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EFFECT OF *DELPHINIUM CONSOLIDA* (L.) DENSITY ON WHEAT YIELD AND ITS COMPONENTS UNDER VARIOUS NITROGEN REGIMES

SUMMARY

Field experiments were conducted during 2010–2011 to study competition between winter wheat and *Delphinium consolida* L. at five weed densities (0, 5, 15, 25, 35 plants m^{-2}) and three nitrogen levels of fertilizer (0, 200, 300 kg N ha^{-1}). The experimental design was a randomized block with four replicates. The parameters were recorded for wheat density, plant height, spike length, number of grains per $spike^{-1}$, grain weight $spike^{-1}$ and 1000 grain weight. The effect of wheat grain yield was established. The results showed that the competitive effect on wheat depends on the density of weeds. Significant differences between *D. consolida* L. densities were observed for most of the parameters. Wheat density, height of plant and grain yield decreased with the increase in weed density. The increase of nitrogen levels improved the competitive abilities of the wheat and effected the inter-specific competitive interactions. Differences in nitrogen levels at interactions with weed density were significant only for grain yield and spike length.

Key words: Wheat, *Delphinium consolida* L., density, nitrogen levels, yield components, grain yield

INTRODUCTION

Delphinium consolida L. is considered to be the most troublesome broadleaved weed for cereals in Bulgaria and causes economic losses in these crops. Competitive interactions of wheat and *D. consolida* L. can be effected by weed density and nutritional conditions. In the contemporary investigations the effect of weed density was studied in the weeds: *Avena ludoviciana* L. and *Rumex spinosus* L. (Wallia and Manprect, 2005), *Alopecurus myosuroides* L. and *Avena. Spp.* (Mennan et al., 2003), *Avena fatua* L. (Nakova, 2003a; Hassan and Haroon, 2006; Khan and Hassan, 2006), *Papaver rhoeas* L. (Nakova, 2003b), *Galium aparine* L. (Nakova, 2007), *Silibum marianum* L. (Khan et al., 2005), *Secale cereale* L. (Amini et al., 2005), *Chenopodium album* L., *Stelaria holostema* L., *Fumaria spp, Polygonum aviculare* L. and *Convolvulus spp* (Ghanbai et al., 2005). The authors found the effects of density in terms of the wheat grain yield and its components. An increase in weed density resulted in a reduction in wheat growth and yield components. The greatest number of spikes

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m^{-2}, spike length, number of grains per $spike^{-1}$ and 1000 grain weight were recorded for wheat monocultures. These morphological parameters decreased with increases in weed density. Wheat yield components were considered as an index for effect of weed competition on wheat grain yield.

Nitrogen (N) is the nutrient that most often comes into play in crop-weed competition. Competition for nitrogen between wheat and weeds is influenced by the amount of N and the weed species. Mechanisms of yield elaboration in wheat have been studied in different situations of inter-specific competition and nitrogen nurture (Blackshaw, 2004a; Blackshaw et al., 2004b; Blackshaw et al., 2005). Nitrogen was found to have a higher effect on radiation use efficiency of *Avena fatua* L. than on that of wheat at rates 25, 50, 75 and 100 kg ha^{-1} (Ahmadvand, 2005a; Ross and Acker, 2005). Intra- and inter-specific competition indices and Nich differration indices of wheat and *Avena fatua* L. at different nitrogen topdressing levels (0, 70, 140, 210 and 250 kg N ha^{-1}) showed that weeds are more competitive than wheat and increasing nitrogen fertiliser increases its competitive ability (Ahmadvand, 2005b). N at 180 kg ha^{-1} significantly reduced the dry matter accumulation of *Phalaris minor* L. The two-split application of N also significantly increased grain yield compared to single application (Wallia and Amandeep, 2004). The date of nitrogen application could be a good way to reduce the aggression of *Veronica hederifolia* L. if there is no other major factor restricting wheat development. When the onset of competition of a weed species is compared with the phases of formation of wheat yield components, it should be possible to adjust the nitrogen dose at a favourable time in order to enhance the establishment of yield components not affected by weeds (Angonin et al., 1996).

The data found in the contemporary literature on the effect of *D. consolida* L. at different densities on wheat yield and its components at various nitrogen levels were very little. Maneva (2007) investigated the competitive relationship between wheat and *D. consolida* L. in various densities (0, 1, 2, 3, 8, 15, 19, 21, 29, 32, 33, 35, 40, 42, 48, 50, 51, 58, 64, 72, 96 plants per m^2) in field conditions. Reductions of all of them observed morphological parameters of the productiveness – wheat spike m^2, wheat spike length, spikelets $spike^{-1}$, number of grains per spike, grain weight of $spike^{-1}$ and grain yield, presented as an index of depression, was strong for *D. consolida* L. The wheat spike m^2 showed the strongest decrease (45% respective to the control). Increasing the weed density could reduce the grain weight $spike^{-1}$ at 45%. The number of spikelets $spike^{-1}$ was the least affected by the weed competition, at nearly 4%.

In view of the importance of the wheat *D. consolida* L., competition experiments were conducted to investigate the impact of various weed densities on wheat, with these objectives: (i) to investigate the competition between wheat and *D. consolida* L. at various densities; (ii) to study the response of wheat to different nitrogen levels; and (iii) to decipher the interaction of *D. consolida* L. and wheat at different nitrogen levels and populations.

MATERIAL AND METHODS

Two field experiments were set up in 2010 and 2011 on fine sandy loam soil at Plant Protection Institute, Kostinbrod, Bulgaria. The experimental design was a randomized complete block with four replicates. Treatments consisted of five *D. consolida* L. densities (D_1 0; D_2 5; D_3 15; D_4 25; D_5 35 plants m^{-2}) and three nitrogen levels (N_1 0; N_2 200; N_3 300 kg N ha^{-1}). Plot size was 10 m^{-2} (1m wide x 10m length). Seed of weed was not planted as there were sufficient natural soil reserves of seed of this species. The seed of Pobeda wheat variety were sown at 190 kg ha^{-1} in October during the both years. All the recommended cultural practices were carried out uniformly in all the treatments during the experiments expect for variables intended for studies. The numbers m^{-2} of *D. consolida* L. plants for each variant present at harvest were determined. All other weeds removed by hand during the crop cycle. The fertilizer treatments were applied to the plots in the spring of each year. The conventional fertilizer was ammonium nitrate, which was applied at the same total rate of N. The experiments were harvested in the late July or early August.

The data were recorded on wheat: density m^{-2}, wheat plant height (cm) at maturity, wheat spike length (cm) at maturity, number of grains $spike^{-1}$, grain weight (g) $spike^{-1}$,1000 grain weight (g). These yield components were determined on 100 wheat plants from every repetition in all treatments. Grain yield (kg ha^{-1}) by variants and replications was established.

The data recorded individually for each parameter were subjected to the ANOVA by using SAS Version 5.0 and the significant means were separated by using Duncan`s new multiple range test. The tables are based on the average data over the period 2010-2011.

RESULTS AND DISCUSSION

The data (table. 1) exhibit that among the *D. consolida* L. densities maximum (362.0) wheat density was recorded in 0 number m^{-2} (control) while minimum (275.8) wheat density was found in 35 weeds m^{-2}. Between the nitrogen levels, maximum (320,4) wheat density was recorded in 300 kg N ha^{-1} while minimum (277.4) wheat density in 0 kg N ha^{-1} was established. For interaction of nitrogen with the weed densities the maximum was recorded in N_2D_1 while minimum wheat density was in N_1D_5 treatment.

Between the *D. consolida* L. densities, maximum wheat plant height was obtained (90.1cm) in 0 (control treatment) while minimum (83.8 cm) war recorded in 15weed plants m^{-2}. For the nitrogen rates wheat plant height varies many little. It was established for the interaction the maximum (90.5cm) wheat height in N_3D_1 and minimum (80.8 cm) wheat height in N_3D_3 treatments (Table 2).

Results in (table 3) showed that among the weed densities have no significant differences on wheat spike length. Data exhibit that for the nitrogen levels wheat spike was longest at 300 kg N ha^{-1} and shortest at 200 kg N ha^{-1}, respectively. For interaction of nitrogen levels with weed densities the maximum wheat spike length was established in $N_3D_1$and minimum in N_2D_2 treatments.

Table. 1 Wheat density m^{-2} affected by different nitrogen levels and *D.consolida* L. densities.

N level ($kg\ ha^{-1}$)	*Delphinium consolida* L. densities m^{-2}					N mean
	0	5	15	25	35	
0	343.5	305.3	288.0	295.8	254.8	277.4
200	386.8	284.0	266.3	323.5	288.8	310.2
300	355.8	322.0	348.3	292.3	284.0	320.4
Density means	362.0a	300.1b	300.8b	303.8b	275.8bc	

Table. 2 Wheat plant height (cm) affected by different nitrogen levels and *D. consolida* L. densities

N level ($kg\ ha^{-1}$)	*Delphinium consolida* L. densities m^{-2}					N mean
	0	5	15	25	35	
0	89.7	88.3	87.4	89.1	85.2	87.9
200	90.2	85.8	83.3	90.5	87.4	87.4
300	90.5	87.7	80.8	84.7	85.2	87.7
Density Means	90.1a	87.3abc	83.8c	88.1ab	85.9bc	

Table.3 Wheat spike length (cm) affected by different nitrogen levels and *D. consolida* L. densities

N level ($kg\ ha^{-1}$)	*Delphinium consolida* L. densities m^{-2}					N mean
	0	5	15	25	35	
0	8.6ab	8.7ab	8.7ab	9.1ab	8.9ab	8.8
200	8.5b	7.8b	8.7ab	8.3b	8.7ab	8.4
300	10.0a	8.7ab	8.6ab	8.5ab	8.3b	8.8
Density Means	9.0	8.4	8.6	8.6	8.6	

Table. 4 Number of grains spike affected by different nitrogen levels and *D. consolida* L. densities

N level ($kg\ ha^{-1}$)	*Delphiniun consolida*L. densities m^{-2}					N mean
	0	5	15	25	35	
0	48.6	49.2	52.5	53.2	49.2	50.5
200	56.6	54.2	53.8	49.7	53.7	53.6
300	66.3	52.3	43.8	48.5	43.1	50.8
Density Means	57.1	51.9	50.0	50.4	42.0	

The data (table 4) exhibit that among the nitrogen levels, the maximum (53.6) number of grains $spike^{-1}$ were recorded in 200 kg N ha^{-1}, but minimum (50.5) was found in 0 kg N ha^{-1}. Among the *D. consolida* L. densities the maximum (57.1) number of grains $spike^{-1}$ were recorded in 0 (control) while minimum (42.0) numbers of grains $spike^{-1}$ were found in 35 number m^{-2}. For the

interaction of N with weed densities the maximum and minimum of grain spike were recorded in N_3D_1 and N_3D_5 treatments, respectively. The results from effect of different nitrogen levels and weed plant densities on grain weight spike^{-1} were unidirectional with these presented in table 4 (Table 5).

Table. 5 Grain weight spike (g) affected by different nitrogen levels and *D. consolida* L. densities

N level (kg ha^{-1})	*Delphinium consolida*L. densities m^{-2}					N mean
	0	5	15	25	35	
0	1.77	1.57	1.91	2.01	1.85	1.82
200	1.89	1.97	1.86	1.54	1.56	1.76
300	2.20	1.69	1.60	1.60	1.87	1.79
Density Means	1.95	1.74	1.79	1.71	1.76	

Table.6 1000 grain weight (g) of wheat affected by different nitrogen levels and *D. consolida* densities

N level (kg ha^{-1})	*Delphinium consolida* L. densities m^{-2}					N mean
	0	5	15	25	35	
0	44.32	43.33	41.91	40.15	39.56	41.85
200	44.74	42.13	43.15	41.20	40.37	42.31
300	44.08	40.39	41.91	41.77	40.49	41.92
Density Means	44.38a	41.95ab	42.33ab	41.04b	40.14b	

Table.7 Grain yield (kg ha^{-1}) affected by different nitrogen levels and *L. D. consolida* L densities

N level (kg ha^{-1})	*Delphinium consolida* L. densities m^{-2}					N mean
	0	5	15	25	35	
0	2960	2590	3130	2310	1750	2548ab
200	2780	2620	2570	2420	1870	2332b
300	3810	2810	3250	2470	2140	2890a
Density means	3190a	2680bc	2990ab	2400c	1920d	

Results in table 6. showed that *D. consolida* L. densities m^{-2} from 5 to 35 have negative effect on 1000 grain weight of wheat. The best 1000 grain weight was found in control variants (0 plant). Among the nitrogen levels and their interference with weed densities have no influence on 1000- grain weight.

The data in table 7 show that for the nitrogen levels, the maximum (2890 kg ha^{-1}) grain yield was observed in 300 N kg ha^{-1}. Among the weed densities, the maximum (3190 kg ha^{-1}) grain yield was recorded in 0 *D. consolida* L. density (control variant). Regarding interaction of nitrogen with weed density it is, although not statistically significant. The highest grain yield (3810 kg ha^{-1})

was observed in N_3D_1, while minimum grain yield (1750 kg ha^{-1}) was observed in N_1D_5 treatments.

Statistical analysis of data indicated that wheat density was significantly affected by *D. consolida* L. densities. Increasing the proportion of weed plant wheat density decrease. These results showed that wheat competed with the *D. consolida* L. plants more efficiently at highest weed densities rather than lowest weed densities. The magnitude of wheat density losses were weed density dependent. The reason could be the higher inter-specific competition among two species at higher weed densities. Increased of nitrogen levels resulted in increase wheat density. Interaction between different nitrogen regimes and weed plant densities was not statistically significant. The main factor that affected wheat density was weed population. Our conclusions are in line with the work of (Kazincz *et al* 1998), who have confirmed that early emerging of *D. consolida* L. was more vigorous and competitive with wheat.

Wheat plant height at maturity was also affected mainly from weed densities. Increasing *D. consolida L.* L. density decreased wheat height which showed that inter-specific competition starts early at highest weed densities. The effect of different nitrogen levels was not significant. Interference between two factors weed density and fertilizer rates on wheat plant height it was not established.

Statistical analysis of the data showed that nitrogen levels and *D. consolida* L. densities have not significant effect alone, but interaction has significant influence on wheat $spike^{-1}$ length. Increasing weeds that nitrogen increases interference of competition of species for joint resources. The data exhibit that the spike length in wheat is strictly under genetic control (v. Pobeda) and not significantly influenced by the environment.

With increasing of density of *D. consolida* L. plants, the yield components- number of grains and grain weight $spike^{-1}$ decreased. The reduction in these parameters resulted in the reduction of grain yield. There was not effect of nitrogen on these studied parameters. The reproductive components observed varied under different combinations of both factors and in means were not statistically significant. For example, components decreased or did not significantly vary in treatments with *D. consolida* L. and treated with 200 and 300 kg N ha^{-1}, indicating that weed competition decrease the exploitation of additional nitrogen fertilize by wheat.

Wheat 1000 grain weight was significantly affected by weed densities while nitrogen level and relationships of weed plant densities and fertilizer rates were not statistically significant for the study parameter. Our results depict that weight was directly proportional to the weed density. Under the lesser densities of weed the wheat was able to make better use of soil and environmental resources and partition higher photosintate to the grains resulting in bolder grains. These findings are in agreement with the work of (Gonsales and Satin, 2001).

Statistical analysis of data revealed that nitrogen levels and *D. consolida* L. densities were statistically significant, while their interaction was not significant for grain yield. Increasing proportion density of weed plants decreased wheat grain yield, but increasing nitrogen fertilizer increases competitive ability of wheat against *D. consolida* L., respected in grain yield. Previous reports in the literature reach clear conclusions where reduced wheat grain yield, as a result of competition will be affected by reduced N supply. High level of N applied to wheat may increase the competitive success of wheat against *D. consolida* L, which is in agreement with (Rrood-Williams 1985; Roone *et al* 1990).

CONCLUSIONS

Inter-specific competition between *Delphinium consolida* L. and winter wheat for two factors, i.e. weed densities (0, 5, 15, 25 and 35 plants m^{-2}) and 3 levels of nitrogen fertilizer (0, 200 and 300 kg N ha^{-1}) was established. Under different fertilizer levels, the increase in *D. consolida* L. density resulted in the reduction of yield components and the reduction of grain yield was greater than the decrease in other yield parameters. The rate of nitrogen application is an important factor. Under all weed densities, the increase in nitrogen rate to 200 kg ha^{-1} and 300 kg ha^{-1} resulted in mainly increases in wheat density and grain yield. Increasing the nitrogen rate of wheat reduced the adverse effects of *D. consolida* L. on wheat and improved their interactions.

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UTICAJ GUSTINE DELPHINIUM CONSOLIDA (L.) NA PRINOS PŠENICE I NJENE KOMPONENTE POD RAZLIČITIM REŽIMIMA PRIMJENE AZOTA

SAŽETAK

Tokom 2010-2011. godine, vršeni su ogledi radi proučavanja konkurencije između zimske pšenice i *Delphinium consolida* L. u pet gustina korova (0, 5, 15, 25, 35 biljaka/m^{-2}) i sa tri nivoa primjene azotnog đubriva (0; 200; 300 kg N ha^{1}). Ogled je sproveden po sučajnom blok sistemu sa četiri ponavljanja. Parametri bilježeni kod pšenice: gustina, visina biljke, dužina klasa, broj zrna po $klasu^{-1}$, masa zrna po $klasu^{-1}$, masa1000 zrna. Utvrđen je uticaj na prinos pšenice. Rezultati su pokazali da uticaj konkurencije na pšenicu zavisi od gustine korova. Zapažene su značajne razlike u većini parametara zavisno od gustine *D. consolida* L. Gustina pšenice, visina biljke i prinos zrna opadao je sa povećanjem gustine korova. Povećanje nivoa azota poboljšalo je konkurentne sposobnosti pšenice i uticao je na interakcije konkurencije između ove dvije vrste. Razlike u nivoima azota u interakciji sa gustinom korova bile su značajne samo za prinos zrna i dužinu klasa.

Ključne riječi: pšenica, *Delphinium consolida* L., gustina, nivoi azota, komponente prinosa, prinos zrna