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Effect of nano-iron chelate fertilizer on grain yield, protein percent and chlorophyll content of Faba bean (*Vicia faba* L.)

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Abstract

In order to study the effect of time and concentration of Nano-Iron on yield and yield components of faba bean, a field experiment was conducted in Ahvaz, Iran. Experimental design was factorial based on RCB with 3 replications. First factor was 3 spraying times (i. e. spraying at vegetative, befor flowering and at flowering) and second factor was 5 Iron concentrations (i. e. control, Iron 2 g/L, Nano-Iron with 2,4 and 6 g/L). Our results showed that the highest (467.7 g/m2) and lowest (352.7 g/m2) grain yield belonged to Nano-Iron 6 g/L and control, respectively. Increasing of Nano-Iron concentration had a positive and significant effect on grain yield, protein percent and chlorophyll content.Moreover, spraying at vegetation period had the lowest effect onboth grain yield, and grain protein percent. But, spraying at different periods had not significant effect on chlorophyll content.In conclusion; the highest grain yield was obtained with spraying Nano-Iron 6 g/L during flowering period.

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Introduction

Faba bean (viciafabaL.) is one of the major winter sown legume crops grown in the Middle East region and has considerable importance as a low cost food rich in proteins and carbohydrates (Sepetoglu, 2002). Although, micronutrient elements are needed in relatively very small quantities for adequate plant growth and production, their deficiency may cause great disturbance in physiological and metabolic processes involved in the plant. Thus, the application of micronutrients fertilizer in the cultivation zone may not be meeting the crop requirement for root growth and nutrient use (Bozorgi, 2012). The alternative approach is to apply these micronutrients as foliar sprays. Six micronutrients including Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Mortvedt, 1991) iron is one of the essential elements for plant growth and plays an important role in the photosynthetic reactions. Iron activates several enzymes and contributes in RNA synthesis and improves the performance of photosystems (Malakouti and Tehrani, 2005).Iron compound can use as foliar on leaves and seed coating (Debermann, 2006). Nano technology can present solution to increasing the value of agricultural products and environmental problems. With Using of Nano-particles and Nano-powders, we can produce controlled or delayed releasing fertilizers. Nano-particles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features simplify the absorption of fertilizers and pesticides that produced in Nano scale (Anonymous, 2009).

Abdzad-Gohari and Noorhosseini-Niyaki (2010) with study effects of iron foliar spraying in four levels (0, 1.5, 3 anand yield d 4.5g/1 per plot) and nitrogen fertilizers in four levels (0, 30, 60 and 90 kg/ha) on yield and yield components of peanut (Arachishypogaea L.) were reported that among iron fertilizer treatments, maximum pod yield (2916 kg/ha) and seed yield (1828 kg/ha) were recorded from the 4.5g/1 iron foliar spraying treatment. Singh and Dayal, (1992) concluded that spraying iron would cause a 38-42% increase in the peanut yield in alkaline soils. Zareie*et al.*,(2011) with study effect of nitrogen and iron fertilizers on seed yield and yield components of safflower genotypes was reported that, use of foliar spraying of iron fertilizer (sulphate of iron) had significant effect on seeds per head and seed yield of safflower genotypes.

Iron deficiency is a widespread agricultural problem in many crops, especially in calcareous soils. In these soils, total Fe is high but occurs in chemical forms not available to plant root (Lindsay and Schwab, 1982). Plants respond to Fe limitation by inducing a series of physiological and morphological changes in the roots to facilitate the mobilization of sparingly soluble Fe compounds in the root environment. The narrow limit between phytotoxicity and deficiency of iron brings the need for defining appropriate rates to be used. Even on the world scale, it is estimated that Fe deficiency is widespread occurring in about 30 to 50% of cultivated soils (Cakmak, 2002).Using different shape of chelates that are obtained by reaction between metal salts and artificial and natural complexes is the most important way for preserving iron against increasing precipitation of iron in soil with increasing pH (Koksal *et al.*, 1998). Iron chelate Nano fertilizer can be considered as a rich and reliable source of bivalent iron for plant because of its high stability and gradual release of iron in a wide pH range (3 to 11). One advantage of this nano fertilizer is using no ethylene compounds in its structure. Ethylene enhances growth process and prevents appearing indications caused by chlorosisin leaves (Monsef-Afshar *et al.*, 2013).

The aim of this study is evaluation of different foliar Iron concentrations at different phenological stages on grain yield and yield components of Faba bean. The main objective of this study is evaluation the effect of Nano-Iron foliar spraying on yield and yield components of faba bean.

Materials and methods

In order to investigation the effect of different concentration of Iron chelate Nano fertilizer at different phenological stages on yield an yield components of faba bean, a field experimental was conducted at ahvaz, Iran, during 2011-2012 that located in 31°29´N latitude and 48 °.26´ E longitude. According to soil analysis performed prior to sowing, the PH=7.25, Ec=37, %N=0.15, %P=12.5, %K=129, %C=0.65, Fe=6 ppm and soil texture clay loam.

Experimental design was factorial with 3 replications. First factor was 5 different Iron concentrations (i. e. control, non-nano Iron 4g/L and 3 Nano- iron, 2, 4 and 6 g/L) and second factor was 3 different time of foliar applications (i.e. Vegetative stage, before and after flowersing). Land preparation process before cultivation was performed by moldboard plow and two step perpendicular disc. Seeds of faba been were inoculated with Rhizobium leguminosarum before planting and then were planted on 15 Oct. Plant density was 20 plant per/m2. The normal agricultural practices required for irrigation and also, weed control.At maturity stage, grain yield and yield components of faba bean were calculated. Data were analyzed by using SAS soft ware and LSD tests was used to compare the means at 5% of significant g/m2.

Results and Discussions

Grain yield

Effect of different Iron concentration treatments onfaba been grain yield was significant (p≤0.05) (Table1). Spraying 6g/L Nano-Iron concentration and control treatment had the highest (467.7 g/m2) and lowest (352.7g/m2) grain yield, respectively (Table 2).It seems that the signification effect on both pod dry weight and 100-seed weight which finally led to positive effect on grain yield. Also, we could find that there was a liner relationship between increasing of Nano-Iron concentration and grain yield. Kobraee *et al.* (2011) reported that Iron foliar application enhanced soybean yield by influencing number of seeds per plant and seed weight. Therefore, Iron defficiency in soils could be a restricting factor of yield and extremely decrease crop yield quality (Salwa *et al.* 2011). Application of nano-Iron oxide at 0.75 g/L compare to other treatments had maximum effect on dry pod weight. It seems that the use of iron nano-particles causes increasing in pod and dry leaf weight and finally will increase total yield (Sheykhbaglou *et al.* 2010).

Table 1. Analysis of variance of some recorded traits under the effect of Growth stage andIron concentration.

Source of variation	dF	Grain yield (g/m2)	Biological yield (g/m2)	Harvest index (%)	Iron concentration (mg/g)	Grain protein (%)	Leaf chlorophyll (SPAD)
Replication	2	ns33953	138926*	ns86.22	-0.001 ns	ns100.0	ns2.15
Growth stage(T)	2	ns11561	ns13526	ns06.44	0.031 *	ns6.0	7.6 ns
Iron concentration(F)	4	65250*	85475*	07*.151	0.062 *	3*.3	83*.36
T×F	8	ns9650	ns25265	ns59.25	0.006 ns	6.2 ns	ns15.8
Error	82	17595	37576	9.33	0.009	001.0	4.18
Coefficient of Variation (%)		27.32	72.23	78.11	0.001	001.0	88.9

**And* ns respectively significant at the one percent and five percent level, and no significant difference.

Biological yield

Results of analysis of variance (ANOVA) showed that the significant (P≤0.05) effect of Iron spraying concentration treatment on biological yield (Table1). Among different Iron concentrations, spraying 6g/L concentration Nano-Iron and control treatment had the highest (403.3 g/m2) and lowest (733.3 g/m2) biological yield, respectively (Table 2). The most evident effect of Fe deficiency is a decreased content of photosynthetic pigments, which results in the relative enrichment of carotenoids over chlorophyll and leads to the yellow color that is characteristic of lower photosynthesis active area. In this condition, total plant biomass wil reduced. It is reported that Iron is an essential element for plant growth. Lack of Iron causes young leaves to yellow photosynthesis activity to reduced significantly and consequently biomass is produced (Briat *et al.,* 2007). It was shown that microelements affect leaf area and then lead to larger amounts of assimilate production in common bean (Kakiuchi and kobata, 2008). Nazaran *et al.*(2012) also reported that some sweet corn yield characteristics including the number of rows in cob, number of grain per row, number of grain per cob and seed weight were affected by foliar application of Iron, which fallowed by increassing of corn yield.

Table 2. Mean comparison of some of estimated traits in faba bean.

Treatments	Grain yield (g/m2)	Biological yield (g/m2)	Harvest index (%)	Iron concentration (mg/g)	Grain protein (%)	Leaf chlorophyll (SPAD)
Growth stage						
T1	379 b	782.6 a	47.5 a	0.61 a	18.6 c	43 a
T2	428.6 a	835.3 a	50.8 a	0.54 b	18.8 b	44.9 a
T3	425.3 a	834 a	50 a	0.53 b	19 a	43 a
Iron concentration						
F1	352.7 c	733.3 c	48 c	0.48 c	19 b	42.6 b
F2	401.1 b	796.6 bc	49.5 ab	0.49 c	18.6 c	43.6 b
F3	415.5 b	845.5 b	48.4 c	0.48 c	18.6 c	43.2 b
F4	417.7 b	807.7 b	51.2 a	0.75 a	18.3 d	42.2 b
F5	467.7 a	903.3 a	50.1 b	0.61 b	19.3 a	45.2 a

Means with same letter in each column are not significantly different at probability level of 5%.

Harvest index

Results of analysis of variance (ANOVA) showed that the significant ($P \leq 0.05$) effect of Iron spraying concentration treatment on harvest index (Table 1). Means comparison indicated that the maximum harvest index (51.2%) was obtained in spraying Nano-Iron 4g/L concentrationtreatment. The minimum harvest index (48%) also, belonged to control (No Iron) treatment (Table2). Semilar results also reported by Gohari and Niyaki (2010) and Bozorgi (2012).

Table 3. Correlation coefficient of yield components of faba been.

Treatments	Grain yield (g/m2)	Biological yield (g/m2)	Harvest index (%)	Grain protein (%)	Iron concentration (mg/g)	Leaf chlorophyll (SPAD)
Grain yield(g/m2)	1					
Biological yiel(g/m2)	0.966**	1				
Harvest index (%)	0.770**	0.595**	1			
Grain protein(%)Iron	0.131	0.167	-0.048	1		
Concentration(mg/g)	-0.073	-0.126	0.091	.442*0	1	
Leaf chlorophyll(spad)	0.40*	0.335*	0.449*	0.247	-0.051	1

Means with same letter in each column are not significantly different at probability level of 5%.

Iron concentration

Results of analysis of variance (ANOVA) showed that the both spraying time and Iron concentration treatments had significant ($P \leq 0.05$) effect on this parameter (Table 1). Amoung different spraying times, earlier spraying at vegetive stage had highest Iron concentration (0.61) than others. Also, spraying 4g/L Nano-Iron and control treatments had the highest (0.75) and lowest (0.48) plant Iron concentration, respectively (Table 2). Positive effect of Nano-Iron on grain Iron concentration was shown by Sheykhbaglou *et al.* (2010) which reported that the application of nano-Iron oxide cause increasing iron concentration compared to non Nano-Iron form.

Leaf chlorophyll

Effect of different Iron concentration treatments on leaf chlorophyll was significant ($p \leq 0.05$) (Table 1). Spraying 6 g/L concentration of Nano-Iron had the highest (45.2 SPAD) chlorophyll content (Table 2).

But, no significantly differences were showed between other Iron concentration treatments. Iron is critical for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants [8]. Torun *et al.* [9] and Grewal *et al.* [10] reported increased dry matter production for application of micronutrients over control. Macro and micronutrients deficiencies have been reported for different soils and crops [11]. Moreover, the most evident effect of Iron deficiency is a decreased content of photosynthetic pigments, which results in the relative enrichment of carotenoids over chlorophylls and leads to the yellow color that is characteristic of chlorotic leaves (Pirzad and Shokrani, 2012).

Grain protein

Results of analysis of variance (ANOVA) showed that the significant ($P \leq 0.05$) effect of Iron spraying concentration treatment on grain protein (Table 1). Spraying 6 g/L concentration Nano-Iron and both spraying 2 & 4 g/L concentrations of Nano-Iron had the highest (19.3 %) and lowest (18.6 %) grain protein, respectively (Table 2). Effect of iron on grain protein also reported by Sheykhbaglou *et al.* (2010) in Soybean and by Monsef-Afshar *et al.* (2013) in cowpea.

Correlation coefficient: Based on correlation coefficient (Table 3) faba bean grain yield had positive and significant correlated with biological yield (0.966), fallowed by harvest index (0.770). But, grain yield had negative correlation with Ironconsentration (-0.073). Moreover, grain yield had to significant correlation (0.131) with protein percent.

In conclusion, we found that application of Nano-Iron had better effect on grain yield of faba bean than non nano-Iron form.Also; the highest Iron concentration (i.e. 6g/L) had the highest grain yield and grain Iron content.

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