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Effects of nitrogen on competition between wheat and grassy weeds

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ABSTRACT

Field experiments were conducted in microplots to study the effect of N supply on competition between wheat and two prominent grassy weeds *viz*., *Phalaris minor* and *Avena ludoviciana*. Six treatments comprising three species combinations (wheat monoculture, weed monoculture, wheat and weed mixture in equal proportions) and two levels of N fertilization (20 and 120 kg/ha) were studied in a factorial randomized block design with four replications. Results revealed that total dry weight of wheat was significantly lower in mixture than in monoculture. Wheat was more competitive than *P. minor* at high N, but less competitive at low N. *A. ludoviciana,* was more competitive than crop at both N levels. Wheat reduced photosynthesis of weeds to a greater extent as compared to pure weed population. *A. ludoviciana* exhibited higher values of *P*n as compared to *P. minor* at both N levels in both stand (monoculture and mixture) types. Leaf area index and leaf chlorophyll content of both wheat and weed were at par in mixture at high N and in monoculture at low N, indicating a higher competitiveness (for nitrogen) of *A. ludoviciana.*

Key words: *Avena ludoviciana,* Crop-weed competition, *Phalaris minor,* Wheat

Littleseed canary grass (*Phalaris minor*) and wild oat (*Avena ludoviciana*) are the two most troublesome winter season grassy weeds reducing the yields of wheat (*Triticum aestivum* L.) crop in rice-wheat system of Indo-Gangetic plains (Brar *et al*. 2002). These weeds resemble wheat so closely that hand-weeding at the critical seedling stage is extremely difficult. A single plant of *Phalaris minor* may produce as many as 1,100 seeds and 150 plants/m^2 will reduce the wheat yield by 30% (Balyan and Malik 1989). The loss due to *P. minor* may range from 30-80% (Brar and Singh 1997). It is a major problem in the states of Haryana, Punjab and Uttar Pradesh (Malik and Singh 1995). Wild oat is a very troublesome weed in non-paddy rotations in light to medium textured soils and 30 plants/m^2 can cause nearly 50% yield losses in wheat (Walia and Brar 2001). Nitrogen (N) is a major nutrient required by crop plants for optimum vegetative and reproductive growth. Increasing application of N may improve the ability of cereals to suppress weeds. However, the effects on individual weed species differ. Although growth of some weed species is decreased as a result of greater crop competition, growth of others may be increased to the extent that they can gain a competitive advantage (Okafor and De Datta 1976, Carlson and Hill 1985). Wheat has a high demand for N during grain filling. If this cannot be met by uptake from soil, premature senescence occurs as N is remobilized from leaves to meet the requirements of the developing grains, resulting in a lower photosynthetic rate (Frederick and Camberato 1995). Therefore, decreased N supply may reduce yields of wheat directly by reducing photosynthetic productivity, and indirectly by resulting in increased weed competition. Hence, the present field study was made to assess the effect of N supply on competition between wheat and *P. minor* and *A. ludoviciana*.

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MATERIALS AND METHODS

Field experiments were conducted during *Rabi* seasons (November to April) of 2007 and 2008 at the Directorate of Weed Science Research, Jabalpur located at 23.90° N latitude, 79.58° E longitude and at an altitude of 411.78 m above mean sea level. The experimental soil was clay loam in texture, neutral in reaction (pH 7.5) with medium organic carbon (0.65%) content and low in available N (225 kg/ha). Six treatments comprising three species combinations [wheat monoculture, weed monoculture (*P. minor* and *A. ludoviciana*), wheat and weed mixture in equal proportions] with two levels of N (20 and 120 kg/ha) were studied in a factorial randomized block design with four replications. Replacement series technique (De Wit 1960) was used in which the overall plant density was kept constant. Sowing of wheat *cv. GW-273* was done in microplots of 1 m^2 by drilling the seeds in rows 20 cm apart. All plots uniformly received 60 and 40 kg P_2O_5 and K_2O/ha applied before sowing. Fertilizer N was applied as urea, as full basal dose in case of low N

(20 kg/ha) and as 50% basal and 25% each at first and second irrigation in case of high N (120 kg/ha). Other weeds which emerged later were manually removed. However, after 35 days, no attempt was made to remove freshly germinated weeds, if any, except in weed free plots. All broadleaved weeds and grassy weeds other than *P. minor* and *A. ludoviciana* were removed by hand pulling.

Gas exchange measurements were made by using portable infrared gas analyzer (IRGA, model LI 6400 P, LI COR Biosciences, Inc. 4421 Superior Street, Lincoln, Neraska 68504). A constant volume flow rate of 500 cm^3 $/min^1$ dry air was used. To minimize fluctuations in CO_2 concentration, the inlet air was drawn through a sampling mast located around 5 m away from the IRGA. Broadleaf chamber (maximum 6 cm^2) was used for wheat, *P. minor* and *A. ludoviciana*. Measurements were made starting at 09.30 GMT and were done on 4 plants of each species per plot. During measurement, the leaf chamber was clamped over the central portion of the leaf with the adaxial surface of the uppermost leaf. Light Emission Device (LED) was used and PAR of 1000 µmoles/m^2/s was maintained. In wheat and both weeds, measurements were made on flag leaf of the main stem as it became fully expanded at that time *i.e.* 60 DAS. Leaf Area Index was determined by using an automatic area measurement system (Delta-T Devices Ltd.).

Two sets of analyses were performed on the data. The effects of N supply and competition were determined by computing analyses of variance on the data recorded for each separate species. The effects of N supply on the relative competitive ability of the two species were determined by calculating relative yields, the relative yield total of the mixture and relative crowding coefficient. According to method of Spitters and Van den Bergh (1982), the relative yield (RY) of each species was calculated as: (yield per plot in mixture/yield per plot in monoculture). The relative yield total (RYT) was calculated according to de Wit and Van den Bergh (1965) as the mean of the relative yields 0.5X (RY_{crop} + RY_{weed}) and relative crowding coefficient (RCC) as the ratio of the relative yields (RY_{crop}/ RY_{weed}). RY, RCC and RYT were determined for total dry weight and total N uptake.

RESULTS AND DISCUSSION

A significant decrease in total dry weight and ears/m row length of wheat was recorded at low N level (Table 1). Wheat grain yield and total N uptake were significantly lower at low N with both weed species. Total dry weight of wheat was significantly lower in mixture than in monoculture at both N levels. The data for grain yield followed the similar trend of dry weight. In both the experiments lower grain dry weight in mixture was due to significant decrease in number of ears/m row length. In the experiment with both weed species, the number of grains/ ear was lower in mixture at low N level with a significant reduction at low N with *A. ludoviciana.* Iqbal and Wright (1997) also obtained similar results in their study on effects of nitrogen supply on competition between wheat and three annual weed species.

Averaged over the two N levels, *A. ludoviciana* was more competitive than *P. minor*. It resulted in decrease in

Table 1. Effects of nitrogen and weed competition on wheat dry weight, grain yield and yield components and N uptake of wheat and weeds

Parameter	Weed species	High		Low		LSD (P=0.05)
		Monoculture	Mixture	Monoculture	Mixture	
Wheat						
Total dry weight (g/m^2)	*P. minor*	1334	1153	1032	874	120.5
	A. ludoviciana	1310	1061	996	735	133.1
Grain yield (g/m^2)	*P. minor*	572	404	361	230	69.2
	A. ludoviciana	556	295	357	242	64.1
No. of ears/m row length	*P. minor*	68.2	46.2	42.3	39.2	3.0
	A. ludoviciana	70.2	38.4	39.3	30.1	0.9
No. of grains/ear	*P. minor*	57.2	51.1	52.3	50.4	2.6
	A. ludoviciana	55.1	53.2	49.6	41.3	2.9
Total N uptake (g/m^2)	*P. minor*	8.1	6.3	6.1	4.2	0.3
	A. ludoviciana	8.3	5.9	5.7	3.9	0.3
Weeds						
Total dry weight (g/m^2)	*P. minor*	598	396	283	245	60.7
	A. ludoviciana	542	472	305	341	52.1
Total N uptake (g/m^2)	*P. minor*	4.2	4.0	3.4	3.2	0.4
	A. ludoviciana	6.1	9.1	4.8	5.7	0.3

Table 2. Influence of N on relative yield of wheat and weeds, relative crowding coefficient (RCC) and relative yield total (RYT)

	Species	High N		Low N	
		Dry weight	N uptake	Dry weight	N uptake
RY_{wheat}	*P minor*	0.86	0.77	0.84	0.75
	A. ludoviciana	0.80	0.71	073	0.75
RY_{weed}	*P minor*	0.66	0.95	0.86	0.94
	A. ludoviciana	0.87	1.49	1.11	1.18
RCC	*P minor*	1.30	0.81	0.97	0.79
	A. ludoviciana	0.91	0.47	0.65	0.63
RYT	*P minor*	0.76	0.86	0.85	0.84
	A. ludoviciana	0.83	1.10	0.92	0.96

wheat plant dry weight, grain yield and total N uptake by 22%, 41% and 30%, respectively. The corresponding decrease in these parameters because of competition from *P. minor* was 14%, 19% and 26%.

Low N supply significantly decreased plant dry weight of all species, however, its effect on weeds was greater than that on wheat. The decrease in wheat plant dry weight at low N varied from 23% to 26% while it was 35% and 20% for *P. minor* and wheat, respectively. *A. ludoviciana* depleted significantly higher amount of N in mixture than in monoculture while it was just reverse for *P. minor.* This shows the high competitive ability of *A. ludoviciana.*

Competitive ability of wheat and weeds

The effects of N supply on competitive ability were examined by calculating plant relative yields (RY), relative yield total (RYT) and relative crowding coefficient (RCC) (Table 2). In both experiments, RY of wheat was <1, indicating greater effects of interspecific competition than that of intraspecific competition. In the study with *P. minor,* for both species and N treatments, relative yields (RY) were <1 for both dry weight and N uptake. The effect of low N was to decrease the relative yield of wheat (for dry weight and N uptake) and increase the relative yield of weeds (for dry weight). The RYT was <1 for dry weight and N uptake, indicating that mutual antagonism or allelopathy was occurring. The values of RCC indicate that wheat was more competitive than *Phalaris minor* at high N, but less competitive at low N. The results were in conformity with those obtained by Iqbal and Wright (1997).

In the study with *A. ludoviciana,* RY of weed was greater than that of wheat for both dry weight and N uptake. This shows that, for this species, the effects of intraspecific competition were greater than those of interspecific competition. RYT was close to unity at both N levels, indicating both species competing for limiting sources. RCC was <1 indicating, weed was more competitive than crop at both N levels.

Gas exchange

Significant reduction in photosynthesis of wheat was found by lowering the N dose in monoculture (Table 3). *A. ludoviciana* significantly lowered the rate of photosynthesis (*P*n) at low N application rate. Averaged over the two stand types (monoculture and mixture), the decrease in *P*n of wheat was 38.5% and 40.3% with *P. minor* and *A. ludoviciana*, respectively, while it was 24.2% and 36.5% for *P. minor* and *A. ludoviciana*, respectively. Photosynthetic rate of *P. minor* and *Avena ludoviciana* decreased significantly in mixture at low N level than pure cultures at high N. At low N wheat suppressed *P. minor* by increasing its *P*n. Photosynthesis of both weed species was found to be less than wheat crop. Wheat reduced photosynthesis of weeds to a greater extent as compared to pure weed population. In case of monoculture *A. ludoviciana* at low N also showed significant reduction in *P*n as compared to high N. *A. ludoviciana* exhibited higher values of *P*n as compared to *P. minor* at both N levels and both stand types (monoculture and mixture). Hence *A. ludoviciana* had more suppressive effect on wheat than *P. minor.*

There is no detectable effect of competition from *P. minor* and *A. ludoviciana* on stomatal conductance (g_s) of wheat. In contrast stomatal conductance of both weed species reduced significantly in mixtures at low N level.

In wheat sub-stomatal CO_2 conductance (C_i) decreased in mixture with *P. minor* and increased with *A. ludoviciana* indicating poor efficiency of CO_2 consumption of wheat with *A. ludoviciana.* C_i of *A. ludoviciana* was significantly higher in mixture with low N, indicating poor utilization of CO_2 in the process of photosynthesis. *P. minor* showed poor efficiency of CO_2 utilization than *A. ludoviciana* at both N levels.

Leaf parameters

Low N significantly decreased the LAI and leaf chlo-

Table 3. Effects of nitrogen supply and competition on net photosynthesis *(P*n), stomatal conductance (g_s) and substomatal CO_2 conductance (C_i) of the flag leaf of wheat and weeds

Parameter	Species	High N		Low N		LSD (P=0.05)
		Monoculture	Mixture	Monoculture	Mixture	
Wheat						
*P*n (µmol $CO_2/m^2/s$)	*P. minor*	12.26	9.96	5.56	8.10	4.2
	A. ludoviciana	12.73	9.23	7.10	6.0	2.9
g_s(mol/m^2/s)	*P. minor*	0.19	0.20	0.11	0.16	0.12
	A. ludoviciana	0.20	0.15	0.12	0.13	0.06
C_i(µL/L)	*P. minor*	228.63	217.06	262.25	251.21	19.0
	A. ludoviciana	218.50	242.75	230.41	272.12	18.2
Weeds						
*P*n (µmol $CO_2/m^2/s$)	*P. minor*	6.41	5.37	5.06	3.87	1.6
	A. ludoviciana	9.82	7.60	5.41	5.65	2.7
g_s(mol/m^2/s)	*P. minor*	0.13	0.08	0.13	0.07	0.03
	A. ludoviciana	0.17	0.12	0.10	0.09	0.06
C_i(µL/L)	*P. minor*	255.88	226.0	264.03	254.0	30.5
	A. ludoviciana	205.6	220.1	241.50	242.13	21.7

Table 4. Effect of nitrogen supply on leaf area index and leaf chlorophyll content of wheat and weeds

Parameters	Species	High N		Low N		LSD (P=0.05)
		Monoculture	Mixture	Monoculture	Mixture	
Wheat						
LAI	*P. minor*	4.37	2.83	2.47	2.37	0.25
	A. ludoviciana	4.07	2.10	2.13	1.93	0.25
LC (mg/g fresh wt.)	*P. minor*	3.69	3.10	2.73	2.47	0.23
	A. ludoviciana	3.63	2.97	2.73	2.60	0.34
Weeds						
LAI	*P. minor*	3.43	2.97	2.47	1.90	0.34
	A. ludoviciana	4.57	2.93	2.70	2.20	0.25
LC (mg/g fresh wt.)	*P. minor*	2.37	2.00	1.77	1.50	0.15
	A. ludoviciana	3.20	2.20	2.10	1.70	0.23

rophyll content of wheat and *P minor*, both in monoculture and mixture (Table 4).

Leaf Area Index (LAI) and leaf chlorophyll (LC) content of both wheat and weeds were at par in mixture at high N and in monoculture at low N, indicating higher competitiveness (for nitrogen) of *A. ludoviciana.* Averaged over the two stand types (monoculture and mixture) and both weed species, low N decreased LAI of wheat by 33% and LAI of *P. minor* and *A. ludoviciana* by 32% and 35%, respectively. Both weed species resulted in a significant reduction in LAI of wheat. Averaged over the two N levels these were 24% and 35% for *P. minor* and *A. ludoviciana,* respectively. There was significant decrease in wheat leaf chlorophyll content with *P minor* at both N levels and with *A. ludoviciana* at high N level. In weeds, the LAI was also significantly lesser in mixture than in monoculture at both N levels. Leaf chlorophyll content was significantly lower in mixture than in monoculture in both weed species.

The results of the present investigation have shown that wheat was more competitive than *P. minor* at high N, but less competitive at low N. However, *A. ludoviciana,* was more competitive than crop at both N levels.

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