

Production potential of wheat (*Triticum aestivum*) as affected by varying population densities of wild oat (*Avena ludoviciana*)

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ABSTRACT

A field experiment was conducted during 2007–08 and 2008–09 at Ludhiana, Punjab, to study the effect of varying population densities of wild oat (*Avena ludoviciana*) (0–250 plants/m²) on the production potential of wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] crop and to find out the critical population level of *Avena ludoviciana* in wheat crop for guiding the farmers to take proper control measures to keep the population level of this weed below economic threshold level. As the plant population density of *Avena ludoviciana* increased, the dry matter production, effective tillers (reduced by more than 50% in presence of 250 plants/m²) and ultimately yield of wheat decreased exponentially. Even presence of 15 plants/m² of *Avena ludoviciana* resulted in significant decrease (10–14%) in grain yield. Reduction in yield was mainly caused by the reduction in effective tillers, number of grains per spike and 1,000-grain weight.

Key words : Crop production, Growth parameters, Production potential, Wheat, Wild oat, Yield

Wheat occupies the number one position in the world. India is one of the principal wheat-producing and consuming countries in the World. Its importance in Indian agriculture is second to only rice. Punjab has the highest productivity of wheat among all the states which is favoured by better irrigation facilities as about 97.4% of the area is irrigated and the state on an average account for 23% of wheat of the whole country. Major impediments to higher productivity of wheat are stiff competition from weeds, multiple nutrient deficiencies, insect-pests and incidence of diseases. Weeds alone reduce the wheat yield to the tune of 20–57%. Severe weed competition has resulted from the change in morphological characteristics of wheat varieties and shift in sowing paradigm over a period of four decades. In Punjab about 80–85% of area under wheat is treated with herbicides, as chemical method of weed control is very effective, economical and quick. The continuous and indiscriminate use of same herbicide year after year has led to the development of resistant biotypes of some weeds and their flow down to the soil surface resulted in soil and ground water pollution.

Wild oats is one of the most competitive grass weeds

and are near equal competitors with wheat. Competition with the crop begins soon after emergence with most of the yield loss occurring in the first 6 weeks. An infestation as small as 20 plants/m² can cause a yield loss of 10% in a wheat crop yielding 2 t/ha Anderson (2003). Yield losses are strongly influenced by the density of the infestation and the vigour of the crop, and are greatest when the wild oats emerge at the same time as the crop. Wheat yield, tiller number and dry matter reduce in a linear pattern proportional to the length of time in which wild oats compete with the wheat crop. Therefore maximum yield benefits will be obtained when controlled early as early as possible even though small yield increases can occur after removal later in the season.

Phalaris minor Retz. and *Avena ludoviciana* have been reported as the frequently occurring and densely populated weeds of wheat in the country. *Avena ludoviciana* is very troublesome particularly in non-rice rotations. The present study was, therefore, undertaken to investigate the effect of infestation of different densities of *Avena ludoviciana* on growth and yield of wheat crop.

MATERIALS AND METHODS

A field experiment was conducted at the Punjab Agricultural University, Ludhiana, during winter (*rabi*) seasons of 2007–08 and 2008–09. Soil of the experimental field was sandy loam, with normal soil reaction (pH 7.63), elec-

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trical conductivity (0.14 dS/m), low in organic C (0.35%) and available N (238.7 kg/ha), and medium in available P (19.2 kg/ha) and K (207.2 kg/ha). Treatments consisted of 12 population densities of *Avena ludoviciana*, viz. 0, 10, 15, 25, 50, 75, 100, 125, 150, 200, 250 plants/m² and a sole (solid stand) *Avena ludoviciana* treatment laid out in randomized block design with 4 replications. Wheat variety 'PBW 343' was sown in mid-November with *kera* method using 100 kg seed/ha. All other management practices, like fertilizers, irrigation, insect-pest etc were done according to the recommendations of package of practices for raising wheat crop. Except in sole wheat, the rest of plots were charged with *Avena ludoviciana* seed at the time of sowing of wheat and different densities of *Avena ludoviciana* were deliberately maintained 25 days after sowing. Other species of weeds, if any, were removed manually or chemically. Biometric observations on growth parameters and yield characters were recorded on *Avena ludoviciana* as well as wheat. Data were analysed statistically as per the procedure prescribed by Cochran and Cox (1967) and adapted by Cheema and Singh (1991) in statistical package CPCS-1 and treatment comparisons were made at 5% level of significance. Plant height (cm) of wheat crop and wild oat plants was recorded at harvesting from 10 random plants from each plot and it was recorded from plant base (soil surface) to the base of the last fully opened leaf. The samples for dry matter production were taken from 25 cm row length, oven-dried at 65° C till a constant weight has attained and weighed for dry matter. The dry matter so recorded was converted into g/m². Leaf area was recorded with the help of calibrated Plant Canopy Analyzer (LICOR-make, Model LAI 2000). The leaf-area index (LAI) was measured by placing the sensor once above the canopy followed by placing it at four different points below the crop canopy diagonally across the rows.

The number of effective tillers were recorded at the time of harvest from 25 cm row length in each plot and then converted into per square meter basis.

For recording dry matter accumulation by weeds, weed plants were removed from ground level using quadrat of 50 cm × 50 cm. These samples were first sun-dried and then dried in oven at 65°C, when samples reached a constant weight, the dry matter was recorded and expressed as g/m². The weed samples taken from 50 cm × 50 cm quadrat were also used for recording leaf area through leaf area meter (Model GA-5).

Five random plants were from each plot and tillers were counted, averaged and recorded as tillers/plant. Yield attributes of wheat (number of grains/spike, 1,000-grain weight etc), grain yield and straw yield were recorded at the time of harvesting.

Grains/spike were counted from 10 random ears from each plot and mean values calculated. Thousand grain weight was recorded by taking 2 random samples of grains from produce of each plot during threshing and 1,000-grains were counted and weighed. After threshing, the net plot grain yield (kg/plot) was recorded. Straw yield was calculated by subtracting the grain yield from the biological yield of each plot.

RESULTS AND DISCUSSION

Weed growth

Plant height of *Avena ludoviciana* increased with its increasing population from 10 plants/m² to 250 plants/m² (Table 1). The maximum plant height was recorded under sole *Avena* which was statistically at par with treatments having 100, 125 and 150 plants/m². The lowest height of *Avena* plants varied from 100.05 to 105.80cm in its population density of 10-75 plants/m². The increase in plant height at higher population densities might be due to competition for light and space.

Dry matter accumulation increased with increase in its population from 10 to 250 plants/m² (Table 1). The dry matter accumulation was slow at initial stages but became rapid later on and again rate of increase declined till harvest. Maximum dry matter was recorded with 250 plants of *Avena*/m². At harvest, the increase in dry matter was 94.0 and 90.0 % higher under sole *Avena* stand and 250 plants/m², respectively, over 10 plants of *Avena*/m². Minimum dry matter was produced with 10 plants/m² which was statistically at par with 15, 25 and 50 *Avena* plants/m². Walia *et al.* (1989) reported that dry matter by wild oats

Table 1. Plant height, dry-matter accumulation, leaf-area index and number of tillers of *Avena ludoviciana* under its variable population densities in wheat (mean data of 2 years)

Treatment (Wild oat plants/m ²)	Plant height (cm)	Dry-matter accumulation (g/m ²)	Leaf-area index (100 DAS)	Tillers/ plant (100 DAS)
10	102.5	31.5	2.48	8.1
15	101.8	31.5	2.83	8.1
25	100.0	49.0	2.85	8.0
50	105.8	87.5	2.64	8.0
75	104.9	162.3	2.73	7.9
100	105.9	165.0	2.98	7.6
125	107.7	179.0	3.12	7.5
150	107.8	222.0	3.12	7.4
200	101.4	292.0	3.26	7.2
250	100.5	327.5	3.14	6.0
Solid wild oat stand	112.9	526.0	3.37	5.7
SEm±	2.75	19.4	0.15	0.07
CD (P=0.05)	7.84	58.5	0.39	0.18

DAS, Days after sowing

increased progressively with increase in its intensity.

Leaf area index (LAI) of *Avena* is a good index to describe the competitiveness of weeds with crop. The LAI of *Avena ludoviciana* was significantly influenced by different population levels of *Avena ludoviciana*. Minimum LAI was obtained under the lowest *Avena* population of 10 plants/m², whereas highest LAI was under sole *Avena*, which was statistically at par with 100–250 plants/m².

In general, tiller number per plant declined with increase in *Avena* density from 100 to 250 plants/m². At 100 days, tiller number decreased with increasing *Avena* density beyond 100 plants/m². Significantly higher number of tillers/plant was recorded with 25 and 50 plants/m² which were at par with 10–100 plants/m². The lowest number of tillers were produced with sole *Avena*, which was statistically at par with 250 plants/m². The decline in tillers/plant with increasing plant density beyond 100 plants/m² can be attributed to the increased competition for different growth factors and availability of space.

Growth parameters of wheat

Plant height of wheat increased with increase in population of *Avena ludoviciana* from 10 to 75 plants/m², and then decreased with further increase in weed densities (Table 2). At harvest, maximum plant height (87.3 cm) was recorded with 75 plants/m², which was significantly more than all higher levels of weed density except 0, 10, 25, 50 and 100 plants/m². The minimum plant height (66.7 cm) was obtained with *Avena* density of 250 plants/m². The treatments having *Avena ludoviciana* density ranging from 125 to 250 plants/m² being at par with each other, were statistically inferior to the remaining weed densities.

Table 2. Plant height, dry-matter accumulation, leaf-area index and number of tillers of wheat under different population densities of *Avena ludoviciana* (mean data of 2 years)

Treatment (Wild oat plants/m ²)	Plant height (cm)	Dry- matter accumulation (g/m ²)	Leaf-area index	Effective tillers/m ²
Solid wheat stand	81.5	1,034.5	3.90	439.6
10	81.6	1,052.5	4.09	427.2
15	79.7	1,056.0	4.33	394.9
25	80.5	981.0	4.08	373.8
50	82.9	937.0	4.06	346.7
75	87.3	938.0	4.22	326.5
100	84.9	923.1	4.23	277.2
125	76.3	867.0	4.13	236.2
150	72.3	837.5	4.20	186.9
200	69.2	824.0	4.32	169.8
250	66.7	816.0	4.72	146.5
SEm±	2.7	19.5	0.13	19.8
CD (P=0.05)	7.5	61.0	0.33	53.3

Similar findings have been reported by Walia *et al* (1989).

Dry matter accumulation of wheat was significantly affected by weed competition and decreases with increase in weed density. At harvest, the maximum dry matter was accumulated by the crop infested with 15 plants/m² of *Avena*, which were at par with sole wheat (T₀) and 10 plants/m² of *Avena*. The lowest dry matter accumulation was recorded with 250 *Avena* plants/m². The reduction in dry matter with 25, 50, 100, 150, 200 and 250 plants of *Avena*/m² was to the tune of 5.2, 9.4, 10.8, 19.0, 20.34 and 21.3%, respectively, as compared to the sole crop. The difference in dry matter accumulation under various treatments is due to severe competition posed by *Avena* to the wheat crop. Our findings support those of Graf and Hill (1992). They reported that even at a density of 100 rice plants/m², 10 plants of *E. crus-galli*/m² cause a yield loss of about 50%.

The LAI increased slowly in the early stages of crop growth followed by a rapid increase during the grand growth phase, decreased thereafter due to senescence of leaves. An increase in leaf-area index was observed with increasing *Avena* density from 10 to 250 plants/m². At 100 days, maximum LAI (4.72) was recorded with *Avena* density of 250 plants/m² which was significantly higher than all other treatments. These findings are in agreement with the findings of Chang *et al.* (2005). The plots having higher densities of plants, recorded higher leaf-area index. This is because the leaf area for wheat crop was recorded with canopy analyzer and it gives the representative LAI of the plot as a whole which includes the crop as well as weeds present and not for wheat crop alone. These results are in agreement with the findings reported by Graf *et al.* (1990).

The effective tillers decreased with increasing population pressure of *Avena* due to competition for space, moisture and nutrients between wheat and *Avena*. At harvest, the number of effective tillers was found to be highest under sole wheat (T₀) and the lowest number of effective tillers (146.5) was recorded with *Avena* density of 250 plants/m², which resulted in reduction of number of effective tillers by more than 50% compared to sole wheat (T₀). Walia *et al.* (1989) reported that variable densities of wild oats significantly influenced the number of effective tillers and grain yield of wheat. The higher leaf-area index in high weed density plots caused an increasing light extinction which reduced tillering of wheat (Table 2) and increased tiller mortality rate.

Wheat yield

Grains/spike were significantly influenced and a linear decrease was noticed in grains/spike with increasing population levels of *Avena ludoviciana* (Table 3). Maximum

grains/spike were produced under sole wheat (T_0), being at par with 10 plants/m², was significantly superior to rest of the treatments. Significantly lesser grains/spike were obtained with 250 plants of *Avena*/m². Lesser grains/spike in high weed density treatments as compared to the sole crop could be due to severe competition faced by wheat crop for light, nutrients and space with high weed density treatments. Walia *et al* (2001) reported significant yield reductions with increasing *Avena* intensity compared to the weed-free treatment in wheat.

Sole wheat crop produced bolder grains and was statistically at par with 10, 15 and 25 plants of *Avena*/m², but significantly superior to rest density levels of *Avena*. The lowest 1,000-grain weight (32.3 g) was recorded with 250 plants of *Avena*/m², which was significantly inferior to all other population levels of *Avena*. Weed populations of 125, 150, 200 and 250 plants/m² recorded 21.0, 22.2, 23.7 and 32.8% reduction in the 1,000-grain weight compared to sole wheat (T_0). This reduction in grain weight of wheat in higher weed population treatments was caused by severe competition posed by weeds to wheat crop.

Straw yield (t/ha) of wheat decreased with increasing *Avena* intensity from 10 to 250 plants/m². The lowest

straw yield was recorded with 250 plants of *Avena*/m² which was statistically at par with 200 plants of *Avena*/m². The highest straw yield (5.80 t/ha) was recorded in sole wheat stand, was statistically at par with 10, 15 and 25 plants of *Avena*/m².

Grain yield of wheat decreased with increasing density of *Avena* from 10 to 250 plants/m² (Table 3). The highest grain yield was recorded under sole wheat stand, which was statistically superior to all other treatments with different population levels except 10 plants of *Avena*/m². Even 25 plants of *Avena*/m² reduced the grain yield of wheat to the tune of 22.5%. There was a significant reduction in grain yield ranging from 22.5 to 62.7% with 25 and 250 plants of *Avena*/m² compared to sole wheat (weed free) crop. The reduction in grain yield in presence of 125, 150, 200 and 250 plants of *Avena*/m² was 46.6, 51.9, 58.3 and 62.7%, respectively, compared to the sole crop. The lowest grain yield (2.29 t/ha) was recorded with 250 plants/m² being at par with 200 plants of *Avena*/m².

At higher population density of *Avena*, there was a gradual increase in dry matter and plant height of *Avena* (Table 1) which caused suppression of wheat growth and ultimately resulted in lower grain yield.

Walia and Brar (2001) reported decline in yield of wheat to an extent of 30–40% due to 10 plants/m² of *Avena* (wild oats). Wilson *et al.* (1990) reported that low infestation of *Avena fatua* was likely to result in yield losses in the region of 1% for every wild oats plant/m². Singh *et al.* (1993) reported that infestation of *Phalaris minor* throughout the crop span caused 29–40% loss as compared to weed-free treatment.

With increasing weed density from 10 to 250 plants/m², the harvest index decreased. The lowest value (0.42) was recorded where there was a maximum competition between the crop and weeds, i.e. 250 plants of *Avena ludoviciana*/m². The highest harvest index was recorded with 15 and 25 plants of *Avena*/m².

CORRELATION

There was a positive correlation between various growth parameters of *Avena ludoviciana* and negative correlation of these parameters with wheat yield (Table 4). Growth of *Avena ludoviciana* adversely affected yield of

Table 3. Yield attributes, grain yield, straw yield and harvest index of wheat under different *Avena ludoviciana* population densities (mean data of 2 years)

Treatment (Wild oat plants/m ²)	Grains/ear	1,000-grains weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
Solid wheat stand	48.0	48.1	6.14	5.80	0.51
10	47.7	46.5	5.71	5.10	0.52
15	45.4	45.7	5.50	5.06	0.52
25	45.0	42.1	4.76	5.05	0.48
50	44.4	40.95	4.33	4.80	0.47
75	43.2	41.4	4.16	4.90	0.45
100	41.9	38.8	3.69	4.95	0.42
125	41.6	37.9	3.28	4.50	0.42
150	39.75	37.4	2.95	4.00	0.42
200	38.8	36.7	2.56	3.25	0.44
250	37.0	32.3	2.29	3.01	0.42
SEm \pm	0.83	1.15	0.17	0.28	0.026
CD (P=0.05)	2.35	4.37	0.501	0.842	0.08

Table 4. Correlation between plant height, dry-matter accumulation, leaf-area index, tillers/plant of *Avena ludoviciana* and wheat yield

Treatment	Plant height	Dry-matter accumulation	Leaf-area index	Tillers/plant	Wheat yield
Plant height	-	0.943	0.965	0.971	-0.835
Dry-matter accumulation	-	-	0.935	0.925	-0.748
Leaf-area index	-	-	-	0.949	-0.731
Tillers/plant	-	-	-	-	-0.769
Wheat yield	-	-	-	-	-

wheat, as the correlation coefficient (r) was higher than 0.5. Plant height of *Avena ludoviciana* recorded the highest correlation coefficient ($r = -0.835$), followed by tillers/plant ($r = -0.769$), dry matter accumulation ($r = -0.748$) and leaf-area index of ($r = -0.731$) *Avena ludoviciana*. Wheat yield, tiller number and dry matter reduce in a linear pattern proportional to the length of time in which wild oats compete with the wheat crop (Anderson, 2003).

It was concluded that presence of even 15 plants of *Avena ludoviciana*/m² significantly reduced the grain yield of wheat and also resulted in significant reduction in other growth parameters which ultimately results in poor grain yield of wheat crop and this population level of weed plants in crop is considered to be critical level of population.

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