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Research Article

Competitive Ability of Triticale (*Triticale Hexaploide*) Compared to Barley and Wheat Against *Avena Sterilis* and *Papaver Rhoeas*

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Abstract

This study was conducted to assess the competitive ability of triticale compared to barley and wheat against the important weeds *Avena sterilis* and *Papaver rhoeas* and to evaluate the potential efficacy of reduced rates of herbicides. The experiment was laid out in a split plot - Randomized Complete Block Design (RCBD) with three replications. The results revealed significant differences between the three winter cereals regarding their weed competitive ability, with triticale being more competitive than wheat and less competitive than barley. Moreover, our findings showed that the 50% reduction of the herbicide recommended rate was adequate for the effective control of *A. sterilis* and *P. rhoeas*. Therefore, the further use of triticale instead of wheat in cases of high weed pressure is suggested, while low herbicide doses can be also helpful towards environmental and economical sustainability.

Keywords: *Triticale; Barley; Wheat; Weed Competitive Ability; Reduced Herbicide Rates*

Abbreviations

WAT: Weeks After Treatment; ANOVA: Analysis of Variance

Introduction

Several studies advocate for developing sustainable cropping systems with a reduced reliance on plant protection products including herbicides [1]. Today, one of the major challenges is to keep the weed community at an acceptable level of control rather than to keep the crop totally free of weeds. In some cases, adequate control of weeds and high yields may be obtained even when herbicides are used fewer times and at lower doses than the ones normally recommended [2,3]. In particular, herbicides at reduced doses and combined with other methods are sometimes sufficient to control weed flora and reduce the farmers' costs [1]. Under that concept, the selection of competitive crop plant species or cultivars could also have a pivotal role [4,5]. It has to be noted that significant differences in the weed competitive ability between crop plant species and cultivars have already been documented [6]. Differences in competition ability between species or cultivars may be related to several parameters including morphological properties affecting light interception such as canopy closure, plant height or tiller number [7].

Triticale (*Triticale hexaploide*) is a Man-made cereal grass crop obtained from hybridization of wheat with rye in order to combine the high yields of wheat and the tolerance to the biotic and abiotic stresses of rye [8]. As such, literature is rather inadequate regarding the competitive ability of this species against agronomically important weeds. Therefore, the objectives of this study were to assess the weed competitive ability of triticale in comparison with barley and wheat and evaluate the effects of reduced rates of the herbicide mesosulfuron–methyl + iodosulfuron–methyl–sodium on the density and growth of the weeds *Avena sterilis* and *Papaver rhoeas.*

Materials and Methods

A field experiment was conducted during 2010 (and repeated in 2011) in the experimental field of Agricultural University of Athens (37^{o} 59' 12'' N, 23^{o} 42' 96'' E, 29 m altitude) in order to study the weed competitive ability of triticale (*Triticale hexaploide*) in comparison to barley (*Hordeum vulgare*) and wheat (*Triticum durum*). The previous crop was vetch (*Vicia sativa*). *Avena sterilis* and *Papaver rhoeas* were among the dominant plant species. Total monthly rainfall and mean monthly temperature data are shown in table 1.

Month	Rainfall		Temperature	
	2010	2011	2010	2011
	----------mm----------		----------^{o}C----------	
January	-	-	-	-
February	-	-	-	-
March	11	25.6	14.4	12.2
April	0	40	17.9	15.5
May	7	40.8	22.2	20.3
June	12	30.4	25.9	25.5
July	0	0	29.3	29.7
August	0	0.6	28.4	28.8
September	22.6	3.4	24.9	26.6
October	81.8	38.4	19	17.5
November	15.6	2.2	18.4	12.3
December	25	100.8	13.7	12
Total	175	282.2	-	-

Table 1: *Mean monthly rainfall and temperature during the field experiment in 2010 and 2011.*

The soil was clay loam [9], with pH 7.29 (1:1 H_2O), 15 g/kg organic matter [10] and 160 g/kg $CaCO_3$. All winter cereals were shown on 19 November 2010 and 26 November 2011. A split-plot arrangement of treatments was used with three plots and three replicates in a randomized complete block design. The plot size was 2 X 8 m. In each of the nine plots, four subplots of 2 X 2 m were created. Crop (barley, wheat and triticale) was the main plot factor, while herbicide dose (0, 0.063, 0.126 and 0.25 kg ha^{-1} of the herbicide product Hussar maxx WG) was the subplot factor. The herbicide used (Hussar maxx WG, Bayer Crop Science AG, Monheim, Germany) was a commercial mixture formulated as a water dispersible granule of mesosulfuron-methyl (3% w/w) and iodosulfuron-methyl-sodium (3% w/w) and mefenpyr-diethyl (9%). Mesosulfuron-methyl is a post-emergence grass weed herbicide for wheat, triticale and rye, providing also control of some broad-leaved weeds. This herbicide is mixed with iodosulfuron-methyl-sodium to complement the control of broad-leaved weeds. Both herbicides belong to the group of sulfonylureas. When crops reached the three to six leaf stage (Zadoks stage Z13 - 16, following Zadoks., *et al*. 1974) [11], applications of the above-mentioned doses of herbicide, using a backpack sprayer delivering 300 l ha^{-1} spray solution at 3 kg cm^{-2} pressure.

Mean monthly temperature and rainfall data are given in table 1. Weed density was measured in all subplots at 5 WAT. Additionally, at the ear emergence growth stage of the three winter cereals, the two dominating weeds were harvested and their aboveground biomass

was determined. ANOVA was conducted for all data and differences between means were compared at the 5% level of significance using the Duncan Multiple Range Test at P ≤ 0.05. Means were averaged across the two years in the case of not significant differences. All statistical analyses were conducted using the Statistica 9 software package (Stat Soft, Inc. 2300 East 14th Street, Tulsa, OK 74104, USA).

Results and Discussion

As shown in table 2, weed density was inversely proportional to each herbicide rate. In average, the highest recommended herbicide rate reduced density of *A. sterilis* and *P. rhoeas* by 77 to 92% and 81 to 90%, respectively, compared with the untreated control. On the contrary, the reduction of herbicide rates by 50% resulted to a weed density reduction for *A. sterilis* and *P. rhoeas* ranging from 71 to 83% and from 80 to 81%, respectively.

Year	Herbicide dose (kg ha^{-1})	Weed species	
		A. sterilis	*P. rhoeas*
		–––––––plants m^{-2} –––––––––	
2010	0	14.3a*	9.6d
	0.063	5.3b	3.1ef
	0.126	4.1b	1.8ef
	0.25	3.3b	0.9f
2011	0	14.8a	10.6d
	0.063	4.6bc	3.8ef
	0.126	2.5bc	2.1ef
	0.25	1.2c	1.1f

Table 2: *Density of A. sterilis and P. rhoeas in our field experiment and both years (2010 and 2011) for all treatments, averaged across the three species of winter cereals at 5 WAT. *Means in the same column for each year and species followed by the same letter do not differ significantly using Duncan Multiple Range Test at P≤ 0.05.*

Regarding weed growth (dry weight), barley and wheat were the most and less weed suppressive out of the three winter cereals, respectively, in the absence of herbicide applications (Table 3). In particular, against *A. sterilis*, triticale was 22% more competitive than wheat and 17% less competitive than barley. Also, triticale was 15% more competitive against *P. rhoeas* than wheat and 11% less competitive than barley. Similar differences between cultivated plant species and cultivars have been previously reported [12].

Species	Herbicide dose (kg ha^{-1})	Weed species	
		A. sterilis	*P. rhoeas*
		–––––––––– g ––––––––––	
Barley	0	10.2ab*	6.8bc
	0.063	2.8ef	3.4d
	0.126	1.6f	2.1ef
	0.25	1.5f	1.6f
Wheat	0	15.7a	8.9a
	0.063	6.9bc	4.1cd
	0.126	3.7de	2.1ef
	0.25	2.9ef	1.5f
Triticale	0	12.3a	7.6ab
	0.063	5.1cd	4.1cd
	0.126	2.8ef	2.4ef
	0.25	1.7f	1.8f

Table 3: *Dry weight of A. sterilis and P. rhoeas counted at the ear emergence stage of the winter cereals. *Means in the same column followed by the same letter do not differ significantly using Duncan Multiple Range Test at P≤ 0.05.*

In the case of triticale, the best weed control was achieved with the highest herbicide dose, but lower rates of mesosulfuron + iodosulfuron often provided adequate weed control. The reduction of the upper recommended dose by 50% slightly decreased the control efficiency without any significant differences observed. Table 3 showed that herbicide dose reduced by 50% resulted in the control of *A. sterilis* and *P. rhoeas* up to 77 and 68%, respectively. It has to be noted that in some cases reduced rates of herbicides have been adequately effective against weeds [13]. However, their effectiveness can be further increased and ensured by means of the use of integrated weed management approach and under that view weed competitive crops and cultivars can play a crucial role [14].

Conclusion

Conclusively, the results revealed differences between the three winter cereals regarding their weed competitive ability. In general, the 50% reduction of the herbicide recommended rate was adequate for the effective control of *A. sterilis* and *P. rhoeas*. Our findings showed that triticale can be used instead of wheat in cases of high weed pressure, while low herbicide doses can be also an effective and realistic way to reduce the overreliance on chemical weed management. In all cases, further experiments with more crop and weed species and herbicides in a wide range of soil and climatic conditions are required.

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