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Evaluation the Effect of Wild Mustard Densities and Nitrogen Fertilizer on Wheat Yield and Correlation between Traits

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RESEARCH ARTICLE

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ABSTRACT

In order to study the effects of wild mustard competition and different levels of nitrogen on effective traits of wheat yield, this research was conducted in Ahvaz, south west of Iran. The study was consisted of a split plot experiment, on the basis of Randomized Complete Blocks Design with three replications. Different levels of nitrogen (90, 150 and 210 $kgN.ha^{-1}$) were assigned in the main plots and the sub-plots consisted of four wild mustard densities (0, 5, 10 and 15 weed $plant.m^{-2}$). Result of analysis of variance showed the effect of nitrogen treatments on number of tiller per m^2, number of spikelet per spike, seed yield, wild mustard biomass, wheat and wild mustard nitrogen agronomic efficiency was significant at 5% probability level and on number of seed per spike was significant at 1% probability level. Also effect of weed density on all measured traits (instead 1000-seed weight) were significant. But interaction effect of treatments on all traits was non-significant. Weed density had negative effects on nitrogen agronomic efficiency of wheat and positive effects on nitrogen agronomic efficiency of wild mustard. Seed yield was decreased in 0, 5 and 10 wild mustard densities per area unit. In the control plots by increasing nitrogen application wheat seed yield increased, but in wild mustard plots, with increasing nitrogen application loss of weed on economical yield increased. Generally, it seems that, wild mustard densities should be considered in determining the amount of nitrogen application, although 150 $kgN.ha^{-1}$ recommended.

Keywords*:* *Nitrogen agronomic efficiency, Weed density.*

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INTRODUCTION

In recent years, concerns over the environmental effects, economic costs, and long-term efficacy of conventional weed management systems have led a growing number of farmers and scientists to seek alternative systems that are less reliant on herbicides and more reliant on ecological processes (Davis and Liebman, 2001). Effective weed management is one of many critical components of successful wheat production. Weeds compete with wheat for light, nutrients, water, and space. Severe weed infestations can reduce wheat yields by as much as 70%. In addition, weeds can attract harmful insects and diseases and decrease harvest efficiency. Wild mustard (*Sinapis arvensis*) lived in most parts of the world and is generally native to Europe and Middle East and East Asia. It has been seen in 52 countries and in 30 crops. Wild mustard is a serious weed in cereal crops including wheat. Synthetic herbicides can control weeds effectively and reduce labor in weeding. However, in recent years the increasing cost of herbicides and ecological and human health concerns, have renewed interest in exploiting non-chemical alternatives including allelopathy and crop competitiveness (Movaghatian and Khorsandi, 2014). Research supporting the development of ecologically based weed management has been scarce over the past 50 years but is now the highest scientific priority is that farmers do not use herbicides (Benbrook, 1996). One approach to improving weed management while reducing reliance on herbicide technology involves the integration of soil, crop, and weed management (Liebman and Davis, 2000). Nitrogen is the most important nutrient supplied to most nonlegume crops, including wheat and barley (Modhej *et al.*, 2008), but it is always recognized that altered soil fertility level can influence crop-weed competitive interactions (Mohammad-doust *et al.*, 2006). Nitrogen fertilizer is known to break the dormancy of weed seeds and thus may directly affect weed infestation and competition ability (Blackshaw *et al.*, 2002). Some weed species such as wild mustard (Moradi Telavat *et al.*, 2010) and wild oat (Carlson and Hill, 1985) are luxury consumers of nitrogen and thus reduce the nitrogen availability for wheat growth. Many studies only have investigated the effects of nitrogen application on weed abundance, particularly density and dry matter (Blackshaw *et al.*, 2003). Pourreza and Bahrani (2015) showed that application of 150 kgN.ha^{-1} before crop seeding had high effect on competitive ability of wheat against wild oat weed. Kazemeini *et al.* (2014) showed that increase sunflower yield and suppress weeds, it is recommended to integrate cultural practices with use of 450 Kg Urea.ha^{-1} fertilizers and left over 25% of rapeseed residue. Banisaeidi *et al.* (2014) indicated that increase plant density and nitrogen fertilizer can improve spring wheat competitiveness and reduce seed yield loss, wild oat seed production and biomass. A strategy based on increased crop density and nitrogen fertilizer can reduce herbicide application in spring wheat production. Depending on the weed density, nitrogen fertilizer can increase the competitive ability of weed more than of crop. Moradi Telavat *et al.* (2010) reported that with the increase of nitrogen, while herbicide levels were low or no control was done, seed yield of wheat and dry matter of wild mustard decreased and increased, respectively. Also, Carlson and Hill (1985) found that the addition of nitrogen fertilizer in a wheat field infested by wild oat (*Avena fatua* L.) increased the density of wild oat panicles and decreased the crop seed yield. Wild oat competition reduced the effectiveness of nitrate in increasing plant weight, seed yield, and whole-plant percent nitrogen of wheat. Also, Blackshaw *et al*. (2003) reported that shoot and root growth of all weeds increased with added nitrogen, but the magnitude of the response varied greatly among weed species. In contrast, Tulikov and Sugrobov (1984) and Mohammaddoust *et al*. (2006) found that nitrogen and NPK application reduced weed density and dry weight, while in barley the reduction in weed density and dry weight only occurred when NPK was applied. It seems that the reaction of weed communities to nitrogen is highly dependent on weed species. Yaghoobi *et al*. (2011) showed that increase in nitrogen rate, particularly after-herbicide application, had positive effect on herbicide efficacy to control Lepyrodiclis, although increase nitrogen consumption led to control mention weed in reduced herbicide dose. The objectives of this investigation were to determine the effects of increasing densities of wild mustard on wheat seed yield under different nitrogen fertilizer levels.

MATERIALS AND METHODS

Field and treatments information

To evaluate the influence of wild mustard competition and different nitrogen levels on seed yield and yield components of wheat (cv. Chamran) the research was conducted in experimental field of Islamic Azad University, Khuzestan province, south west of Iran. Geographical information of experiment field included: latitude 31°20′N, longitude 48°41′E, altitude 22.5 m with moderate winters and hot summers. Chemical and physical properties (0–30 cm) were shown in table 1. The soil texture was silty clay loam (42% clay, 49% silt and 9% sand).

Table 1. Physical and chemical properties of the research field

Depth (cm)	EC ($ds.m^{-1}$)	pH	Organic Matter (%)	Phosphorous (ppm)	Potassium (ppm)	Soil texture
0-30	2.4	7.6	0.91	15.1	327.9	Silty Clay Loamy

The study was conducted as split-plot experiment based on randomized complete blocks design with three replications. Nitrogen levels consisting of 90 (N_1), 150 (N_2) and 210 (N_3) $kgN.ha^{-1}$ were arranged as main plots and the subplots consisted of five wild mustard densities, 0 (D_1, as control), 5 (D_2) 10 (D_3) and 15 (D_4) weed $plants.m^{-2}$. Nitrogen fertilizer was applied as urea (46% N). Phosphorous (100 $Kg.ha^{-1}$ P_2O_5) and 40% of nitrogen of each treatment broadcasted uniformly in the field at sowing time. 40% of nitrogen was applied as top dressing at the beginning of wheat stem elongation (ZGS 31) (Zadoks, 1974). The remaining nitrogen was applied at the beginning of flowering stage. In order to prevent the leakage of nitrogen two meters distance was kept between two main plots and two replications. Chamran cultivar was seeded in rows spaced 20 cm a part at 400 seeds per square meter. Three seeds of wild mustard were sown between the two rows of wheat. Excess seedlings of wild mustard were removed by thinning at four leaf stage. Hand weeding method was followed to remove weeds except wild mustard and wild oat during wheat growth. Normal cultural and management practices for irrigation of wheat plants were used.

Traits measurements

To determine the yield and yield parameters of wheat, two m^2 was harvested in 13-14% seed moisture. Total dry matter, seed yield and yield components were estimated after physiological maturity by harvesting the interior rows. Nitrogen agronomic efficiency (NAE) was calculated according to Novoa and Loomis (1981) and Craswell and Godwin (1984):

Formula 1. NAE ($gr.gr^{-1}$) = (Seed yield at Nx - Seed yield at N_0)/ N applied at Nx

Statistical analysis

The recorded data was analyzed by using SAS software (Ver.8) and mean comparison was done on the basis of Duncan's multiple range tests at 5% probability level. Pearson correlation analysis was also conducted among different variables.

RESULTS AND DISCUSSION

Number of tiller per area unit

According result of analysis of variance effect of different level of nitrogen and wild mustard density on number of tiller per m^2 was significant at 5% and 1% probability level, respectively. But interaction effect of treatments was not significant (Table 1). Result of mean comparison showed the highest and the lowest number of tiller per area unit belonged to 210 and 90 $kgN.ha^{-1}$, respectively. It seems increased consume nitrogen fertilizer led to increase number of tiller per area unit. By increasing weed density number of tiller per m^2 increased. So the highest and the lowest number of tiller per area unit belonged to 15 and zero weed density treatments ($plant.m^{-2}$), respectively (Table 2). Some researchers reported same results (Kolb *et al*., 2012; Olsen *et al*., 2012; Yaghoobi *et al*., 2011).

Number of spike per square meter

The results of analysis of variance showed the effect of wild mustard density on number of spike per m^2 was significant at 1% probability level, while the effect of nitrogen treatments and the interaction effect of different level of nitrogen and weed density was not significant (Table 1). According mean comparison the highest number of spike per m^2 was related to sole planting of wheat and the lowest one was related to 15 $Weed.m^{-2}$ (Table 2). 5, 10 and 15 wild mustard $plant.m^{-2}$ caused a decrease in number of spikes per area unit, 8.5, 14.6 and 19.73% respectively in comparison to sole planting of wheat. The increase of wild mustard density led to a decrease of tiller number and spike number per area unit. Spike number per area unit was affected by weed density more than other yield components. Ramezani (2001) reported that by increasing wild mustard density, number of fertile tiller per area unit decreased. Rastgoo *et al*. (2003) mentioned that the effect of wild mustard on number of spike per area unit was significant and by increasing wild mustard density, number of spike per area unit was decreased.

Number of seed per spike

According to the results of analysis of variance effect of different level of nitrogen and wild mustard density were significant at 1% probability level. But interaction effects of treatments were not significant (Table 1). The highest and the lowest numbers of seed per spike were respectively related to nitrogen treatments of 90 and 150 $kg.ha^{-1}$ (Table 2).

Table 1. Analysis of variance of measured traits

S.O.V	df	Number of tiller per m^2	Number of spike per m^2	Number of seed per spike	Number of Spikelet per spike	1000-Seed weight	Seed yield	Wild mustard biomass	Wheat N.A.E	Wild mustard N.A.E
Replication	2	1826.034^{ns}	2428.880^{ns}	6.834^{ns}	566.1**	4.710^{ns}	2029.480^{ns}	178.14^{ns}	660.119^{ns}	2029.480^{ns}
Nitrogen	2	26610.589*	3186.046^{ns}	33.900**	6.982*	2.132^{ns}	12711.51*	13811.61*	31225.27*	11211.51*
Error I	4	2676.664	1494.731	5.015	1.158	6.186	2107.560	33211.9	2107.560	1160.57
Weed density	3	11682.881**	14990.196**	34.820**	6.125**	6.471^{ns}	53046.44**	820.94*	2010.629*	5346.44*
Nitrogen and Weed density	6	747.116^{ns}	2197.089^{ns}	1.155^{ns}	0.113^{ns}	1.213^{ns}	3949.149^{ns}	8929.659^{ns}	7948.319^{ns}	3889.135^{ns}
Error II	18	2155.081	703.415	3.079	0.427	4.518	1464.344	164.340	134.274	8346.148
CV (%)	-	7.05	6.18	6.33	5.17	5.52	8.6	5.62	4.6	6.1

^{ns}, * and **: no significant, Significant at 5% and 1% of Probability level, Respectively.

Table 2. Mean comparison of measured traits via Duncan test.

Treatment	Number of tiller per m^2	Number of spike per m^2	Number of seed per spike	Number of Spikelet per spike	1000-seed weight (gr)	Seed yield ($gr.m^{-2}$)	Wild mustard biomass ($gr.m^{-2}$)	Wheat N.A.E** ($gr.gr^{-1}$)	Wild mustard N.A.E ($gr.gr^{-1}$)
Nitrogen ($Kg.ha^{-1}$)									
90	606.1^{b}	426.2^{a}	25.83^{b}	11.77^{a}	38.97^{a}	430.1^{b}	187.4^{b}	47.79^{a}	1.867^{a}
150	672.5^{ab}	446.9^{a}	29.03^{a}	13.17^{b}	38.26^{a}	482.5^{a}	229.4^{b}	32.16^{b}	1.344^{b}
210	697.2^{a}	414.7^{a}	28.33^{ab}	12.99^{ab}	38.22^{a}	432.9^{b}	342.9^{a}	20.14^{c}	1.322^{b}
Weed density ($Plant.m^{-2}$)									
0	702.9^{a}	480.8^{a}	29.81^{a}	13.61^{a}	39.66^{a}	543.6^{a}	-	39.87^{a}	-
5	671.0^{ab}	439.8^{b}	28.69^{ab}	12.96^{ab}	38.41^{a}	462.1^{b}	139.7^{c}	34.47^{b}	0.90^{c}
10	639.2^{ab}	410.6^{bc}	27.14^{bc}	12.30^{bc}	38.21^{a}	410.5^{bc}	248.8^{b}	31.22^{bc}	1.53^{b}
15	621.2^{b}	385.9^{c}	28.25^{c}	11.70^{c}	37.64^{a}	364.5^{c}	371.2^{a}	27.90^{c}	2.10^{a}

*Similar letters in each column show non-significant difference at 5% probability level. **NAE: Nitrogen Agronomic Efficiency.

By increasing weed density per m^2, the number of seed per spike decreased. 5, 10 and 15 wild mustard wild plants per m^2 caused a decrease in seed number per spike 3.75, 8.95 and 15.19% in comparison to the control treatment. Number of seed number per spike decrease in high densities of weed because of the significant decrease of the spikelet number per spike (Table 2). Lackshaw and Sturko (1981) reported that increasing weed density because of shading effect bring about a decreasing in spikelets, floret fertility and seed number per spike.

Number of spikelet per spike

The results of analysis of variance showed the effect of different levels of nitrogen and wild mustard density on number of spikelet per spike were significant at 5% and 1% probability level, respectively. But interaction effects of treatments was not significant (Table 1). The highest and the lowest spikelet numbers per spike were related to 150 and 90 kgN.ha^{-1} treatments respectively (Table 2). By increasing wild mustard density, number of spikelet per spike decreased and the highest and the lowest one were respectively related to control and 15 wild mustard plants per m^2. 5, 10 and 15 wild mustard plant per m^2 caused decreasing number of spikelet number per spike (4.77, 9.62 and 14.3% in comparison to the control treatment, respectively) (Table 2). Modhej *et al.* (2008) concluded that the reasons of the increase in the number of seed per spike in suitable levels of nitrogen consumption were the increase in spikelet number per spike and the number of fertile floret per spikelet. Mohajeri and Ghadiri (2003) reported that increasing the amount of nitrogen had a significant effect on increasing the seed number per wheat spike and this increase was clear at nitrogen levels from 0 to 100 kg.ha^{-1} but higher than this range, increasing the seed number per spike was not significant. At 200 kg.ha^{-1} nitrogen level in 20, 30 and 40 of wild mustard plant m^2, a significant decrease was seen in seed per spike. Indicating that extra nitrogen fertilizer was used in competition wild mustard instead of wheat. Puri *et al.* (1985) reported that increasing in plant density because of shading effect and decreasing received of radiation has negative effect on spikelet number per spike.

1000-Seed weight

The effect of different level of nitrogen, wild mustard density and their interaction effect on the 1000-seed weight were not significant (Table 1). These results were compatible with the findings of Modhej *et al.* (2008) and Thomas *et al.* (1994) about the non significant effects of nitrogen and weed densities on seed weight.

Seed yield

The results of analysis of variance showed that effect of different levels of nitrogen and wild mustard density on seed yield was significant at 5% and 1% probability level, respectively. But interaction effect of treatments was not significant (Table 1). The lowest and the highest seed yields were obtained in of 90 and 150 kgN.ha^{-1} treatment, respectively. Increase of weed density led to a decrease in seed yield, so that densities of 5, 10 and 15 wild mustard plant per m^2 caused a decrease in seed yield of wheat (15, 24.5 and 32.9% respectively in comparison to planting without weed). Results showed that the increase of every wild mustard plant per m^2 decreased seed yield to 2.5%. Decrease of seed yield in weed treatments was because of the significant decreasing of spike number and seed number per area unit (Table 2).

Hassan and Khan (2007) who reported that 50 wild oat.m^{-2}, *Avena fatua* L., reduced the grain yield of wheat by 55.4, 58 and 59.6% under 75, 100 and 125 kgN.ha^{-1}, respectively. Donavan (2001) concluded that every wild mustard plant can decrease seed yield by 1%. Rastgoo *et al.* (2003) reported the increase of wild mustard density through decreasing the tiller number, spike number per area unit and seed number per spike caused the decrease of biological and seed yields of wheat. Mohajeri and Ghadiri (2003) reported that in zero and 50 kgN.ha^{-1}, increase of wild mustard density more than 20 plants.m^{-2} reduced seed yield significantly but at levels of 100, 150 and 200 kgN.ha^{-1}, increase wild mustard from 10 plants per m^2 caused a significant decrease in wheat seed yield. Ross and Van Acker (2005) found that the competitive ability of wild oat in wheat field was significantly higher when nitrogen was applied. Mesbah *et al.* (1995) reported that root yield of sugar beet reduced with increasing wild mustard and wild oat density, alone or in combination. The sugar beet root yield decreased by 22 and 26% in alone competition of 3 wild oat and 0.8 wild mustard plants/m of row respectively. While reduction of root yield in the presence of these two mixed densities was 38%.

Biologic yield

According to the results of analysis of variance effect of different levels of nitrogen and wild mustard density on biologic yield was significant at 5% and 1% probability level, respectively. But interaction effect of treatments was not significant (Table 1). The highest amount of biologic yield belonged to 210 kgN.ha^{-1}, although by increasing weed density biologic yield increased. The highest and the lowest biologic yield belonged to 15 and 5 plant.m^{-2} of wild mustard density treatments, respectively (Table 2). Some researchers reported same results (Armin *et al.*, 2011; Hesammi, 2011; Pourreza and Bahrani, 2015).

Nitrogen Agronomic Efficiency (NAE)

According to the result of analysis of variance effect of different levels of nitrogen and weed density on nitrogen agronomic efficiency of wheat and wild mustard were significant at 5% probability level, respectively (Table 1). Wild mustard has high ability to absorb nitrogen at high levels of nitrogen and because of increasing the biomass and developing root system; it was more successful in competition with wheat and its seed yield decrease. By increasing nitrogen from 90 to 210 kgN.ha^{-1}, nitrogen agronomic efficiency (NAE) of wheat and wild mustard decreased to 57 and 29% respectively (Table 2). The increase of wild mustard density reduced nitrogen agronomic efficiency of wheat and in contrast increased in wild mustard (Table 2). This reaction means that in competition with weed, wheat plant cannot use nitrogen sufficiently for producing seed (Carlson and Hill, 1985).

Regression changes trends of seed yield and wild mustard density

In higher densities of weed, more nitrogen fertilizer did not reduce the negative effects of weeds on wheat yield. Increased gradient changes of seed yield in reaction to different densities of wild mustard were more at high levels of nitrogen (Fig. 1). By increasing the nitrogen, the competition ability of wild mustard with wheat increased. This reaction can be related to higher ability of wild mustard in uptaking nutrients and the usage of these nutrients especially nitrogen by it (Moosavi *et al.*, 2003).

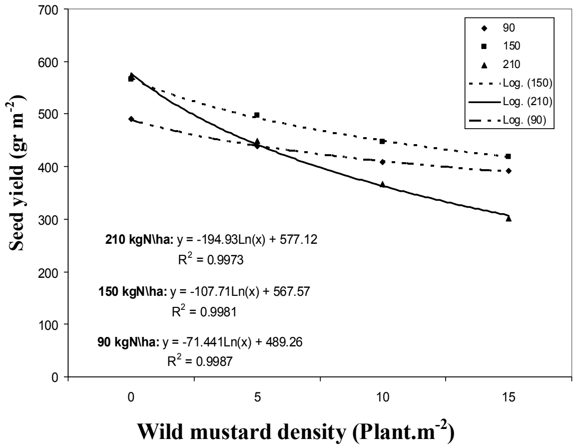

Fig. 1. Regression changes trends of seed yield in wild mustard densities and different levels of nitrogen

Regression changes trends of NAE and wild mustard density

This reaction indicated the protection of nitrogen use efficiency by wild mustard at high levels of nitrogen consumption. The same as seed yield, changes in the gradient of nitrogen agronomic efficiency in wheat in reaction to different densities of wild mustard were more in high levels of nitrogen (Fig.2a). Trend changes in wild mustard were unlike to wheat. In other words, at first, the increase of weed density caused the increase of nitrogen agronomic efficiency by it and second, the gradient of additional changes of efficiency were more in the treatment of 210 kgN.ha^{-1} than the low levels of fertilizer (Fig.2b). These results were conformed by the results of Carlson and Hill (1985).

Correlation between measured traits

Relationship between measured traits and seed yield was effective. Correlation between seed yield with spike number per area unit, seed number per spike and spikelet per spike was positive and significant at 1% probability level (Table 3). Chachar *et al.* (2009) reported same result.

CONCLUSION

In general, the results of this research showed that the increase of wild mustard density caused the decrease of wheat seed yield. The reasons of the decrease in seed yield at high densities of weed were the decrease in spike number and seed number per area unit. Increasing amount of nitrogen consumption increased wheat seed yield in non-competition conditions, however, in competition conditions, by increasing the nitrogen consumption, the negative effect of wild mustard on wheat seed yield increased. At high levels of nitrogen consumption, wheat by lower efficiency and wild mustard by more efficiency used nitrogen.

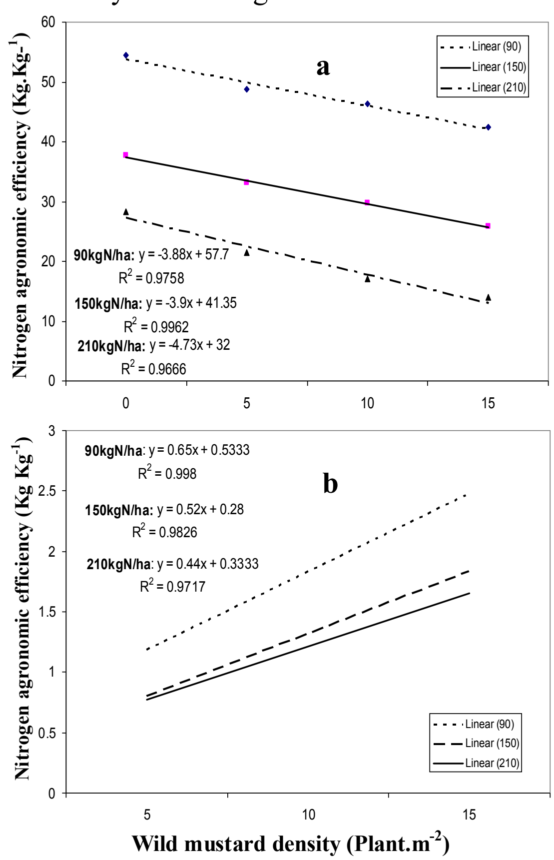

Fig. 2. Nitrogen agronomic efficiency changes trend of nitrogen usage in wheat (a) and wild mustard (b) in nitrogen levels and different densities of wild mustard.

Table 3. Correlation between yield and yield components

Traits	No. spike per m^{-2}	No. spikelet per spike	No. Seed per spike	1000-Seed weight	Biological yield
No. spikelet per spike	0.89**	-	-	-	-
No. seed per spike	0.85**	0.97**	-	-	-
1000-Seed weight	0.76**	0.61*	0.51^{ns}	-	-
Biological yield	0.95**	0.88**	0.87**	0.76**	-
Seed yield	0.93**	0.90**	0.87**	0.78**	0.96**

^{ns}, * and **: no significant, Significant at 5% and 1% of Probability level, Respectively.

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