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Competition of nine wheat (*Triticum aestivum*) cultivars against *Melilotus alba*

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Abstract

Ranking of crop cultivars competitiveness against the weeds could be an effective strategy in weed management that resulted in increased our knowledge about the crop ability to suppression of weeds. A field experiment was conducted at Qrakhyl Agronomy Research Station, Iran, to evaluate 9 wheat cultivars competitiveness against *Melitotus alba*. Wheat cultivars including Morvarid, Darya, Nai 60, Milan, N-85-5, N-87-4, N-86-7, N-80-19 and Shanghai planted in both presence and absence of *M. alba* in split plot design with four replicates. Competition reduced height, tiller number, grain and biological yield of cultivars. Wheat cultivars showed variations in response to competition. Morvarid cultivar was more successful in reducing *M. alba* biomass. A significant correlation was found between wheat height and weed biomass. Morvarid and Nai60 had the maximum competition index that representing higher ability of the cultivars to inhibit *M. alba* than other ones. Grain yield of wheat cultivars positively correlated with the ability to withstand competition (AWC). The wheat cultivars revealed variations in tolerance to competition.

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Introduction

Weeds can result in high yield losses in cereal crop production systems (Powles *et al.,* 1997). In modern cropping systems herbicides application is the most effective weed management. However, the increasing use of herbicides leads to resistance of weeds to herbicides and enhancement of environmental risks and human healthy. Therefore, reducing herbicide application is one the most important approaches for weed scientist.

In the absence of herbicides, weeds are controlled by agronomic practices, including crop rotations, cover crops, intercropping, tillage (Barberi, 2002; Liebman and Davis, 2000) and improvement of crop competitiveness (Rezvani *et al.,* 2013; Lemerle *et al.,* 2001a).

Increasing the ability of crop to compete against weeds could be an important components of the future weed control strategies (Lemerle *et al.,* 2001b), because using varieties with greater competitive ability can lead to effective weed control with reducing herbicide application (Christensen, 1994; Rezvani *et al.,* 2013).

Results of researches indicated some traits of crops such as tillering, height (Lemerle *et al.,* 2001b) canopy diameter, leaf area and partitioning of leaf area and dry matter (Rezvani *et al.,* 2010) can play effective role in increasing competitiveness.

Korres *et al.* (2002), reported crop tillering capacity as suitable attributes for weed suppression and increased crop yield. Early tillering ability has been related to rice competitiveness in several studies (Dingkuhn *et al.,* 1999). Using competitive wheat cultivars may be an effective approach to suppress weed growth in different farming systems. Results of Lemerle *et al.* (2001a) and Lemerle *et al.* (2001b) have shown some variations in wheat cultivars competitiveness.

In north of Iran several commercial wheat cultivars is planted by farmers. Also, *M. alba* is an exotic weed in north of Iran. But, there is no information about their performance in weedy condition. The objective of the experiment was evaluation competitiveness of 9 wheat cultivars against *M. alba*.

Materials and methods

Experimental site characteristics

The experimental site located at Qarakheyl Crop Research Station (36° 27′ N, 52° 46′ E), Mazandaran, Iran. The soil properties were 32% sand, 42% silt, 26% clay and pH 8.1. Fertilizer was applied according to soil tests. Mean monthly temperature and rainfall data recorded at Qarakheyl Weather Station (over a distance of about 50 m) over the duration of the study are shown in Fig. 1. According our observations in previous years, in the station uniform stand of natural population of *M. alba* growth every autumn in wheat field.

Field experiment was carried out in 2010 and 2011. A split plot experiment was carried out in a randomized complete block design with four replicates in order to investigate effect of 9 wheat cultivar competition ability with natural population of *M. alba*. Presence or absence of *M. alba* were as main plots and 9 wheat cultivars including Morvarid, Darya, Nai 60, Milan, N-85-5, N-87-4, N-86-7, N-80-19 and Shanghai randomized as subplots in main plots.

Wheat planted on 9 December 2010 in plots containing six 3 m long rows spaced 20 cm apart. Pure stands of crop were hand-weeded when needed. Wheat was harvested two weeks after physiological maturity, on 21 June 2011 for grain and biological yield assessment. Two 0.25 m^2 quadrates were placed randomly in wheat and *M. alba* plots at the harvest time and *M. alba* density and biomass and wheat tiller number were determined. Samples were dried at 80 °C for 24 h, and weighed. Final height of wheat and *M. alba* also were measured.

Competition measurements

Tolerance of weed cultivars to competition with *M. alba* calculated (Watson *et al.,* 2006).

$$AWC = \left(\frac{Winfested}{Wpure}\right) * 100 \quad (1)$$

Where AWC is ability to withstand competition, $W_{infested}$ is yield of cultivar i in *M. Alba* infested condition and W_{pure} is yield of cultivar i in *M. alba* free condition. Higher AWC represent ability of crop to weed tolerance.

Another measure of competitive ability is the ability to compete (AC) (Watson *et al.,* 2006), which is calculated:

$$AC = 100 - \left(\frac{bw}{bt}\right) \times 100 \quad (3)$$

Where b_w is *M. alba* biomass and b_t is total *M. alba* and wheat cultivars biomass.

Ability of wheat cultivars to inhibit *M. alba* enhancement biomass (Challaiah *et al.,* 1986) was measured by

$$CI = \left(\frac{Vi}{Vmean}\right) / \left(\frac{Wi}{Wmean}\right) \quad (2)$$

Where CI: competition index, V_i: yield of cultivar i in presence of M. alba, V_{mean}: average of wheat cultivars yield in presence of *M. alba*, W_i: *M. alba* biomass in cultivar i and W_{mean}: average of *M. alba* biomass in presence of wheat cultivars.

Statistical analysis

Grain and biological yield of wheat and *M. alba* biomass were subjected to analysis of variance. Means were tested for significance using the LSD test. Pearson's correlation coefficient between wheat parameters and weed biomass and also competition indices were calculated. The level of significance was $P=0.05$ for all statistical analyses. The SAS (version 9.1) and SPSS (PASW statistics 18) programs were used for the statistical analysis.

Results and discussion

Cultivars yield

Interaction between *M. alba* and wheat cultivars did not influenced on wheat height, tiller number, grain and biological yield of wheat cultivars (Table 1). Wheat cultivars including Morvarid (105.50 cm), Nai60 (103.23 cm) and Darya (99.75 cm) were taller than the other ones. Milan, Shanghai and N-80-19 produced the maximum tiller number (Table 2). Grain and biological yield of wheat cultivars was not varied (Table 2). Table 2 indicates Darya cultivar produced the highest grain and biological yield. The minimum grain and biological yield produced by Shanghai cultivar (Table 2). A significant positive correlation between HI and biological yield of wheat cultivars was observed (Table 3). In presence of *M. alba* a significant correlation between biological yield and grain yield of wheat cultivars was found (Table 4). Also, HI strongly correlated with grain yield in presence of *M. alba* condition. HI inversely correlated with wheat height (Table 4). Yield variations in different wheat cultivars were reported by Mennan and Zandstra (2005), Cousens *et al.* (2003) and Lemerle *et al.* (2001b). Rezvani *et al.* (2013) and Paolini *et al.* (2006) also were found variations in crops yield in weedy conditions. This differential performance of wheat cultivars is due to variation in rapid germination, initial quick growth, tillerring capacity and leaf area (Lemerle *et al.,* 1995; Challaiah *et al.,* 1986). According to Rezvani *et al.* (2010) findings differentials in leaf area and profile of leaf area in canopy could be more effective in light interception that is a key factor in enhancement photosynthesis and yield production of crops.

Table 1. Analysis of variance (Mean Square) of Wheat cultivars parameters.

S.O.V	MS					
	D.F.	Wheat height	Tiller number	Economic yield	Biologic yield	Harvest index
Replicates	3	278.20	0.58	1609441.87	8768118.48	0.003
M. alba	1	5345.78*	$0.29^{n.s}$	3147540.50*	17008872.59*	$0.00002^{n.s}$
Error	3	374.33	0.19	793175.05	844185.05	0.01
Wheat Cultivars	8	1948.30*	0.63*	$320935.30^{n.s}$	$1271539.21^{n.s}$	0.0041*
*M. alba**Cultivar	8	$198.55^{n.s}$	$0.23^{n.s}$	$512014.60^{n.s}$	$1749214.33^{n.s}$	0.0031*
Error	48	14.43	0.23	323326.77	1368484.50	0.001

n.s and *: non-significant and significant difference at 5% level of probability.

Table 2. Mean comparison of wheat yield and *M. alba* biomass.

Wheat cultivars	Wheat height	Tiller number	Grain yield (kgha-1)	Biological yield (kgha-1)	*M. alba* biomass (kgha-1)
N-80-19	93.20d	2.75a	2511.70ab	5145.40ab	2746.5b
Shanghai	97.48c	2.80a	2097.10b	4549.80b	2705.05b
Morvarid	105.05a	2.68ab	2514.20ab	5072.70ab	1850.40c
Darya	99.75bc	2.49abc	2759.20a	5882.80a	2418.00c
Nai60	103.23ab	2.68ab	2252.10ab	5320.10ab	2440.36c
Milan	91.05de	2.71a	2251.00ab	4571.00b	3917.95a
N-85-5	93.00d	2.10c	2358.50ab	5191.80ab	2630.55b
N-87-4	89.10e	2.21bc	2571.10ab	5186.10ab	3861.55a
N-86-7	99.10c	2.96a	2451.60ab	5225.30ab	3545.25a

In each column, numbers with the same letter have not significantly differences.

Table 3. Correlation between wheat cultivar traits in absence of M. alba.

	Wheat height	Tiller number	Grain yield	Biological yield	HI1
Wheat height	1				
Tiller number	0.40	1			
Grain yield	0.34	-0.12	1		
Biological yield	0.50	-0.20	0.82*	1	
HI	-0.23	-0.17	0.32	0.28-	1

Abbreviation: 1HI: Harvest index.

M. alba biomass production

The response of *M. alba* biomass production was varied in wheat cultivars. In Morvarid, Darya and Nai60 cultivars plots the lowest *M. alba* biomass was produced (Table 2). There was the highest biomass of *M. alba* in plots of Milan (3917.95 kgha^{-1}), N-87-4 (3861.55 kgha^{-1}) and N-86-7 (3545.25 kgha^{-1}) (Table 2). An inversely significant correlation between height of wheat and *M. alba*. *Melilotus alba* biomass inversely correlated with wheat height (Table 4). Enhancement of wheat height decreased *M. alba* height and biomass that indicated wheat height was important factor of wheat cultivars in suppression of *M. alba*. Wheat cultivars grain and biological yield had not significantly correlation with *M. alba* parameters. Also, our results indicated that tillering capacity of wheat cultivars was not an effective parameter in suppression of *M. alba* (Table 3). Rezvani *et al.* (2013), Lemerle *et al.* (2001a), Aminpanah *et al.* (2012) and Drews *et al.* (2009) reported significantly reduction of crop height by weed pressure. The differences in the ability of cultivars to suppress weed growth more than other might be due to taller plants, high leaf area index and light interception, tillering capacity and vegetative growth habit (Seavers and Wright, 1999; Dhima *et al.*, 2008). The importance of wheat cultivars height also confirmed by Lemerle *et al.* (2001b), Cousens *et al.* (2003) and Blackshaw (1994). Taller plants are more successful in light interception therefore are more aggressive. This differential response among cultivars is partly attributable to competition for light (Blackshaw, 1994).

Competition indices

Ability of wheat cultivars to withstand competition (AWC) was different. The cultivars of Shanghai and N-85-5 were the most tolerant to competition. Also, differences in CI and AC were found for all wheat cultivars (Table 5). Morvarid and Nai60 had the maximum competition index that representing higher ability of the cultivars to inhibit *M. alba* than other ones (Table 2 and Table 5). According to AC calculated Milan was competitive cultivars but they were not as successful as Morvarid and Nai60 in reduction of *M. alba* biomass (Table 5). *Melilotus alba* biomass was lesser in Morvarid and Nai60 plots than Shanghai and N-85-5 (Table 2). Grain and biological yield and Harvest index of wheat cultivars positively correlated with AWC. Also, a strong correlation between biological yield and CI was observed (Table 6). Fig. 2 indicated that N-80-19, Shaghai and Darya were cultivars with the maximum AWCs. Milan, N-87-4 and N-86-7 had the highest ACs. Our results showed that by increasing in ability of wheat cultivars to withstand competition of grain yield enhance. Competitive ability has two components, the ability to withstand competition (AWC) and the ability to compete (AC). These parameters used for screening of crop cultivars for their weed suppressive ability. Results of Watson *et al.* (2002) revealed considerable differences in barley (*Hordeum vulgare*) cultivars AWC and AC which can both be because of greater emergence and early height increase. Aminpanah *et al.* (2013) were found variation of the ability to withstand competition (AWC) canola (*Brassica napus* L.). Paolini *et al.* (2006) suggested that Chick-pea (*Cicer arietinum* L.) genotypes have different plasticity and are differentially adapted to competitive stress, with possible effects on seed yield.

Table 4. Correlations between wheat cultivars and *M. alba* traits in presence of *M. alba*.

	Wheat height	Tiller number	Grain yield	Biological yield	HI[1]	*M. alba* density	*M. alba* height	*M. alba* biomass
Wheat height	1							
Tiller number	0.54	1						
Grain yield	-0.25	-0.39	1					
Biological yield	0.04	-0.27	0.95*	1				
HI	-0.67*	-0.45	0.83*	0.63	1			
M. alba density	-0.44	0.30	-0.19	-0.36	0.05	1		
M. alba height	-0.69*	-0.20	0.17	-0.03	0.39	0.71*	1	
M. alba biomass	-0.79*	-0.07	-0.20	0.47-	0.31	0.73*	0.75*	1

Table 5. Competition indices calculated for wheat cultivars.

Wheat cultivars	**AWC[1]**	**CI[2]**	**AC[3]**
N-80-19	93.48	1.16	35.63
Shanghai	93.80	1.05	37.00
Morvarid	78.40	1.57	27.66
Darya	91.35	1.43	30.93
Nai60	59.78	0.91	38.07
Milan	86.24	0.70	48.01
N-85-5	87.27	1.26	34.08
N-87-4	79.62	0.78	46.11
N-86-7	62.23	0.70	46.08

Abbreviations: [1]AWC: Ability to Withstand Competition; [2]CI: Competition index; [3]AC: Ability to Competition.

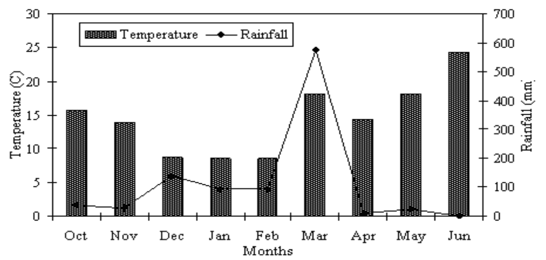

Fig. 1. Total monthly rainfall and mean monthly temperature during the experiment.

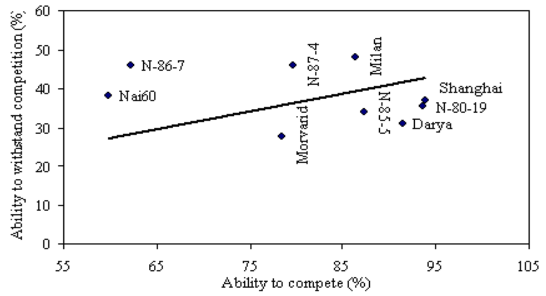

Fig. 2. Scatter plot of wheat cultivars' ability to compete (AC) against ability to withstand competition (AWC.

Table 6. Correlation coefficients calculated between wheat parameters and competition indices.

HI[1]	AWC[2]	CI[3]	AC[4]
Wheat height	-0.31	0.57	-0.66
Tiller number	-0.21	-0.51	0.02
Grain yield	0.81*	0.61	-0.47
Biological yield	0.73*	0.80*	0.70*-
HI	0.80*	0.14	0.04-

Abbreviations: [1]HI: Harvest index; [2]AWC: Ability to Withstand Competition; [3]CI: Competition index; [4]AC: Ability to Competition; **: significant at *P=0.05*.

Our results showed wheat cultivars had inter-genotypic variation in suppression of *M. alba*. Wheat cultivars revealed differences in AWC, CI and AC. Enhancement of wheat height decreased *M. alba* height and biomass that indicate wheat height was a key factor of wheat cultivars in suppression of *M. alba*, but tillering capacity of wheat cultivars was not effective in suppression of *M. alba*. Crop cultivars are nearly always evaluated for yields in weed free conditions, therefore our knowledge about their competitive interaction with weeds in very little. Ranking the ability of wheat varieties to compete with weeds could be an appropriate approach for ecological base agroecosystems and organic farming system.

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