild oats was delayed by three weeks. In the 3rd experiment wheat and wild oats achieved 100% germination 9 and 15 days after sowing, respectively. In the 4th experiment, wheat and wild oats were sown on 1, 15 and 30 November or 15 December. The optimum sowing date for wheat was 30 Nov. while the growth of wild oats was most vigorous when sown on 1 November.

Walia *et al.* (1998) reported that a field experiment was conducted at Ludhiana, Indian Punjab in 1993-95 to study the effect of artificial infestations of wild oats (*Avena fatua*) in wheat. Crop density was kept constant while wild oats density varied from 0 to 100 plants m^{-2}. As the density of wild oats increased, wheat yield decreased exponentially. Wheat yield loss was below 1% up to 3 plants of wild oats m^{-2}, reached 2.2% at 5 plants and was 50-60% at 100 plants of wild oats m^{-2}. Wheat yield loss could also be related mathematically to the dry weight of wild oats.

Lajos *et al.* (2000) carried out experiments on wheat crop at 5 places under the same condition, but the weed flora differed between sites. Crop density treatments (3, 4, 5 and 6 million wheat seeds ha^{-1}) were applied to 75m² plots using the sowing rate as only tool to control weeds had low efficiency. Weeds were least controlled under the lower sowing rates.

High seeding rates also reduced the impacts of weed on crops in a number of previous studies (Barton *et al*., 1992; Carlson and Hill, 1985; Justice *et al*., 1994; Radford *et al*., 1980).

In view of the importance of the problem for nutrition of human being and national economy, the experiment was designed with the following objectives:

- To quantify the losses caused by A*vena fatua* in wheat.
- To predict the effect of *Avena fatua* on wheat and vice versa at various densities.

MATERIALS AND METHODS

The experiment was conducted at Malkandher Research Farm, NWFP Agricultural University, Peshawar during Rabi season 2004-2005, using variety Ghaznavi-98. The experiment was laid out in Randomized Complete Block (RCB) design with split plot arrangement, having four replications. In each replication, there were four main plots. Each main plot consisted of seven sub-plots. The wheat seed rates viz. 100, 130, 160 and 190kg ha^{-1} were kept in main plots while the wild oat (*Avena fatua*) densities. 0, 5, 10, 15, 20, 25, and 30 plants m^{-2} were assigned to the subplots. The size of subplot was 5x1.5m². Row to row distance was kept at 25cm apart. Wheat seeds were sown with the help of hand hoe. Seeds of wild oat (*Avena fatua*) were planted manually, the same day as the wheat. All other weeds were removed manually throughout the wheat season. The data were recorded on number of spikes m^{-2}, spike length (cm), grains $spike^{-1}$, 1000 grain weight (g), tiller wild oat^{-1}, number of seed/ tiller of wild oat and grain yield (kg ha^{-1}). The data recorded for each trait was individually subjected to the ANOVA technique by using MSTATC Computer Software and means were separated by using Fisher's Protected LSD test. Regression analysis was also run for grain yield and protein content data (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Number of spikes m^{-2}

Analysis of the data revealed that wild oat densities and seed rates, had significant effect on number of spike m^{-2}, while their interaction showed non-significant variation .The data in (Table-1) exhibit that maximum (281.6) spikes m^{-2} were recorded in control plots, while the minimum (269.9) spikes m^{-2} were noted in 30 wild oats seeded m^{-2}. Among the seed rates the highest (283.4) spikes m^{-2} was noted in 160 kg ha^{-1}, while the lowest (269.9) spikes m^{-2} was recorded in 190kg ha^{-1}. For interaction of seed rates with wild oats densities the differences although were non-significant statistically yet the maximum (288.5) spikes m^{-2} were recorded in 160 kg ha^{-1} x 0 wild oat density. The minimum (263.0) number of spikes m^{-2} was noted in 190kg ha^{-1} x25 wild oats seeded m^{-2}. Weed competition in wheat reduced yield due to decreases in spike numbers (Bell and Nalewaja, 1969; Cudney *et al*.,1989; Liebl and Worsham, 1984) and spike length (Burrows and Olson, 1955).

Table-1. Effect of wheat and wild oats density on number of spikes m^{-2} of wheat.

Oats Density (m^{-2})	**Seed rate** (kg ha^{-1})				**Density means**
	100	**130**	**160**	**190**	
0	275.25	276.75	288.50	272.50	281.6ab
5	325.75	275.25	286.25	273.00	278.3abc
10	273.50	274.50	284.50	270.75	290.1a
15	271.25	270.25	282.00	268.00	275.8bc
20	270.00	265.75	278.50	266.50	272.9bc
25	265.50	266.50	272.50	263.00	270.2bc
30	278.50	277.25	294.75	275.75	266.9c
Seed rate means	280.0ab	272.4b	283.4a	269.9b	

Spike length (cm)

The analysis of the data showed that differences among the wild oats densities and seed rates were significant statistically while the interaction of wild oats densities with seed rates showed non-significant variation. The minimum (7.78) spike length was recorded in 30 wild oat seed m^{-2}, while the highest (9.34) spike length was recorded in control (0) plots. Among the seed rates, the highest (8.58) spike length was noted in 160kg ha^{-1}, while lowest spike length (8.09) was recorded in 190kg ha^{-1}. The data (Table-2) further depicts that the interaction though failed to reach the statistical significance level, the maximum spike length (9.52) was recorded in 160kg ha^{-1} x 0 wild oat density .The minimum (7.62) spike length was noted in 190kg ha^{-1} x30 seed m^{-2} treatment. Similar results were reported by Fang and Wang (1990). They reported that weeds affected the yield of wheat mainly through reducing spike length. Earlier researchers have also concluded that weed competition in wheat caused yield reduction via decreases in spike numbers (Bell and Nalewaja, 1969; Cudney, et al .1989; Liebl and Worsham, 1984) spike length (Burrows and Olson, 1955) and number of grains per spike (Wilson and Peters, 1982).

Table-2. Effect of wheat and wild oats density on spike length (cm) of wheat.

Oats Density (m^{-2})	Seed rate ($kg\ ha^{-1}$)				Density means
	100	130	160	190	
0	9.38	9.53	9.53	8.93	9.34a
5	8.53	8.55	9.20	8.33	8.65b
10	8.25	8.35	8.48	8.03	8.28c
15	8.33	8.43	8.50	8.10	8.34bc
20	8.15	8.30	8.38	7.85	8.17c
25	7.98	8.08	8.20	7.80	8.02cd
30	7.78	7.93	7.80	7.63	7.79d
Seed rate means	8.34ab	8.45a	8.59a	8.10b	

Grains spike $^{-1}$

Statistical analysis of the data showed that wild oat densities have a significant effect while seed rates and their interaction have non-significant influence on grains $spike^{-1}$. The data in Table-3 showed that maximum (50.0) grains $spike^{-1}$ was recorded in control (0 wild oat density m^{-2}). Minimum (45.01) number of grains was recorded in 30 wild oats seeded m^{-2}. Among the seed rates, the highest number of grains $spike^{-1}$ (46.99) were recorded in 160kg ha^{-1}, which was closely followed by other seed rates included in the studies. For the interaction of seed rates with the wild oats densities the differences although were non-significant statistically, yet the maximum (50.60) grains $spike^{-1}$ were noted in 160kg x 0 wild oats m^{-2}. The minimum number of grains $spike^{-1}$ (43.97) was recorded in 190kg x 30 wild oats m^{-2} plot. Martin *et al.* (1987) also found that increasing wheat density decreased the losses from wild oats. Weed competition in wheat attributed yield reduction to decreases in spike numbers (Bell and Nalewaja 1969, Cudney et al .1989, Liebl and Worsham 1984) number of grains per spike (Wilson and Peters, 1982).

Table –3. Effect of wheat and wild oats density on grain $spike^{-1}$ of wheat.

Oats Density	Seed rate ($kg\ ha^{-1}$)				Density means
	100	130	160	190	
0	50.63	50.58	50.60	48.20	50.00a
5	46.93	47.08	47.00	46.65	46.95b
10	46.80	46.66	46.53	46.53	46.74bc
15	46.63	46.70	46.35	45.30	46.54bc
20	46.18	46.28	45.90	45.88	46.17bc
25	45.78	45.88	45.45	45.53	45.77cd
30	45.28	45.35	45.45	43.98	45.01d
Seed rate means	46.89	46.93	46.99	46.15	

1000-grain weight (g)

Analysis of the data revealed that 1000-grain weight was significantly affected by wild oats densities and seed rate, while interaction of seed rates with wild oat densities were non-significant statistically. The data (Table-4) revealed that maximum (30.26) 1000 grain weight was recorded in control plot. Minimum (29.4) 1000 grain weight was noted in 30 wild oat seed m^{-2}. Among the seed rate the maximum (30.8) 1000 grain weight was recorded in 160kg ha^{-1} while the minimum (29.6) 1000 grain weight was noted in 190kg ha^{-1} seed rates which was closely followed by the other seed rates included in the studies. The data in Table-6 further depicts that the interaction though failed to reach the statistical significance level, the maximum 1000-grain weight (31.30) was recorded in 160kg ha^{-1} x 0 wild oat seed m^{-2}. Minimum (28.90) 1000 grain weight was noted in 190kg ha^{-1} x 25 wild oat seed m^{-2} plot. These findings are in agreement with the work of Justice *et al.* (1994), Radford *et al.* (1989) and Barton *et al.* (1992), who concluded the strong relation of seeding rates with the wild oats management.

Table -4. Effect of wheat and wild oats density On 1000-grain weight (g) of wheat.

Oats Density (m^{-2})	Seed rate ($kg\ ha^{-1}$)				Density means
	100	130	160	190	
0	29.98	30.080	31.30	29.70	30.26b
5	29.85	29.98	31.20	29.60	30.26b
10	29.75	29.85	30.93	29.53	30.16b
15	29.58	29.65	30.58	29.33	30.01b
20	29.48	29.60	30.05	29.18	29.78b
25	29.30	29.43	30.00	28.90	29.57b
30	32.15	32.20	32.05	31.23	29.41b
Seed rate means	30.01b	30.11b	30.87a	29.63b	

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Tillers wild oat plant^{-1}

Statistical analysis of the data showed that the number of tillers of wild oats plant^{-1} was significantly affected by wild oats densities while the seed rates and interaction of wild oats densities with the seed rates were non-significant statistically. The data (Table-5) revealed that the maximum (13.1) tillers of wild oats plant^{-1} were recorded in 5 wild oats seed m^{-2} plots. The minimum (11.8) tillers of wild oat plant^{-1} were noted in 30 wild oat seed m^{-2}. Among the seed rates the highest (11.2) number of tiller wild oat plant^{-1} were recorded in 100kg ha^{-1}, while the lowest (10.2) number of tiller wild oat plant^{-1} were recorded in 160kg ha^{-1}, However it was statistical similar with 130 and 190kg ha^{-1} seed rates .For the interaction of seed rates with the wild oat densities, the differences although were non-significantly yet the maximum (13.7) number of tillers wild oat plant^{-1} were noted in 100kg ha^{-1} x 5 wild oat densities m^{-2} .The minimum number of tillers (11.5) wild oat plant^{-1} were recorded in 160kg ha^{-1} x 30 wild oat densities m^{-2} treatment.

Table-5. Effect of wheat and wild oats density on tiller of wild oat/plant.

Oats Density (m^{-2})	**Seed rate** (kg ha^{-1})				**Density means**
	100	**130**	**160**	**190**	
0	0.00	0.00	0.00	0.00	0.0b
5	13.75	13.25	12.25	13.25	13.13a
10	13.50	12.75	11.25	12.50	12.75ab
15	13.25	12.75	12.25	12.75	12.63ab
20	13.0	12.50	12.0	12.25	12.44ab
25	12.75	12.25	11.75	12.25	12.25ab
30	12.50	11.75	11.50	11.50	11.81b
Seed rate means	11.25	10.75	10.21	10.64	

Seeds/Tiller of wild oats

Analysis of the data revealed that wild oat densities had significant effect on seeds/tiller of wild oat, while seed rates and their interaction had showed non-significant variation. The data in Table–6 indicated that among the mixtures of all the densities had almost equal number of seeds/tiller of wild oats. Similarly, among the seed rates similar number of seeds/tiller of wild oats were recoded for each seed rate.

Table-6. Effect of wheat and wild oats density on seed/tiller of wild oat of wheat.

Oats Density	**Seed rates** (kg ha^{-1})				**Density means**
	100	**130**	**160**	**190**	
0	0.00	0.00	0.00	0.00	0.0b
5	43.025	42.900	42.575	42.825	42.83a
10	42.950	42.875	42.550	42.575	42.74a
15	42.825	42.775	42.475	42.225	42.57a
20	42.775	42.700	42.350	42.200	42.51a
25	42.700	42.650	42.175	41.975	42.44a
30	42.600	42.450	42.050	42.675	43.38a
Seed rate means	36.70	36.62	36.31	36.35	

Grain yield (kg ha^{-1})

Statistical analysis of the data revealed that wild oats seed rates and densities were significant, while their interaction was non-significant statistically. The data in Table-7 show that the maximum (2938kg ha^{-1}) grain yield among the wild oats densities was recorded in 0 wild oats seed m^{-2} while minimum (2283kg ha^{-1}) grain yield was recorded in 30 wild oats seeded m^{-2} treatment. For interaction of seed rates with the wild oats densities, the highest yield (3121kg ha^{-1}) was observed in 160kg ha^{-1} x 0 wild oats seed m^{-2}, while minimum grain yield (2022.50kg ha^{-1}) was observed in 190kg ha^{-1} x 30 wild oats seed m^{-2}. Bhan (1987) reported that wheat at high seeding rates of 150kg ha^{-1} reduced the initial growth of wild oat seedlings. Wheat yield loss due to wild oats competition, involving weed densities as a variable, has been extensively reported in the world literature (Dew, 1972, Tessema and Tanner, 1997; Tessema *et al*., 1996a; 1996b) and various models have been reviewed by Zimdahl (1980) and Cousens (1985). Wilson *et al*. (1990) also reported that increased seeding rates of barley reduced the initial growth of wild oats seedlings.

Table-7. Effect of wheat and wild oats density on grain yield (kg ha^{-1}) of wheat.

Oats Density (m^{-2})	**Seed rate** (kg ha^{-1})				**Density means**
	100	**130**	**160**	**190**	
0	2888.25	2913.25	3121.0	2827.50	2938a
5	2209.25	2371.25	2767.75	2245.0	2398b
10	2202.0	2326.75	2765.0	2232.75	2382b
15	2196.75	2312.0	2757.50	2200.25	2367bc
20	2192.0	2264.50	2741.50	2103.0	2325bc
25	2189.75	2253.50	2737.25	2063.50	2311bc
30	2182.50	2228.25	2696.25	2022.50	2283c
Seed rate means	2294c	2381b	2798a	2242c	

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The regression of yield on wild oats densities across the different seeding rates (Figure-1) showed that grain yields and weed density had a strong negative association. The data in Figure-1 exhibit that wild oats density had a significant negative effect on crop yield (r = -0.757, P < 0.049, R^2 = 0.41). Grain yield was maximum in the 0 wild oat seeded m^{-2} while minimum at 30 wild oats m^{-2}. The trend in relationship is the same across the remaining seed rates (Figure-2). Increase in wild oat density, caused a significant reduction in grain yield (kg ha^{-1}). It is clearly indicated from the graphs that wheat crop don't compete at higher levels of wild oat densities. The data in Tables 8 and 9 further exhibit the regression details.

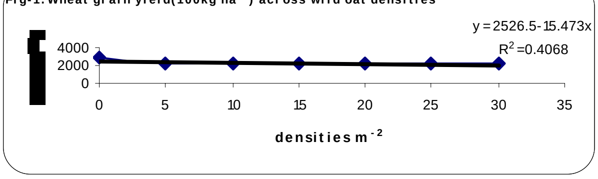

Fig-1. Wheat grain yield(100kg ha^{-1}) across wild oat densities

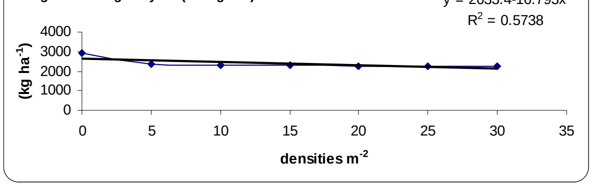

Fig -2. Wheat grain yield (130kg ha^{-1}) across wild oat densites

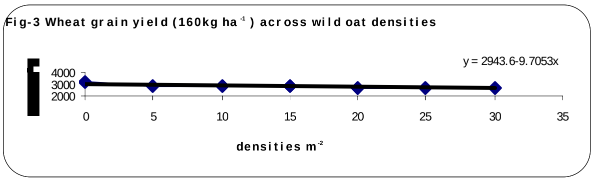

Fig-3 Wheat grain yield (160kg ha^{-1}) across wild oat densities

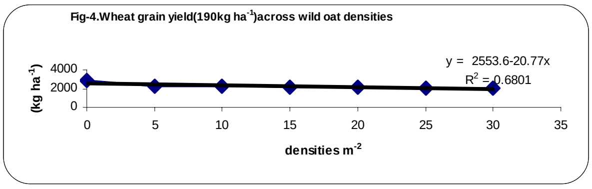

Fig-4.Wheat grain yield(190kg ha^{-1})across wild oat densities

Table-8. Parameter estimates for the simulation of wheat yield as affected by wild oats densities across different seed rates.

Seed Rate (kg ha^{-1})	a (intercept estimate)	b (regression coefficient)	S.E	R^2
100	2526.5	-15.473	8.355	0.41
130	2633.4	-16.793	6.471	0.57
160	2943.6	-9.705	4.115	0.53
190	2553.6	-20.77	6.364	0.68

Table-9. Predicted wild oats densities to cause 1, 10 and 30% losses across different seeding rates of wheat.

Seed Rate (kg ha^{-1})	1%	10%	30%
100	1.63	16.33	48.99
130	1.57	15.68	47.04
160	3.03	30.33	90.99
190	1.23	12.30	36.90

REFERENCES

Arnon, I. 1972. Crop production in Dry Regions, Leonard Hill Book, London.

Barton, D.L., D.C. Thill, and B. Shafi. 1992. Integrated wild oat *(Avena fatua)* management affects spring barley *(Hordeum vulgare)* yield and economics. Weed Tech. 6: 129-135.

Bell,A .R.and J .D.Nalewaja. 1968. Competition of wild oat in wheat and barley, Weed Sci. 16: 505-508.

Burrows, U .S. and Olson, P. J.1955.Reaction of small grain to various densities of wild mustard and the results obtained after their removed with 2,4-D or by hand. I. Experiment with wheat. Can. J. Agric. Sci. 35: 68-75.

Carlson, H.L. and J.E. Hill. 1985. Wild oats *(Avena fatua)* competition with spring wheat: Plant density effects. Weed Sci. 33: 176-181.

Cousens, R. 1985. A. Simple model relating yields loss to weed density. Annals Appl. Biol. 107: 239-252.

Dew, D. A.1972. An index of competition for estimating crop loss due to weeds. Can.J. Plant Sci. 52: 921-927.

Ibrahim, H.M., A.S. Kholosy, M.K. Zakran and E.E. Hassanein. 1995. Study of wild oat (*Avena fatua*) competition with wheat. Annals Agric. Sci. Cairo 40(2): 683-696.

Justice, G.G., T.F. Peeper, J.B. Solie, and F.M. Epplin. 1994. Net returns from Italian ryegrass *(Lolium multiflorum)* control in winter wheat *(Triticum aestivum)*. Weed Tech. 8: 317-323.

Lajos, M., K. Lajos and P. Reisinger. 2000. The effect of crop density on weed flora in winter wheat. Noven-yredelem. 36(4): 181-188.

Liebl ,R. A. and A.D.Worsham.1982. Annual ryegrass *(Lolium multiflorum)* interference in wheat. Proc. Southern Weed Sci. Soc. 37th Annual Meeting 1984, Champaign, Illinois. p. 310.

Martin J. H., W.H. Leonard, and D.L. Stamp. 1976. Principles of Crop Production. 3rd Ed., Macmillan Publishing Co., New York, USA.

Martin, R. J., B.R.Cullis and D.W. McNamara. 1987. Predication of wheat yield losses due to competition by wild oats *(Avena* spp.*)*. Aust .J. Agric.Res.38: 487-499.

Radford, B.J., B.J. Wilson, O. Cartledge, and F.B. Watkins. 1980. Effect of wheat seeding rate on wild oat competition. Aust. J. Exp. Agric. and Animal Husb. 20: 77-81.

Sarwar, G. and Q. Nawaz. 1985. Studies on the efficacy of different post-emergence herbicides for the control of weeds and their effect on yield of wheat. Sarhad J.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and Procedures of Statistics. McGraw Hill Book Co., Inc. New York. p. 481.

Tessema T., D.G.Tanner and H. Mangistu.1996a. Grass weed competition with bread wheat in Ethiopia.I. Effect on selected crop and weed vegetative parameters and yield components. African Crop Sci. J. 4: 399-409.

Tessema T., D.G.Tanner and H. Mangistu 1996b. Grass weed competition with bread wheat in Ethiopia.II. Prediction of grain yield loss by implication for economic weed control. African Crop Sci. J. 4: 411-421.

Tessema, T. and D.G.Tanner. 1997. Grass weed competition and calculated economic threshold densities in bread wheat in Ethiopia. African Crop Sci. J. 5: 371-384.

Walia, U.S., K.B. Dhaliwal and L.S. Brar. 1998. Competitive interaction between wheat and wild oat in relation to wild oat population density. Conf. Agric. towards Sust. Dev. Chandigarh, India, 15-17 Nov. pp.430-434.

Wilson, B.J. and Peters, N .C. B. 1982. Studies of competition between *(Avena fatua)* and spring barley .I. Influence of *Avena fatua* on yield of barley. Weed Res. 22: 143-148.

Wilson,B. J. Cousens, R. and Wright, K .J. 1990. The responses of spring barley and winter wheat to *Avena fatua* Population density. Annals Appl. Biol. 116: 601-609.

Zimdahl, R. L.1980. Weed –Crop competition. A. Review. International Plant Protection Center, Oregon State University. Corvallis. Oregon. p. 196.