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Original article

Effect of nano iron foliar application on quantitative characteristics of new line of wheat

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In order to study the effect of nano iron foliar application on quantitative characteristics of new line of wheat this study was conducted for one year (2012) in the cold climate of Kermanshah. Experiment was conducted as a split plot in a randomized complete block design with three replications. Factors studied were at three levels of foliar (a1= Tillering, a2= Heading, a3= no spray (control)) and the figure of six was (b1= C-87-11, b2= C-87-12, b3= C-87-13, b4= Mihan، b5= Zare and b6= Urom), respectively. Spraying time as the main factor in the main plots and cultivars as sub plots were placed in the subplots. In this study extrusion, Fe percentage, dry matter percentage (DM %), crude protein percentage (CP %), crude fiber percentage (CF %) and starch percentage of wheat were evaluated. In relation to quality traits of the analysis of variance showed that spray the iron chelate had significant effect on the characteristics of starch percentage, Fe percentage, extrusion, crude protein percentage (CP %) and crude Fiber percentage (CF %). Significant differences between treatments were observed. So that in all characters, the highest order of 13/49, 63/28, 31/68, 64/46 and 3/21 respectively obtained when the spray was applied at tillering of wheat. The highest average yield of starch, crude protein and Fe, was observed respectively, with an average yield of 15/38, 58/83 and 63/88 in the Zare figure, the highest average (35/03) Extrusion in figure C-87-13 and the highest percentage of crude fiber (3/17) in figure C-87-12 was observed.

1. Introduction

Micronutrient malnutrition affects over two billion people around the world especially in the developing countries (McGuire, 1993). Iron deficiency is widespread and is one of the most concerned to healthcare officials among almost all developing countries (Buyckx, 1993). Iron deficiency has increased from 30% in the 1960s to 40% in the 1990s among the world population (Welch and Graham, 2002). Wheat crop provides 60% of the daily calorie intake and is the most important cereal crop in the world with regard to total production, cultivated area and human consumption (Cakmak et al., 2004). However, a lot of wheat growing areas are located in arid and semi-arid regions where Fe deficiency exists due to high soil pH, free calcium carbonate and low organic matter, drought and salt stresses, imbalanced application of NPK fertilizers and high bicarbonate content of irrigation water (Narimani et al., 2010; Ali, 2012). The deficiency of iron in the soil causes reduction in wheat grain and quality leading to nutrition disorder (Fe deficiency) in human (Ghorbani et al., 2009). Several approaches were taken to cope with Fe deficiency in wheat grain. Abbas et al. (2009) applied 0, 4, 8, 12 and 12 kg ha-1 in the form of iron sulphate to the soil and showed that iron fertilization increased Fe and protein contents of the wheat grain. With application of 150 g ha-1 iron in the form of Fe_2O_3, Habib (2009) reported that iron and protein contents of the wheat grain were enhanced. Zeidan et al. (2010) applied foliar Fe fertilizer (1.0% $FeSO_4$) and reported that Fe application increased protein and Fe contents of wheat grain. Welch and Graham (2002) and Cakmak (2008) suggested that Fe deficiency in wheat grain can be alleviated by breeding and selection of cultivars that could absorb more Fe from the soil and accumulate it in the grain, whereas Yip (1997) purposed that Fe deficiency could be overcome by food fortification. However, plant breeding is time consuming and iron fertilizers applied to crops by these methods may reach to target site of crops much below the minimum effective concentration. In addition, the effectiveness of inorganic and chelated forms of Fe fertilizers ($FeSO_4$, FeEDTA, FeDTPA, FeEDDHA, Fe-citrate) in overcoming Fe deficiency is highly variable depending on their solubility, stability, penetration ability through leaf cuticle, mobility and translocation following diffusion into the leaf tissues (Schonherr et al., 2005; Fernandez et al., 2009). Reduction of particle size results in increased number of particles per unit of weight and specific surface area of a fertilizer that should increase contact of fertilizer with plant leading to increase in nutrient uptake (Liscano et al., 2000). Below 100 nm nano-particles could make plants use fertilizer more efficiently, reduced pollution and more environmentally friendly, dissolve in water more effectively thus increase their activities (Joseph and Morrison, 2006). Therefore, nanotechnology such as using nano-scale fertilizer particles may offer new techniques in improving existing crop management. Liu et al. (2005) reported that nano-Fe_2O_3 promoted the growth and photosynthesis of peanut. Sheykhbaglou et al. (2010) showed that application of nano-iron oxide particles increased soybean yield. Prasad et al. (2012) reported that nano-scale zinc oxide particles increased stem and root growth and pod yield of peanut as compared with $ZnSO_4$ application. Effect of nano oxide iron alone or with iron chelate and sulphate on wheat production and grain quality especially Fe content has not been compared. In addition, there is a little information on the accumulation of antioxidant enzymes and their possible role on yield and quality of wheat under nano oxide iron, iron chelate, and iron sulphate application. Therefore, this experiment was conducted to compare the effect of nano iron foliar application on quantitative characteristics of new line of Wheat.

2. Materials and methods

An experiment was conducted during 2011-2012 in Kangavar, Kermanshah, Iran. In this cold climatic condition average annual rainfall is 487.3 mm and the average temperature is 15.8° C. In order to determining of chemical and physical properties of farm soil samples were prepared from 0-30 cm depth. Samples were sieved and were analyzed at laboratory. Soil analysis results showed in table 1. Experiment was conducted as a split plot in a randomized complete block design with three replications. Factors studied were at three levels of foliar (a1=

Tillering, a2= heading, a3= no spray (control)) and the figure of six was (b1= C-87-11, b2= C-87-12, b3= C-87-13, b4= Mihan، b5= Zare and b6= Urom), respectively. Spraying time as the main factor in the main plots and cultivars as sub plots were placed in the subplots. Khazra iron nano chelated fertilizer included different microelements such as iron (8.9%), zinc (0.92%), manganesium (0.96%) sodium (9.9%) and brimstone (9.5%). Triple super phosphate added as a phosphate resource at the sowing time and urea as a nitrogen resource at sowing and tillering stages. Each plot consists of 8 sowing rows with 20 cm between rows and 1-2 cm on rows spaces. For sowing 135 kg\ha wheat grain was used. Weeds were controlled by 2,4-D herbicides.

2.1. Grain protein contents

Protein and contents were measured by Near Infrared Reflectance spectroscopy. Grains were ground and flour samples were scanned on a NIR Systems 6500 scanning spectrophotometer (Perten 8620- Inframatic Grain Analysis) in reflectance mode as described by Lemons e Silva et al. (2008).

2.2. Grain iron content

Two grams of dried sample was placed into a crucible and heated at 5500C for 4 h. Then 10 ml 2 N HCl was added to the ashes and diluted to 100 volumes. Iron content was measured by Atomic Absorption Spectrophotometer (Perkin-Elmer 3030) as described by Davidson and Miller (2005).

The data were analyzed by MSTAT-C soft-ware and the figures were drawn by Excel 2010.

Table 1
Soil analysis of physical and chemical properties.

Ec EC dSm-1	pH	Cu ppm	Zn ppm	Mn ppm	Fe ppm	N (%)	K ppm	P ppm	O.C (%)	Deep (cm)
0.73	7.6	0.68	0.8	6.6	7.6	0.13	230	9.2	1.26	0-30

3. Results and discussion

3.1. Extrusion

Analyze of variance released that wheat extrusion was significantly affected by both iron chelate foliar application times and wheat varieties at $p \leq 0.05$ and $p \leq 0.01$ respectively (table 2). There was a significant difference between foliar application time and different varieties while maximum wheat extrusion was in heading stage and the lowest value was belong to control treatment. Maximum and minimum extrusion was observed in C-87-13 line (35.03) and C-87-11 line (28.75) respectively (table 3).

Table 2
Analysis of variance of data on quantitative characteristics of new line of wheat

Resource changes	df	Extrusion	Fe (%)	Dry matter (%)	CP (%)	CF (%)	Starch (%)
Repetition	2	41.43 ns	1876/6 **	0.689 ns	5.47 ns	0.006 ns	1.54 ns
Factor A	2	6.20 *	2212/01 *	1.25 *	38.78 *	0.108 *	10.69 **
Error A	4	10.70	3030.3	0.144	2.257	0.008	0.509
Factor B	5	43.58	135.17 *	0.36 **	2.22 *	0.015 *	23.09 **
A×B	10	13.01 ns	82.66 ns	0.067 **	0.875 ns	0.016 ns	0.488 ns
Error B	30	5.33	83.01	0.026	0.829	0.011	0.280
CV (%)	-	7.3	16.8	1.8	1.5	3.4	4.1

*,**, ns, significant at $p \leq 0.01$ and $p \leq 0.05$, no significant, respectively.

3.2. Fe percentage

From analyze of variance it could be resulted that iron chelate application time and wheat varieties had meaningful effect on Fe percentage ($p \leq 0.05$) (Table 2). A significant difference was observed between application time and varieties. The highest Fe percentage was observed in Zare variety (58.83) and the lowest was observed in

Mihan variety. Application of iron chelate at tillering stage had the highest Fe percentage (63.28) and control treatment had the lowest value (41.78) (Table 3). Since application of foliar iron chelate, grain Fe percentage was 44.2% increased compare to control treatment. Mohamad et al. (1990) reported that application of micro nutrient elements such as zinc and iron increased grain Fe percentage.

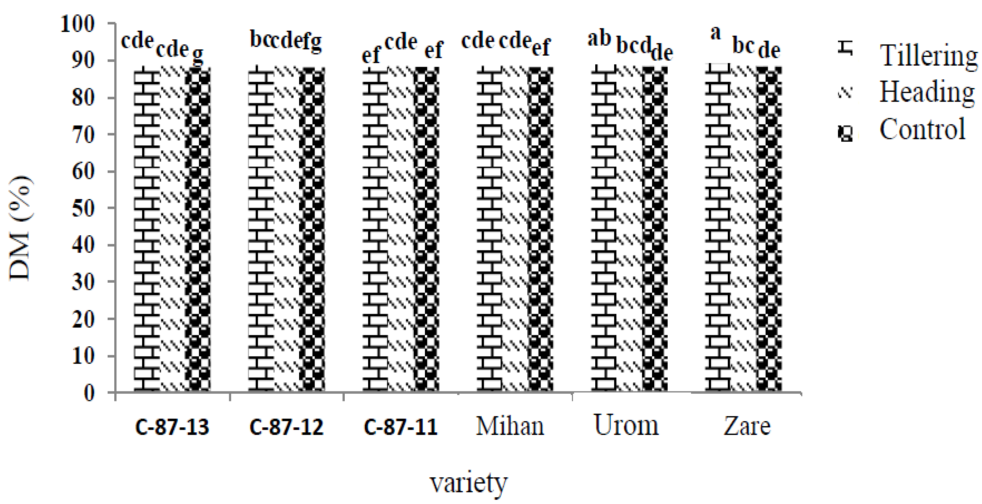
Table 3
means comparison yield and yield components of new line of wheat.

Factors	***Extrusion***	**Fe**	**CP**	**CF**	**Starch**
Tillering	31.68 a	63.28 a	64.46 a	3.21 a	13.49 a
heading	31.88 a	57.22 a	63.03 b	3.10 b	13.33 a
control	29.87 b	41.87 b	61.53 c	3.06 b	12.08 b
C-87-13	35.03 a	55.33	63.01 b	3.07 b	11.20 d
C-87-12	32.08 b	51.9 b	62.96 b	3.17 ab	12.46 c
C-87-11	28.75 c	47.46 b	62.78 b	3.08 b	11.56 d
Mihan	30.64 bc	46.15 b	62.25 c	3.15 ab	12.94 c
Urom	29.91 bc	58.12 a	63.03 b	3.20 a	14.36 b
Zare	32.27 b	58.83 a	63.88 a	3.25 a	15.38 a

Different letters in each column indicate significant difference at p≤0.05.

3.3. Dry matter percentage (DM %)

Analyze of variance table showed that interaction of iron chelate application time and wheat varieties was statically meaningful (p≤0.01) (Table 2). According to figure maximum dry matter was belong to Zare variety which was treated at tillering stage (89.26 kg\ha) and the minimum value was belong to C-87-13 line control (88.07 kg\ha) (Figure 1). Iron is necessary for chlorophyll production and increasing of chlorophyll cause to increasing of leaf area and leaf weight. Iron deficit reduce leaf weight, leaf area, iron concentration and chlorophyll (Mariotti, et al. 1996). Thereby, zinc and iron treatment because of their effect on leaf area index and chlorophyll and subsequently increasing of photosynthesis had effective impact on dry matter accumulation. Treham and Sharma (2000) indicated that application of zinc caused to increasing of corn, wheat and sunflower dry matter yield.



3.4. Crude protein percentage (CP%)

Analyze of variance indicated that interaction of iron chelate foliar application and wheat varieties on crude protein was significant (p≤0.05) (Table 2). There was significant difference between application time and different varieties. Maximum wheat crude protein was observed in Zare variety (63.88) and minimum of it was belonging to Mihan (62.25). Application of iron chelate at tillering stage let to the highest crude protein (64.46) and non-application treatment had the lowest crude protein (61.53) while application of iron chelate could promote crude protein up to 3.6% compared to control treatment (Table 3). Farajzadeh et al. (2009) study indicated that optimum using of iron and zinc in about wheat plant increased grain protein content. Tahir et al. (2009) reported that effect of foliar application on grain protein content was meaningful and the highest protein content was related to ZnSO4-EDTA treatment (11.4%) compare to control treatment (9.8%).

3.5. Crude fiber percentage (CF%)

Application of Iron chelate and wheat varieties significantly affected crude fiber ($p \leq 0.05$) (Table 2). There was significant difference between application time and different varieties. The highest crude fiber was observed at tillering stage and the lowest was in control treatment. Between the different varieties maximum and minimum crude fiber were belonging to Zare variety (3.25) and C-87-13 line (3.07) (Table 3).

3.6. Starch percentage

According to table (2), iron chelate foliar application time and varieties had statically meaningful effect on wheat starch percentage ($p \leq 0.05$). Comparison of means revealed a significant difference between treatments while maximum wheat starch percentage was observed at tillering stage by foliar application of iron chelate (13.49%) and among the varieties the highest starch percentage was belong to Zare variety (15.38%) (Table 3). More chlorophyll and IAA could postpone exhaustion and increase photosynthesis duration which improve carbohydrate production and its transition to grain and subsequently increased yield. By application of zinc and iron total carbohydrate, starch, IAA, chlorophyll and grain protein increased (Rajaie and ziyaeyan, 2009). Brown et al. (1993) resulted that application of iron and zinc total carbohydrate, starch and grain protein and in along with this yield increased.

4. Conclusion

According to the results, Urom and Zare varieties had maximum yield and yield components. This study indicated that foliar treatments (tillering, heading) in all studied values were predominant compare to non-foliar application treatments. Among the two foliar application of iron chelate (tillering and heading), foliar application at tillering stage was more effective. Foliar application in this stage had the effective impact on quantitative characteristics of wheat. Maximum Fe, starch, dry matter, crude protein and crude fiber percentage between the varieties was related to Zare variety. Between the iron chelate foliar application times, its application at tillering stage and control treatment had maximum and minimum effect on qualitative characters of wheat.

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