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Assessment Effect of Different Amounts of Iron and Manganese Sulfates on the Qualitative and Quantitative Yield of Wheat in South West of Iran (Ramhormoz Region)

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ABSTRACT

In order to evaluate the effect of different amounts of iron and manganese sulfates on wheat yield (Chamran cultivar), a factorial experiment based a randomized complete block design with three replications. The experiment treatments consisted of different concentrations of iron sulfate (Including; zero, 1500, and 3000 grams per hectare) and manganese sulfate (Including; zero, 1500, and 3000 grams per hectare). The results showed that there was a significant difference between different levels of iron sulfate and manganese sulfate in terms of seed yield and yield components and seed protein content. As the consumption of iron and manganese sulfate increased the number of infertile spike decreased. The highest number of seeds per spike belonged to the consumption of 1500 and 3000 g per hectare iron and manganese sulfates. The treatment with the consumption of 3000 g iron and manganese sulfates in comparison to the control treatment led to the increase of 1000-seed weight as much as almost 10 g. The highest seed yield with an average of 670 $g.m^{-2}$ belonged to the treatment with consumption of 3000 grams of iron and manganese sulfates. As the consumption of iron and manganese sulfates increased from zero to 3000 g per hectare, protein, the content of protein, iron and manganese of seed increased significantly. The results showed that micronutrients by improving growth conditions and influencing the seed yield components can increase the seed yield and quality to some extent. In general, it can be concluded that highest yield and yield components in this experiment belonged to the treatments with 3000 $g.ha^{-1}$ iron sulfate and 3000 $g.ha^{-1}$ manganese sulfate.

Keywords*: Fertile spikes, Seed protein content*

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INTRODUCTION

Wheat is one of the most important crops playing an important role in providing food security of the country. Lack of adequate amounts of micronutrients such as iron, copper and manganese in environment will cause disorder in growth and yield of this plant. Nowadays, due to the low concentration of micro-nutrients in wheat seed which is the main food of Iranians, the emergence and spread of many diseases, such as kidney stones, anemia, fatigue and gastrointestinal diseases are common in the country. Lack of micronutrients is mainly observed in calcareous soils (Ziaeian and Malakouti, 1999). The purpose of the use of these elements in the process of crop production is to improve the quality and quantity of products and to enrich them in addition to increasing production. So far, much many studies have been done on the effect of each micronutrient on increasing the quality and quantity of wheat (Hung *et al.,* 2009). Among the micronutrients iron plays an important role in plant photosynthesis and respiration. Iron is considered as one of the micronutrients for plants. Although micronutrients are needed by plants in small amounts, they play an important role in plants growth and development such as their role in enzymes' activities, growth, cell differentiation, formation of flower, and crop quality improvement. The plants are found in many parts of the world who suffer from iron deficiency. There are some plants in many parts of the world that suffer from the shortage of iron (Cesco *et al*., 2010). Manganese is involved in some enzymatic systems for the production of protein and iron in the structure of some enzymes and some colored materials. Manganese plays a key role in the formation of chloroplast and enzyme systems of plants and the use of this fertilizer will improve plant photosynthesis and crop production. Therefore, use of chemical fertilizers containing this element improves the nutritional conditions of plants and removes many nutritional disorders (Khald Barin and Islamzade, 2001). Baibordi and Malakouti (2003) reported that any factor which increased the concentration of micronutrients such as iron, zinc and manganese in plants would improve the seed yield. Siadat *et al.* (2001) reported that micronutrient fertilizers had a significant effect on the yield and yield components of wheat. In order to investigate the effect of foliar application of iron sulfate on yield, yield components, protein and gluten contents of wheat cultivars, Shahrokhi *et al*. (2012) carried out an experiment and stated that the treatment with iron sulfate significantly increased the yield, yield components, and protein content in comparison with the control treatment. Zeidan *et al*. (2010) did a research to compare the effect of the soil and foliar application of iron and manganese on the yield and yield components of wheat. They found that the concurrent use of the iron and manganese was significantly different from the control treatment. The highest 1000-seed weight, number of seeds per spike, seed yield, and protein content of seed belonged to the treatments with foliar micronutrients. Abbas *et al*. (2009) did an experiment to examine the effect of iron consumption on the yield and yield components of wheat. They figured out that as the concentration increased from zero to the 16 $kg.ha^{-1}$, the growth of plants increased significantly. The highest yield and yield components belonged to the treatments with concentrations of 12 and 16 $kg.ha^{-1}$. The present research was conducted to investigate effects of foliar application of iron and manganese micronutrients on seed yield and qualitative traits of wheat.

MATERIALS AND METHODS

Field and Treatment Information

The research was conducted in 2014-2015 seasonal year in the south west of Iran (Ramhormoz region) at latitude 31° 16´N, longitude 49° 37´E and altitude of 160 meters above the sea level. The research site had a clay loamy soil texture with pH of 7.2. The research was conducted as a factorial experiment in the form of a randomized complete block design with three replications. The experiment treatments consisted of the different consumptions of iron sulfate (Including zero, 1500, and 3000 grams per hectare) and manganese sulfate (Including zero, 1500, and 3000 grams per hectare). The physical and chemical properties of studied field were mention in table 1.

Table 1. Soil properties of the studied field

Depth (cm)	EC ($ds.m^{-1}$)	pH	Organic matter (%)	Phosphorous (ppm)	Potassium (ppm)	Soil texture
0-30	3.5	7.8	0.79	18.6	387.7	Clay Loamy

Crop Management

Before planting operations the land was first irrigated and then land preparing operation was done in October including the plow to a depth of 30 cm and 2 perpendicular discs. The base fertilizers were added to the soil before the second disc and were mixed with soil by disc and then field was leveled by the trowel and finally the crop was planted. The base fertilizer used in the field consisted of 90 $kg.ha^{-1}$ of triple super phosphate and 90 $kg.ha^{-1}$ of potassium sulfate fertilizer and 180 $kg.ha^{-1}$ of nitrogen fertilizer from the urea source as the split in two stages (50% at planting stage and 50% at spiking stage). Each experimental plot included 7 planting lines as long as 5m each, and distance between the planting lines was considered to be 20 cm and the distance between the experimental plots was 1 m. The rate of required seeds for planting was considered based on the density of 400 plants per square meter. Irrigation was done after planting the seeds and the first irrigation was considered as the planting date and the rest of irrigations were done as required and based on the rainfall in plots. Weeds were controlled via topic and granestar herbicides.

Traits measure

In order to determine the yield and yield components, the two side rows and half a meter of the beginning and end of each plot were eliminated as the marginal effects and finally the ultimate samples were taken from an area of 1 m^2. In order to determine the number of spikes per area unit, the spikes were taken from an area of 1 m^2 of then three middle lines of each plot after considering half a meter of beginning and end of each line as the margin and after counting the spikes their mean was considered as the number of spikes per area unit. As many as 10 spikes were randomly selected from the middle lines of each plot and the number of seeds was counted carefully and their mean was recorded. Two 500-seed samples were randomly selected from the produced seeds by each plot and if the weight difference of the two samples was less than 5%, the total weight of the two samples was considered as weight of 1000-seed. After full maturity of the seeds, the spikes were taken from the 3 middle lines of each plot in an area of 1 m^2 and the seed yield of each plot with moisture of 14% was calculated per area unit and then was recorded.

In order to measure the rate of iron and manganese in seeds, first the seeds of each treatment were ground in the laboratory then 1 g of the dried flour was changed into ash at 75°C for 48 hours. The ash samples were dissolved in 10 ml HCL 2N and then were placed in hot plot at temperature of 75°C for 30 minutes. Then the volume of the samples was brought to 100 ml by distilled water and was filtered through the filter paper. The needed amount of the filtered samples was taken and the rate of iron and manganese was measured by the means of atomic absorption machine (Schimadzu UV-VIS 1201) (Shahrokhi *et al.,* 2012).

Statistical analysis

SAS software (Ver.8) was used to analyze the data variance; also Duncan test at 5% probability level was used to compare the means.

RESULTS AND DISCUSSION

Number of fertile spikes

The effects of Iron and manganese sulfates effects on the number of fertile spikes per square meter at physiological maturity stage were significant at 1% probability level but interaction effect of treatments was not significant (Table 2). In the iron sulfate treatment, the highest number of fertile spikes belonged to fertilizer treatments of 3000 and 1500 $g.ha^{-1}$ (by the average of 586 and 557, respectively) and the lowest number belonged to the treatment without use of iron sulfate (by the average of 530 (Table 3). Among different levels of manganese sulfate, the highest number of fertile spikes by the average of 582 belonged to the treatment with 3000 $g.ha^{-1}$ and the lowest number belonged to the control treatment by the average of 528 (Table 4). The number of fertile spike is very important in determining the final yield and is considered as one of the main components determining the yield of crops. Therefore, according to the above results it can be concluded that as the levels of iron and manganese increases and they are supplied for the plant, the vegetative and reproductive growth of wheat will increase and greater production of nutrients will increase the yield components in wheat and ultimately number of fertile spike will increase. High photosynthetic capacity of plants under treatment assimilates transfer to seed and productions of dry matter are factors that influence number of fertile spikes.

Table 2. The ANOVA results of the effect of iron and manganese sulfates on the studied traits

S.O.V	df	Number of fertile spikes	Number of seeds per spike	1000-seed weight	Seed yield	Seed protein content	Seed iron content	Seed manganes e content
Replication	2	218.7	2.9	4.6	64573	1.23	18.09	15.4
Iron sulfate	2	7693.8**	79.7**	183.4**	597589**	41.2**	174.5**	25.4^{ns}
Manganese sulfate	2	6944.8**	85.4**	144.3**	486494**	31.6**	$24.11^{n.s}$	1853.4**
Iron sulfate * manganese sulfate	4	5739.2^{ns}	217.2^{ns}	244.25^{ns}	63193^{ns}	33.47^{ns}	108.7^{ns}	165.2^{ns}
Error	18	192.4	2.48	15.2	65312.8	4.2	19.4	21.4
C.V	-	11.83	5.8	8.65	10.4	4.7	6.2	4.9

ns, *, and ** respectively mean non-significant, significant at 5% and 1% probability levels.

Table 3. Mean comparison effect of different concentrations of iron sulfates on studied traits

Treatnments	Number of fertile spikes	Number of seeds per spike	1000-seed weight (g)	Seed yield ($g.ha^{-1}$)	Seed protein content (%)	Seed iron content ($mg.kg^{-1}$)	Seed manganese content ($mg.kg^{-1}$)
Iron sulfate							
Lack of foliar application	530.6^{c}	24.9^{c}	30.5^{c}	402.9^{c}	8.1^{c}	46.4^{c}	46.8^{a}
1500 $g.ha^{-1}$	557.2^{b}	27.5^{b}	35.3^{b}	538.5^{b}	10.6^{b}	62.2^{b}	44.5^{b}
3000 $g.ha^{-1}$	585.5	30.3^{a}	38.6^{a}	667.3^{a}	13.2^{a}	73.5^{a}	44.7^{b}

*The numbers with at least one similar letters in each column are not significantly different at 5% probability level.

Table 4. Mean comparison effect of different concentrations of manganese sulfates on studied traits

Treatnments	Number of fertile spikes	Number of seeds per spike	1000-seed weight (g)	Seed yield ($g.ha^{-1}$)	Seed protein content (%)	Seed iron content ($mg.kg^{-1}$)	Seed manganese content ($mg.kg^{-1}$)
Manganese sullfate							
Lack of foliar application	528.4^{c}	24^{bc}	29.4^{b}	376^{c}	7.8^{b}	-	45.8^{c}
1500 $g.ha^{-1}$	555.7^{b}	25.8^{b}	36.1^{a}	520.6^{b}	10.9^{a}	-	59.5^{b}
3000 $g.ha^{-1}$	582.3^{a}	28^{a}	37.2^{a}	618.5^{a}	11.74^{a}	-	67.7^{a}

*The numbers with at least one similar letters in each column are not significantly different at 5% probability level.

Adding micro nutrients to soil at sensitive growth stages of plant especially at tillering stage and stem elongation stage will increase number of spikes per square meter and consequently will enhance yield (Gastillo *et al*., 1992).

Number of seeds per spike

The number of seeds per spike was significantly affected by the use of iron and manganese sulfates at 1% probability level but interaction effect of treatments was not significant (Table 2). The highest number of seeds per spike (By the average of 30 seeds) belonged to the treatment with consumption of 3000 $g.ha^{-1}$ iron sulfate and the lowest number of seeds per spike (by the average of 25 seeds) belonged to the treatment without the consumption of iron sulfate (Table 3). As the consumption of manganese sulfate increased, the number of seeds and the number of fertile spikes increased, so that the highest number of seeds per spike belonged to the treatment with consumption of 3000 $g.ha^{-1}$ manganese sulfate (by the average of 28) and the lowest number belonged to the control treatment and then treatment with consumption of 1500 $g.ha^{-1}$ manganese sulfate (By the average of 24 and 25.8), respectively (Table 4). Hu and Schmidhalter (2001) reported that the consumption of micro nutrients such as iron and manganese would increase the number of seeds per spike. The treatment with consumption of 3000 $g.ha^{-1}$ iron sulfate and 3000 $g.ha^{-1}$ manganese sulfate could produce higher number of seeds per spike in comparison other treatments due to better use of conditions and more potential to produce dry matter, leaf and stem (Pahlavan rad *et al*., 2008).

1000-seed weight (g)

According to the ANOVA results, the effect of iron and manganese sulfates on 1000-seed weight were significant at 1% probability level but interaction effect of treatments was not significant (Table 2). The highest weight of 1000-seed belonged to treatment with consumption of 3000 $g.ha^{-1}$ iron sulfate (by the average of 38.5 g) (Table 3). Manganese sulfate treatment also increased the weight of 1000-seed significantly, the highest and the lowest weight of 1000-seed respectively belonged to the treatment with 3000 $g.ha^{-1}$ (by 37 g) and control treatment (by 29.5 g) (Table 4). Increase of iron and manganese will greatly increase rate of carbohydrates and also due to increasing the storage power and enhancing the plant resistance against the environmental stresses more assimilates would accumulate in seed and the weight of 1000-seed will increase in wheat (Majidi and Balali, 2001; Ziaeian and Malakouti, 1999). Zeidan *et al.* (2010) found that the concurrent use of iron and manganese was significantly different from the control treatment in terms of different traits. The highest rate of 1000-seed weight, number of seeds per spike, seed yield, and seed protein content belonged to the treatment with foliar application of micro nutrients. Silspoor (2002) observed that in the weight of 1000-seed increased in treatment with consumption of manganese sulfate. Baji *et al.* (2001) stated that application of manganese element would cause production of various enzymes in plant would increase the transfer of assimilates and elements into seed and would increase weight of 1000-seed.

Seed yield

Seed yield was significantly affected by the use of iron and manganese sulfates effect at 1% probability level but interaction effect of treatments was not significant (Table 2). In both treatments, the increase of concentration concurrently increased the seed yield. The highest seed yield belonged to treatment with concentration of 3000 $g.ha^{-1}$ iron sulfate (by 667 $g.m^{-2}$) and the lowest seed yield belonged to the control treatment with consumption of 0 $g.ha^{-1}$ iron sulfate (by 403 $g.m^{-2}$) (Table 3). The increase of manganese sulfate concentration also increased the seed yield. The highest seed yield belonged to treatment with concentration of 3000 $g.ha^{-1}$ manganese sulfate (by 618 $g.m^{-2}$) and the lowest seed yield belonged to the control treatment without the consumption of iron sulfate (by 376 $g.m^{-2}$) (Table 4). The rate of photosynthesis and the capability of using assimilates, the number of fertile spikes, the number of seeds per spike and 1000-seed weight are the factors affecting the seed yield (Baibordi and Malakouti, 2001). The results indicated that the concurrent use of iron and manganese sulfates would increase the seed yield and yield components. The increase of seed yield might be associated with the concurrent increase of yield components. Shahrokhi *et al.* (2012) stated that the treatment with iron sulfate in comparison to the control treatment significantly increased yield, yield components and protein content. The maximum seed yield belonged to the treatment with 6 $kg.ha^{-1}$ iron sulfate by the mean yield of 8.120 $t.ha^{-1}$. Majidi and Balali (2001) examined the effect of manganese treatments on seed yield and concluded that the highest seed yield belonged to the fertilizer treatment with 50% more than the recommended fertilizer in the region (45 $kg.ha^{-1}$ manganese sulfate) which showed the 26% growth. Mentioned results showed that the concentrations with more vegetative growth and further dry weight had higher yield too, which indicates the supply of more food by the source (photosynthetic area) for the destination (Seed). Therefore, it can be concluded that the difference of various concentrations in terms of vegetative and reproductive growth of plant can increase the seed yield. The treatments with 3000 g of both elements by having the highest number of seeds per fertile spike in square meter and the highest number of seeds per spike could increase the seed yield significantly in comparison with the other two concentrations. Due to lack of these two elements in the control treatment, the plants could not possibly increase the seed yield and with the increase of iron and manganese sulfates in fertilizer treatments up to 3000 $g.ha^{-1}$ the difference between the yield and yield components was revealed. This is due the plant production potential in response to the level of fertilizers as well as the reaction of seed yield components. With regard to the role of iron and manganese in the increase of plant dry matter at different stages and their effect on yield components, the increase of yield in wheat in expected with the consumption of these two elements. The results of the experiments by Barraclogh and Kient (2001); Shahrokhi *et al*. (2012); Majeedi and Balali (2001); Hu and Schmidhalter (2001) Ziaeian and Malakouti (1999) indicate the increase of seed yield with the increase of soil iron and manganese.

Seed protein content

According to the ANOVA results, the effect of iron and manganese sulfates on seed protein content were significant at 1% probability level but interaction effect of treatments was not significant (Table 2). The highest rate of seed protein belonged to treatment with concentration of 3000 and then 1500 $g.ha^{-1}$ iron sulfate (by 13.2% and 10.6% respectively) and the lowest rate of seed protein belonged to the control treatment with (by 8%) (Table 3). The highest rate of seed protein belonged to treatment with concentration of 3000 and then 1500 $g.ha^{-1}$ manganese sulfate (by 11.7% and 11% respectively) and the lowest rate of seed protein belonged to control treatment without consumption of manganese sulfate (by 8.7%) (Table 4). The increase of the rate of seed protein due to the use of iron and manganese is associated with role of these two elements in activating the RNA polymerase enzyme (Qeibi and Malakouti, 2004). Motamed (2005) in an experiment concluded that by adding 30 $kg.ha^{-1}$ manganese sulfate to the soil in which the rate of manganese is less than the critical amount, the rate of seed protein in wheat, Pishtaz Cultivar, increased by 11%. Shahrokhi *et al.* (2012) stated that use of iron as spray had a positive effect on seed protein and as use of iron increased from 0 to 6 $kg.ha^{-1}$, protein content increased significantly and the highest rate belonged to treatment with 6 $kg.ha^{-1}$ and then treatment with 4 $kg.ha^{-1}$. Silspoor (2007) concluded that concurrent use of iron and zinc fertilizers increased wheat yield by 867 kg, who reported reason increase of yield was increase of starch and protein in seed, so seed protein percentage was affected by fertilizer treatments and highest seed protein percentage in iron treatment was reported as 12.4%.

Seed iron content

The ANOVA results indicated the significant effect of iron sulfate on the iron content of seed at 1% probability level but effect of manganese sulfates and interaction effect of treatments on mentioned trait was not significant (Table 2). Among different levels of iron sulfate, the highest content of iron in seed (by 73.5 $mg.kg^{-1}$) belonged to the treatment with consumption of 3000 $g.ha^{-1}$ iron sulfate and the lowest content belonged to control treatment (by 46.5 $mg.kg^{-1}$) (Table 3). As the concentration of manganese increased, the rate of stored iron in seed decreased. After the foliar application and absorption of iron, these two elements and the increase of their concentration in leaves concurrently might have had a negative effect on their transfer, so that the excess of manganese over a specific amount might decrease the content of iron in seed by disrupting the transfer of iron. Mohammad *et al.* (2009) reported that the use of iron and zinc increased the wheat yield in comparison to the control treatment and the maximum yield and zinc concentration were achieved by foliar application of zinc. Mousavi *et al.* (2007) reported that the consumption of micro nutrients particularly zinc and manganese sulfates increased the production and enriched the seeds of wheat and the wheat seeds became more powerful due to storing. Therefore, the use of micronutrients is an effective step to increase the wheat seed yield, to enrich its seed, to compensate for malnutrition resulting from lack of such elements and is a method to secure community health and wellness in a long time which is consistent with results of the present research.

Seed manganese content

The ANOVA results indicated the significant effect of manganese sulfate on manganese seed content at 1% probability level, but the effect of iron sulfate and interaction effect of treatments was not significant (Table 2). Among different levels of iron sulfate, the highest content of iron in seed (by 46.8 $mg.kg^{-1}$) belonged to the treatment lack of foliar application and the lowest content belonged to consume 1500 $g.ha^{-1}$ treatment (by 44.5 $mg.kg^{-1}$) (Table 3). There was a significant difference among different levels of manganese sulfate in terms of manganese content in seed, so that maximum content of manganese in seed belonged to the treatment with consumption of 3000 $g.ha^{-1}$ manganese sulfate (by 67.7 $mg.kg^{-1}$) and the lowest content belonged to the control treatment without consumption of manganese sulfate (by 45.8 $mg.kg^{-1}$) (Table 4). In the research conducted by Chen *et al.* (2004), shortage of iron led to the increase of concentration of cupper in roots and shoots. They stated that iron deficiency would lead to the induction of expression of gens in iron-carrying proteins and since heavy metals are absorbed bi similar carriers, under iron deficiency conditions, the accumulation of zinc, manganese, cupper, and cadmium in the roots and shoots of plants would increase. Pahlavan Rad *et al.* (2008) came to the conclusion that foliar application of manganese sulfate would increase the concentration of manganese in seed as much as 11.5%. When the manganese sulfate was not consumed, plants faced manganese deficiency, but at high concentrations of manganese sulfate plants could store more amount of manganese in seed and as the rate of manganese sulfate increased, difference between various level was revealed differently, so at concentration of 3000 $g.ha^{-1}$, plants could absorb more manganese by increasing their area and rate of manganese in seed increased significantly at this level. Reduction of manganese concentration with consumption of iron was also observed in experiment conducted by Ming and Chungren (1995) and Majeedi and Balali (2001).

CONCLUSION

Examining the yield and yield components at different levels of iron and manganese sulfates showed that all the measured traits had variable trends with the increase of consumption of iron and manganese sulfates. The consumption of iron and manganese sulfates significantly affected the yield and yield components. In iron sulfate treatment, the seed yield and yield components increased as concentration increased. It can be stated that in conditions with lack of micronutrients of iron and manganese, the new leaves will develop slowly that is because of the interaction between these elements and enzymes and growth regulators. Among different treatment, the highest number of fertile spikes and the number of seeds per spike resulted from the interactive effect of iron and manganese sulfates. The number of spikes and the number of seeds per fertile spike are very significant in determining the final yield and are among the main components determining the wheat yield. The mean comparison of protein percentage showed that the use of iron and manganese sulfates increased the content of iron and manganese in seed. The increase of each one of these elements in seed might be due to the increase of mobilization towards seed or the sink in plants. In general, it can be concluded that the highest yield and yield components in this experiment belonged to the treatments with 3000 $g.ha^{-1}$ iron sulfate and 3000 $g.ha^{-1}$ manganese sulfate.

REFERENCES

Abbas, G., M. Q. Khan, M. J. Khan, F. Hussain. and I. Hussain. 2009. Effect of Iron on the growth and yield contributing parameters of bread wheat (*Triticum aestivum* L.). J. Animal and Plant Sci. 19(3): 135-139.

Baibordi, A. and M. J. Malakouti. 2003. Effect of iron, zinc and copper on the quantity and quality of wheat in saline conditions. J. Soil. Water. Sci. 17(2): 53-74.

Barraclough, P. B. and J. M. Kient. 2001. Effect of water stress on chlorophyll meter readings in wheat (*Triticum aestivum* L.). Plant Nutr. J. 23: 722-738.

Baji, M., S. Lutts. and J. M. Kient. 2001. Water deficit effects on solute contribution to osmotic adjustment as afunction of leaf ageing in durum wheat cultivars performing differently in arid conditions. Plant Sci. J. 160:669-681.

Cesco, S., G. Neumann, N. Tomasi, R. Pinton. and L. Weisskopf. 2010. Release of plant-borne flavonoids into the rhizosphere and their role in plant nutrition. Plant Soil. J. 329: 1-25.

Chen, Y., J. Shi, G. Tin, S. Zheng. and Q. Lin. 2004. Fe deficiency induces Cu uptake and accumulation in Commelia communis. Plant. Sci. J. 166: 1371-1377.

Gastillo, E. G., R. J. Buresh. and K. T. Ingram. 1992. Lowland rice yield as Affected by timing of water deficit and nitrogen. Agron. J. 84: 152- 159.

Hu, Y. and U. Schmidhalter. 2001. Effect of salinity and macronutrient levels on micronutrient in wheat. J. Plant Nutr. 24 (2): 273-281.

Hung, P. V., T. Maeda, K. Miyatake. and N. Morita. 2009. Total phenolic compounds and antioxidant capacity of wheat graded flours by polishing method. J. Food Res. (42): 185–190.

Khald Barin, B. and T. Islamzadeh. 2001. Mineral feeding of higher plants. Shiraz University Pub. 120 pp.

Majeedi, A. and M. Balali. 2001. The effects of micro nutrients iron, zinc, manganese and copper on wheat yield. Agric. Res. Center West Azerbaijan. Res. Rep. 45 pp. (Abstract in English)

Motamed, A. 2005. The effect of zinc, manganese and iron fertilizers on qualitative and quantitative yield of bread wheat, Pishtaz cultivar. J. Seedling and Seed. 21: 634-638.

Ming, C. and Y. Chungren. 1995. Effect of manganese and zinc fertilizer on nutrient balance and deficiency diagnosis of winter wheat crops in pot experiment. Beijing Agric Univ. Pub. 81 pp.

Mohamad, W., M. Iqbal. and S. M. Shal. 2009. Effect of mode of application of zinc and iron on yield of wheat. Sarhad. J. Agric. 6(6): 615-618.

Moussavi, M., Z. Rangel, G. J. Hollamby. and J. A. aschar. 2007. Seed manganese content is more important than Mn fertilization for wheat growth under Mn deficient condition. Plant Nutr. J. 5: 267-268.

Pahlavan Rad, M., Q. Kikha. and M. R. Narooei Rad. 2008. Effect of zinc, iron and manganese application on yield, yield components, concentration and absorption of nutrients in wheat seed. Res. Develop. Agric. Hortic. 150: 79-142.

Qeibi, M. Sh. and M. J. Malakouti. 2004. Crop Nutrition Guide. Agric. Training Pub. Karaj. Iran. 119 pp.

Siadat, S. A., S. A. Hashemi Dezfooli, M. Radmehr. and A. Q. Lotfali Adine. 2001. The effect of micronutrients on yield and uptake trend of nitrogen, P and K by wheat. Proceedings of the 7th Iranian Cong. Soil Sci. Univ. Mashhad. Iran. (Abstract in English)

Silspour, M. 2001. Optimal intake of micronutrients by wheat in saline conditions. Varamin Agricultural and Research Center. Agric. Res. Edu. Org. Pub. Karaj. Iran. 12 pp.

Silspour, M. 2007. The study of iron and zinc effects on quantitative and qualitative parameters of winter wheat and determination of critical levels of these elements in Varamin plain soils. J. Pajouhesh Sazandegi. 76: 123-133. (Abstract in English)

Shahrokhi, N., A. Khourgami, H. Nasrollahi. and A. H. Shirani-Rad. 2012. The effect of Iron Sulfate spraying on yield and some qualitative characteristic in three wheat cultivars. Annals. Biol. Res. 3(11): 5205-5210.

Zeidan, M. S., F. Manal, L. Mohamed. and H. A. Hamouda. 2010. Effect of foliar fertilization of Fe, Mn, and Zn on wheat yield and quality in low sandy soil fertility. World. J. Agric. Sci. 6(6): 696-699.

Ziaeian, A. and M. J. Malakouti. 1999. The effect of manganese on wheat production in highly calcareous soils of in Fars province. J. Soil Water. 12: 65-71. (Abstract in English)