



RESEARCH PAPER

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Interference effects of wild mustard and wild oat on nitrogen use efficiency, nitrogen and chlorophyll content of wheat in response to nitrogen application

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Abstract

Field experiment was conducted to evaluate nitrogen use efficiency, nitrogen and chlorophyll content of wheat in response to changes in weed density and nitrogen application. The statistical analysis of data indicated that the content of nitrogen and chlorophyll of wheat flag leaf significantly increased by increasing nitrogen level, however the nitrogen use efficiency decreased. The nitrogen use efficiency at 210 kg N ha⁻¹ was 22.74 kg/kg lower than 90 kg N ha⁻¹. Interspecific competition of wild mustard and wild oat significantly decreased the nitrogen use efficiency, nitrogen and chlorophyll content. The density of 15 plants of wild mustard and 75 plants of wild oat decreased the NUE of wheat by 28.2 and 27.3 % as compared to their zero density respectively.

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Introduction

Crop fertigation is an important component to achieve higher crop production (Blackshaw, 2005). For increasing crop yield amongst essential nutrients, nitrogen is major (Camara *et al.*, 2003) and it is often most limiting to profitable crop production (Connor *et al.*, 2011). Nitrogen is an important constituent of chlorophyll, which play a crucial role in photosynthesis utilizing solar energy (Tucker, 1999). Plants with more leaf nitrogen content usually have more chlorophyll content (Fulkes *et al.*, 2009). There is a close correlation between nitrogen and chlorophyll content in the flag leaf. The dark green leaves have higher nitrogen content (Bojovic and Marcovic, 2009). Ephrath *et al.* (1996) stated that leaf nitrogen content can be used as an index for application of nitrogen.

Today Nitrogen Use Efficiency (NUE) in crop production has become the key factor in agriculture (Kanampiu *et al.*, 1997). Nitrogen use efficiency of the cereal crops such as wheat, corn, barley, rice and oat is about 33 %. The loss of nitrogen fertilizer is mainly due to soil denitrification, surface runoff, volatilization and leaching. NUE can be improved by using the crop genotypes with high harvest index, incorporated NH₄-N fertilizer, application of low nitrogen amount at flowering stage and forage production system (Raun and Johnson, 1999).

Weed interference is one of the major factors which affect the nitrogen and chlorophyll content, NUE and harvest index. Soni and Ambasht (1976) in a study on wheat-weed competition found that weed interference caused the reduction in nitrogen and phosphorus content in vegetative stage of wheat growth and the maximum reduction was recorded at the flowering stage. Sorkhy Lalelo *et al.* (2008) stated that increasing wild oat, *Avena fatua* L., density from 2 to 8 plants/pot reduced the chlorophyll content of flag leaf of wheat. Giambalvo *et al.* (2010) noted that the interspecific competition of weed, *Hordeum vulgare* L. significantly affected the NUE of wheat, *Triticum*

durum Desf.. Interspecific competition decreased the NUE of wheat by 17 % in 2004-5 and by 39 % in 2005-6 as compared to weed free condition.

Wild mustard (Topal and Kocacaliskan, 2006) and wild oat [Daugovish *et al.*, 2003] are two of the worst weeds in the field of wheat all over the world. Therefore present study was attempted to investigate interference effects of wild mustard and wild oat on some physiological parameters of wheat under different nitrogen levels.

Materials and methods

Experimental site and design

To evaluate the interference effects of wild mustard, *Sinapis arvensis* L., and wild oat, *Avena ludoviciana* L. on physiological characteristics of wheat, *Triticum aestivum* L. Var. Chamran, a two years field experiment was conducted at Research Field of Islamic Azad University of Ahvaz-Iran at 2007-8 and 2008-9 cropping season. The experiment was performed in split-factorial and in the randomized complete block design with three replications in additive series. Three nitrogen levels including 90, 150 and 210 kg/ha were maintained in main plots. Wild mustard in four densities including 0, 5, 10 and 15 plants m⁻² and wild oat in four densities including 0, 25, 50 and 75 plants m⁻² were maintained into sub-plots.

Application of treatments

Phosphorous (100 kg P₂O₅), potassium (100 kg K₂O) and 40 % of nitrogen were broadcasted uniformly at the sowing time and mixed with soil according to the treatment level in each plot. Remaining 60 % of nitrogen was divided into two topdressings such as 40 % at the beginning of stem elongation and 20 % at the beginning of flowering stage. Wheat seed density was maintained at 400 seeds per square meter. Wild oat and wild mustard were sown between the two rows of wheat. To avoid the risk of non germination, three seeds instead of a single seed of wild oat and wild mustard each were sown and then the population was adjusted as per the requirement through thinning.

Measurement of traits and statistical analysis

Nitrogen and total chlorophyll (a+b) content of wheat flag leaf were determined at flowering stage by micro Kjeldahl (Sadasivam and Manickam, 1996) and (Arnon, 1949) methods respectively. Nitrogen use efficiency was calculated through the following formula: $NUE (kg/kg) = \text{Grain yield (kg/ha)} / \text{Nitrogen applied (kg/ha)}$ [Witcombe *et al.*, 2008].

The recorded data was analyzed statistically by using MSTATC computer software and a comparison of recorded data was done on the basis of Duncan's multiple range tests at Alfa level 5 %.

Results and discussion*Nitrogen use efficiency*

The results of present study (Table 1) showed that the nitrogen use efficiency of wheat was decreased by increasing nitrogen level and the NUE at 90 kg N ha⁻¹ was 58.4 % higher than 210 kg N ha⁻¹. This result was in the line with El-Gizawy (2005) who stated that the application of 100 kg N ha⁻¹ reduced the nitrogen use efficiency of wheat by 60.2 and 58.8 % as compared to 25 kg N ha⁻¹ in 2002-3 and 2003-4 respectively.

Increasing wild mustard and wild oat density decreased the nitrogen use efficiency. The percentage of NUE loss due to 15 wild mustard m⁻² and 75 wild oat plants m⁻² was 28.2 and 27.3 % as compared to zero density of these weeds respectively (Table 1). This finding showed that, wheat cannot use nitrogen efficiently for producing grain in the presence of weeds.

Table 1. Effect of nitrogen levels, wild mustard and wild oat densities on nitrogen use efficiency, nitrogen and chlorophyll content of wheat.

Treatments		Nitrogen use efficiency (kg/kg)	Nitrogen content (%)	Chlorophyll content (mg/g)
Nitrogen levels (kg ha ⁻¹)	90	38.91 a	2.26 c	4.18 c
	150	25.28 b	2.45 b	4.51 b
	210	16.17 c	2.54 a	4.72 a
Wild mustard densities (plants m ⁻²)	0	31.49 a	2.48 a	4.61 a
	5	28.09 b	2.42 ab	4.53 ab
	10	24.97 c	2.40 b	4.43 bc
	15	22.60 d	2.36 b	4.31 c
Wild oat densities (plants m ⁻²)	0	31.41 a	2.51 a	4.67 a
	25	27.76 b	2.45 ab	4.56 a
	50	25.14 c	2.39 bc	4.40 b
	75	22.83 d	2.31 c	4.24 c

Means with different letters are significantly different at P=0.05, using Duncan's Multiple Range Test.

The interference effect of weeds on nitrogen use efficiency of wheat was increased by increasing nitrogen application. The reduction of nitrogen use efficiency by 25, 50 and 75 plants of wild oat m⁻² competition was higher than 5, 10 and 15 plants of wild mustard m⁻² competition respectively in the low level of nitrogen application. Whereas the interference effect of wild mustard on NUE was higher than wild oat in the high level of nitrogen. The density of 15 wild mustard plants m⁻² decreased the

NUE by 22, 27 and 43.1 % under 90, 150 and 210 kg N ha⁻¹ respectively. While the NUE was decreased by 26.2, 27 and 30.3 % as affected by 90, 150 and 210 kg N ha⁻¹ in the presence of 75 plants of wild oat respectively (Fig. 1 A and B).

These results were confirmed by Giambalvo *et al.* (2010) who noted that the NUE of wheat, *Triticum durum* Desf., was decreased by increasing nitrogen level and in the presence of weed, *Hordeum vulgare*

L. They concluded that the interference effect of weed on nitrogen use efficiency of wheat was increased by increasing nitrogen level. The weed competition decreased the NUE of Simeto and Valbelice varieties by 50.7 and 32.3 % in zero level of nitrogen respectively. While in the application of 80 kg N ha⁻¹, the NUE was decreased by 53.1 and 42 % respectively in 2005-6.

The results of present study also indicated that reduction of nitrogen use efficiency in the single competition of wild oat and wild mustard was less than mixed weed densities. The density of 15 plants of wild mustard and 75 plants of wild oat decreased the NUE by 34.5 and 34.4 % when they were grown separately but in the combination of these two weed density the NUE reduced by 50.3 % as compared to weed free condition (Table 2).

Table 2. Interaction effect of wild mustard and wild oat densities on nitrogen use efficiency, nitrogen and chlorophyll content of wheat.

Wild mustard density (plants/m ²)	Wild oat density (plants/m ²)	Nitrogen use efficiency (kg/kg)	Nitrogen content (%)	Total chlorophyll content (mg/g)
0	0	38.92 a	2.61 a	4.91 a
	25	32.81 b	2.55 ab	4.73 abc
	50	28.69 c	2.45 abcde	4.52 bcde
	75	25.54 de	2.33 de	4.29 def
5	0	32.98 b	2.54 abc	4.79 ab
	25	28.47 c	2.42 bcde	4.57 bcde
	50	26.39 cd	2.40 bcde	4.49 bcde
	75	24.52 def	2.32 de	4.29 def
10	0	28.24 c	2.50 abed	4.61 bed
	25	26.23 cd	2.42 bcde	4.54 bcde
	50	23.50 ef	2.35 de	4.30 def
	75	21.92 f	2.34 de	4.26 ef
15	0	25.51 de	2.39 bcde	4.38 def
	25	23.54 ef	2.42 bcde	4.41 cdef
	50	21.97 f	2.36 cde	4.30 def
	75	19.36 g	2.25 e	4.13 f

Means with different letters are significantly different at P=0.05, using Duncan's Multiple Range Test.

Nitrogen content

The results showed that nitrogen content of wheat flag leaf responded positively to increased level of nitrogen. While this parameter decreased by increasing weeds densities. Average reduction in nitrogen content in the presence of 15 wild mustard m⁻² and 75 wild oat m⁻² was 4.8 and 8 % respectively as compared to their zero density respectively (Table 1). The reduction in nitrogen content of the flag leaf may be attributed to impaired N uptake due to reduction in volume of root system and disturbed functioning, minimum translocation to the flag leaf due to weed competition and their allelopathic influence.

The interaction effects between wild mustard and wild oat densities with nitrogen levels showed that increasing nitrogen levels from 90 to 150 and 210 increased the nitrogen content of flag leaf in weeds free treatments and in the presence of wild mustard and wild oat (Fig. 2 A and B).

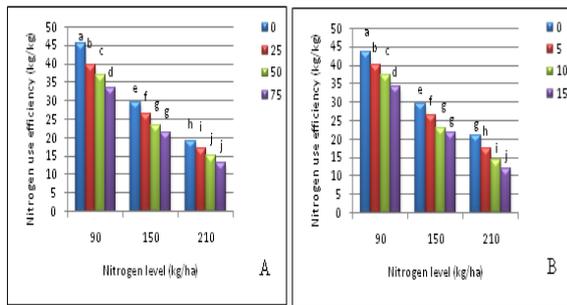


Fig. 1. Effect of wild mustard (A) and wild oat (B) densities on nitrogen use efficiency under different nitrogen levels.

Azeez *et al.* (2006) observed a significant and positive correlation between leaf N and grain yield of maize. Giambalvo *et al.* (2010) reported the application of nitrogen caused an increase in total N absorption of wheat, *Triticum durum* Desf., about 40 %. This result was expected because wheat almost has a positive response to increase N fertilizer. But the wheat N absorption was decreased in the presence of interspecific competition of *Hordeum vulgare*. Normally, N fertilized plots had a larger reduction in nitrogen uptake than unfertilized plots. Inamura *et al.* (2003) stated that N concentration in rice at maturity stage was decreased by weeds competition. Reduction in nitrogen content caused to decrease the panicles number which decreased the seed number per m⁻² and consequently the rice yield.

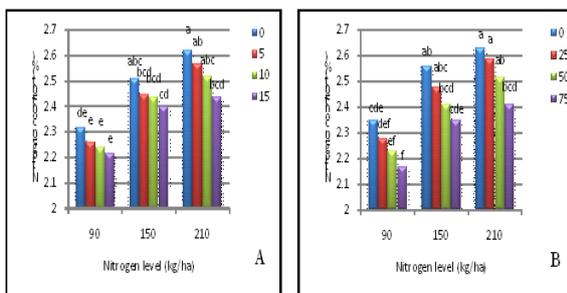


Fig. 2. Effect of wild mustard (A) and wild oat (B) densities on nitrogen content under different nitrogen levels.

Interaction between wild mustard and wild oat densities showed that the negative effect of wild mustard on nitrogen content was decreased in the presence of wild oat and *vice versa*. The nitrogen content decreased by 13.8 % in presence of 15 wild mustard along with 75 wild oat m⁻² as compared to weed free treatment (Table 2).

Chlorophyll content

There is a high correlation between chlorophyll and nitrogen content as N is a part of chlorophyll and protein molecules. Chlorophyll pigments are the master molecules in photosynthesis and synthesis of carbohydrates. The reduction in chlorophyll due to biotic stress like diseases, weeds and insects reduce crop yield and its quality. The results of present study indicated that the chlorophyll content of wheat flag leaf increased by increasing nitrogen level. Average nitrogen content under 90, 150 and 210 hg N ha⁻¹ was 4.18, 4.51 and 4.72 mg/g respectively. Also, chlorophyll content significantly decreased by increasing weed interference and weed density. The density of 15 plants of wild mustard and 75 plants of wild oat decreased the total chlorophyll content by 6.5 and 9.2 % respectively as compared to their zero density (Table 1). In each nitrogen levels, the wheat flag leaf had lower chlorophyll content under weed infested condition as compared to weed free treatment, whereas the negative effects of 25, 50 and 75 plants of wild oat on chlorophyll content were more than 5, 10 and 15 plants of wild mustard interference respectively (Fig. 3 A and B).

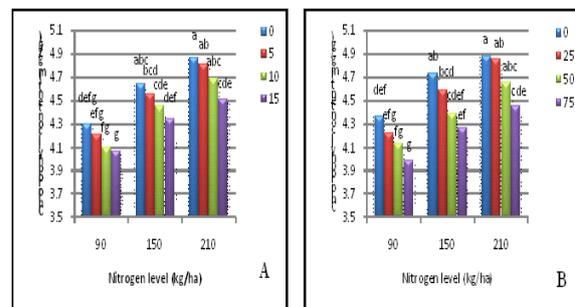


Fig. 3. Effect of wild mustard (A) and wild oat (B) densities on chlorophyll content under different nitrogen levels.

Chikoye *et al.* (2008) noted that weed competition and N levels (0, 30, 60 and 90 kg/ha) had a significant effect on chlorophyll content of corn leaf. Chlorophyll content in the treatments of fertilizer application was more than the control (no-fertilizer) plots and it was more in the weed free treatments than the low or high weed pressure plots. Sorkhy Lalelo *et al.* (2008) stated that increasing *Avena fatua* density decreased the chlorophyll content of

wheat flag leaf. Tollenaar *et al.* (1994) found that chlorophyll concentration of leaves in maize during the grain filling period was significantly higher in the weed free treatment as compared to high weed interference treatment. Also, this parameter was higher at high N level than the low level of nitrogen application.

The results of present study also indicated that the reduction of chlorophyll content in single competition of wild oat and wild mustard was less than mixed weed densities. The reduction of chlorophyll content was 10.8 and 12.6 % in the presence of 15 plants of wild mustard and 75 plants of wild oat when they were grown separately. However in the mixed treatment of these two densities the reduction was 15.9 % (Table 2).

Conclusion

The results of present study indicated that crops infested with weeds get minimum N and chlorophyll content due to interference of weed and cause negative effect on grain yield. As a result of this crop-weed competition, the efficiency of wheat for producing grain decreased by increasing N level in the presence of *S. arvensis* and *A. ludoviciana*. Therefore the growers should consider crops as well as weeds, while application of fertilizers. Managing N application rate can be a good component for integrated weed management system.

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