Using plant density to increase competition ability in more and less competitive wheat cultivars with Wild oat

Mohammad Armin[1], Eskandar Zand and mohammad Ali Baghestani

1-Department of Agronomy, Faculty of Agriculture, Islamic Azad University, Sabzevar, Iran Email:moh_armin@yahoo.com

Abstract

Wild oat is a major weed of field crops in Iran. The effects various densities of wild oat and wheat on the growth and reproductive output of wheat and growth of wild oat were investigated in field study in 2004. The experiment was established as a factorial combination of wheat varieties (Rooshan and Niknejad) wheat density (recommended, recommended+25% and recommended+50%) and wild oat (0, 25, 50, and 75 plants m^{-2}) densities. The effect of wild oat density on wheat yield loss and the effect of wheat density on wild oat biomass were described with a rectangular hyperbola model. The presence of wild oat in wheat reduced grain yield of wheat, number of tiller, number of spike m^{-2} , and the magnitude of this reduction was dependent on weed density. Increasing the density of wheat significantly reduced the unpleasant effects of wild oat on wheat. Wild oat biomass was decreased, as crop density increased. The maximum grain yield of Niknejad and Rooshan were achieved at its recommended+25% and recommended wheat density, respectively and increased density due to increase inter specific competition decrease grain yield at two cultivars. As wild oat density increased, Number of tiller per plant, spike m^{-2} decreased. The results indicated that higher densities of wild oat had heights negative effect on wheat yield and higher wheat densities were able to suppress biomass of this weed species.

Key words: plant density, yield loss, wild oat, competition

INTRODUCTION

A major component of integrated weed management is the use of more competitive crops(Lemerle et al., 2001).If a crop cultivar can tolerate weeds, it may reduce the need for synthetic herbicide, allow the use of less costly and more environmentally sound herbicides, decrease the number of cultivations, or improve yield stability in weedy fields (Lindquist and Mortensen 1998; Lemerle, et al 2001). Large differences exist in the competition ability(CA) of field crops. Baghestani and Zand (2005) found that Niknejad had more CA than Rooshan. CA for Niknejad and Rooshan was 1.7 and 0.56, respectively on wild oat competition. Volunteer barley density had little or no effect on wheat yield at the high wheat seeding. Wheat yield loss was often lower and economic threshold values were higher at the higher wheat-plant densities(O'Donovan et al. 2007). Eslami et al.(2006) reported increasing the density of wheat substantially reduced the adverse effects of wild radish on wheat. As crop density increased, wild radish dry matter, LAI, and seed production per unit area decreased. Wild oat density can have a considerable impact on crop-weed interactions mainly through competition for nutrients and water. In Canada, 150 wild oat plants.m^{-2} emerging 6 days before the crop reduced barley yield by 42% (O'Donovan et al., 2000). Integrated weed management practices, such as using more competitive wheat cultivars and increased plant density, potentially improve weed management (Holman et al. 2004).Yet, few studies compare competitive interactions of weeds with different crops.

METHODS

The factorial set of treatments was arranged within a randomized complete block design with four replicates at Plant, Pest and Disease Institute in Karj IRAN. Individual plot size was 2.4 m wide by 6 m long. Treatments consisted of two cultivars Niknejad and Rooshan (as more and less competitive respectively) 3 plant densities, their recommended density (300 and 450 for Rooshan and Niknejad, respectively); recommended density+25%; and recommended density +50% and 4 wild oat densities (0, 25, 50 and 75 plants/m^2). Wheat cultivar was sown on 10th November 2004 by hand in rows 30 cm apart. The seeds of wild oat were broadcast by hand on the soil surface between wheat row immediately after sowing the wheat. Wild oat seedling density was determined at the

1 to 2-leaf stage of wild oat in two 0.25 m^{-2} quadrates positioned approximately 1 meter from the front and back of each plot. Grain yields were determined by harvesting a 1* 1 m area in each plot. The area outside the harvest plot was used for sampling of above-ground biomass. Yield component was taken as the average of 30 counts of ears in 0.1 m^2 rings randomly placed in each plot. The harvest index was calculated as the ratio of dry matter grain yield to wheat above-ground dry matter. The yield and yield component and biomass data were subjected to analyses of variance using the ANOVA procedure of the SAS statistical analysis system (SAS Institute, 1996). Competitive index (CI) was calculated on the basis of the following equation(Zand and Becki 2002):

$$CI = \frac{V_i}{V_{mean}} \times \frac{W_i}{W_{mean}} \qquad \text{Eqn 1}$$

Where V_i is the yield of each weed-infested cultivar, V_{mean} the mean wheat yield in all weed-free plots, W_i the biomass of wild oat in each weed-infested plot and W_{mean} the mean biomass of wild oat in all weed-infested plots. The effect of the crop on the weed was evaluated by analysing the relationship between *A. ludoviciana* biomass and *A. ludoviciana* plant density for each plant density of wheat separately. The model selected to fit the data was the rectangular hyperbolic equation proposed by Cousens (1985):

$$Y = \frac{I * D}{1 + \frac{I * D}{A}} \qquad \text{Eqn 2}$$

where *y* is the biomass in g·m^{-2} of *A. ludoviciana*, *d* is the weed density in plants·m^{-2}, *i* is the weed biomass per unit weed density as *d* approaches zero and *a* is the maximum weed biomass at infinite weed density.
The effect of the weed on the crop was evaluated by analysing the relationship between weed density and wheat grain yield separately for each plant density, using the rectangular hyperbola described by Cousens (1985):

$$Y = Ywf \left[1 - \frac{I * D}{100 \left[1 + \frac{I * D}{A} \right]} \right] \qquad \text{Eqn 3}$$

where *y* is the yield of wheat , *Ywf* is the weed-free yield, *i* is the yield as weed density approaches zero, *a* is the maximum yield at infinite weed density and *d* is the weed density in plants.m^{-2}.

Results

In both weed-free and weed-infested conditions, Niknejad had greater grain yield compared to the Rooshan(tabel 1). High genetic potential, high harvest index and having more ear number per square meter caused more yield in Niknejad. Niknejad also had higher Competitive Index than Rooshan(table 1). Increase in the competitive index was mainly due to higher wheat grain yield, Leaf Area Index(LAI) and dry matter accumulation under weed-infested conditions(data was not shown). The wheat density had significant effects ($P<0.01$) on all growth and seed production attributes of both wheat and *A. ludoviciana* (table 1). Competition index was increase with increasing of wheat density. The highest competition ability was observed in the highest wheat density (table 1). The component of yield which showed significant response to plant density are presented in table 1. Number of tillers and number of spike.m^{-2} were the components which were affected by plant density. Maximum of tillers were absorbed in recommended density and increase plant density to 50% decreased 23% number of tillers. Decrease in fertile tillers with increasing plant density related to low essential supply for growth for one plant. Maximum of spike.m^{-2} was achieved in recommended+50% density. More plant in high plant density caused increase of spike.m^{-2}.Weed biomass showed significant response to increasing of wheat density (table 1).

Table 2. Effects of cultivar, plant density and weed density on some wheat traits and wild oat biomass

	Treatments	Grain yield (Kg ha^{-1})	CI	NO. of tillers ($plant^{-1}$)	NO. of Spike ($plant^{-1}$)	Wild oat biomass ($g.m^{-2}$)
cultivar	Niknejad	5442.5	1.173762	2.525	644.0286	121.9333
	Rooshan	3408.06	0.490065	1.991667	349.6538	114.4417
	LSD(0.05)	149.21	0.033	0.133	49.71	2.05
Plant density	Recommended	4446.87	0.797401	2.525	464.1363	130
	Recommended+25%	4586.56	0.832316	2.3125	495.2544	116.2875
	Recommended+50%	4242.40	0.866023	1.9375	531.1329	108.275
	LSD(0.05)	182.75	0.041	0.163	60.88	2.52
weed density	0	5046.542	0	2.616667	634.4357	0
	25	4540	1.094451	2.35	549.0813	98.9375
	50	4107.083	1.10358	2.083333	445.6813	103.0333
	75	4007.5	1.129622	1.983333	358.1664	106.6167
	LSD(0.05)	211.02	0.047	0.188	70.32	2.91
	CV(%)	8.2	9.92	14.49	24.57	4.27

The relation between *A. ludoviciana* biomass and weed density were hyperbolic in shape in two cultivars with R^2 being 0.79 or higher indicating that *A. ludoviciana* biomass depend on plant and weed densities(figure 1). The *A* parameter (maximum biomass achieved by the weeds) ranged from 310.18 to 255.69 $g.m^{-2}$ in Niknejad and from 297.12 to 244.68 $g.m^{-2}$ in Rooshan in recommended and recommended+50% plant density. The *I* parameter ranged from 9.84 to 7.69 in Niknejad and from 8.12 to 7.49 in Rooshan in recommended and recommended+50% plant density. As expected, the lowest *I* values were always found in the highest crop densities in two cultivars, supporting the concept that high crop stands tend to reduce the aggressiveness of the weed. Wheat grain yield was affected by different densities of *A. ludoviciana* in two cultivars(table 1.). The highest grain yield were found in weed free condition Grain yield reduction was 10.12, 18.80 and 19.95% in 25, 50 and 75 $plant.m^{-2}$ weed density. In both cultivars as *A. ludoviciana* density increased, the wheat yield decreased substantially. There was a hyperbolic relationship between *A. ludoviciana* density and wheat yield loss. The maximum grain yield estimated by the Y_{wf} parameter of the model declined with increasing wheat density (except in recommended+25% in Niknejad) from 6.31 to 5.80 $t.ha^{-1}$(8.08%) in Niknejad and from 4.20 to 3.63(13.73%) in Rooshan. The parameter *I*, which represents yield loss per *A. ludoviciana* plant, showed a steady decline with increasing wheat density in two cultivars . However, the relative change in *I* was considerably greater in Niknejad. The maximum yield loss (parameter *A*) also showed a consistent reduction with increasing crop density.

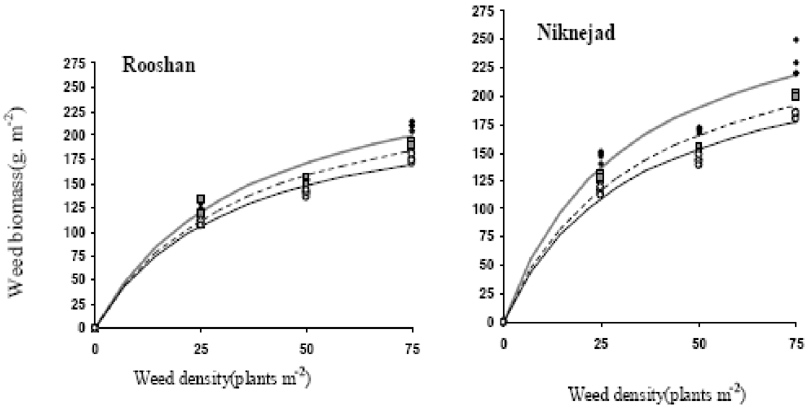

figure 3. Relationships between the biomass (g·m^{-2}) and the density (plants·m^{-2}) of *A. ludoviciana* at the different barley densities

Conclusion

This study indicates that wheat varieties vary in their ability to compete with *A. ludoviciana* .Niknejad compete better with *A. ludoviciana* , because of its higher Leaf Area Index, densely canopy, higher dry matter accumulation , higher growth rate and tiller number. Increasing plant density has long been proposed as a method for improving weed management and negating the effects of weed interference on crop yield. The study showed that in two cultivars yield losses were greatest at the lowest plant density (recommended density) and yield loss from *A. ludoviciana* lessened as plant density increased. Our result confirm pervious reports, where increased plant density decreased crop yield loss due to weed interference. A noteworthy finding in this study was that although, the use of more competitive cultivar and higher plant density may not completely eliminate *A. ludoviciana* competitive effects at high *A. ludoviciana* densities, the use of both tactics results in a more competitive cropping system and may allow for reduction in herbicide rate. Information gained from the current study will be used to develop more integrated programs for weed management in winter wheat .

References

Baghestani MA, Zand E, 2005. The study of competition ability of wheat cultivars against grass weed. Final Report. Plant, pest and disease Institute. 64 pages.

Cousens RD, 1985. A simple model relating yield loss to weed density. Ann. Appl.Biol., 107: 239-252.

Eslami V, Gill GS, Bellotti B, Mcdonald G, 2006. Wild radish (*Raphanus raphanistrum*) interference in wheat. Weed Sci., 54: 749–756.

Holman JD, Bussan AJ, Maxwell BD, Miller PR Mickelson JA, 2004. Spring Wheat, Canola, and Sunflower Response to Persian Darnel (*Lolium persicum*) Interference. Weed Technol., 18: 509–520

Lemerle D, Gill GS, Murphy CE, Walker SR, Cousens RD, Mokhtari S, Peltzer SJ, Coleman R, Lickett DJ, 2001. Genetic improvement and agronomy for enhanced wheat competitiveness with weeds. Aust. J. Agric. Res., 52: 527–548.

Lindquist, JL, Mortensen DA Johnson BE, 1998. Mechanisms of corn tolerance and velvetleaf suppressive ability. Agron. J., 90: 787-792.

O'Donovan JT, Harker KN, Clayton GW, Hall LM, 2000. Wild oat (*Avena fatua*) interference in barley (*Hordeum vulgare*) is influenced by barley variety and seeding rate. Weed Technol., 14: 624–629.

O'Donovan JT, Harker KN, Clayton GW, Hall LM, Cathcart J, Sapsford KL, Holm FA, Hacault K, 2007. Volunteer Barley Interference in Spring Wheat Grown in a Zero-Tillage System. Weed Sci., 55: 70–74.
Zand E, Beckie H, 2002. Competitive ability of hybrid and open pollination canola(*Brassica napus* L) with wild oat(*Avena fatua* L).Can. J. Plant Sci., 82: 473-480.