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The Effect of Iron Sulfate Spraying on Yield and Some Qualitative Characteristics in Three Wheat Cultivars

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ABSTRACT

In order to study the effects of iron sulfate spraying on qualitative characteristics in three cultivars of dryland wheat, an experiment in the form of random complete block design (RCBD) as a split plot with three replications and twelve treatments was conducted at the Research Farm of Khorram Abad Islamic Azad University in the crop year 2011-2012. The main plot of the spraying treatment was at four levels of marker (without spraying), spraying with such concentrations as 2/1000, 4/000, and 6/1000, and the sub-plot of the wheat cultivar was at such three levels as Azar 2, Kouhdasht, and Zagros. Variance analysis and comparing the means was conducted for grain's characteristics, yield, yield components, protein, and gluten, by Duncan Test. Data analysis showed that spraying treatment has a significant effect on grain yield, and proves significant at 1% level. Maximum grain yield is 8125 kg/ha, belonging to the spraying treatment with a concentration of 6/1000 and Zagros 2 cultivar (m4v3), having a yield increase of 3761 kg/ha compared to the marker cultivar. Also, spraying has positive effects on grain's protein and gluten. As spraying concentration increases, wheatear weight, 1000-grain weight, and yield also increase. In addition, grain's gluten and protein percentage has increased compared to the marker treatment. It can be inferred from the results that its genetic record mainly determines the quality of plant gluten. Gluten quality cannot change due to variations in environmental conditions or fertilizer application. Moreover, high yield in any condition may not indicate more desirable protein and gluten. Higher protein level, mainly increasing the quality of bakeries, may be indicative of gluten with a good quality.

Key words: wheat, spraying, micronutrients, yield, protein, gluten

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INTRODUCTION

Wheat is no doubt the most important crop, playing a major role among the few crops cultivated at a large level, and serving to start farming [6].

Increasing price of fertilizers worldwide, necessary for production economy, ground water pollution, and soil structure degradation due to uncontrolled and unwise consumption of chemical fertilizers are the problems that have to be solved by proper methods. Spraying or foliar nutrition is a method for decreasing chemical fertilizers consumption and their environmental hazards, especially nowadays that toxin reduction policy and optimizing fertilizer consumption is under discussion. An important strategy to increase the concentration of trace elements in grains is fertilizing the plants with soil or spraying [5].

Iron is an immobile element; therefore, its deficiency is evident in young leaves. It is quite necessary in chlorophyll synthesis, hydrocarbon production, respiration, as well as oxidation and reduction operations in plants. Iron rate varies from 400 to 200 P.P.m in plant tissues. However, its rate must be more than 100 P.P.m in healthy plants. Its main sign is chlorosis usually seen in young leaves [7].

Iron deficiency has developed in almost 30 percent of the soils under cultivation around the world [5]. In addition, iron absorption decreases in the soils with law organic matters [8]. Numerous experiments have been conducted about the application of trace elements in the world, whose results have showed that their application not only increases quantitative and qualitative yield, but also increases their amounts in wheat grains [10].

Mohammad Aref *et al*. (2006) reported that wheat biological yield has significantly increased with spraying trace elements. Maximum biological yield with trace elements has been 4,833 kg/ha, which has had a significant increase compared to the marker with minimum biological yield of 1,343 kg/ha. These results are consistent with the reports by Torun *et al*. (2001), and Canada *et al*. (2002).

Amal *et al*. (2006) stated that the effect of spraying complete fertilizer on wheat in different proportions has been significant compared to the effect of the marker on grain yield, straw yield, biological yield, harvest index, grain's hydrocarbon and protein percent.

To become self-sufficient in crops, especially this strategic plant, it is required that the rate of yield in surface unit increase, and micronutrient elements play a very important role in increasing yield and improving the qualitative status of crops [19].

Considering the expensive cost of the fertilizers containing micronutrient elements and economic problems about the extension of consuming the fertilizers containing the trace elements, it appeared necessary to carry out an experiment on the effects of consuming the fertilizers containing micronutrient elements through spraying method.

MATERIALS AND METHODS

To study the effects of iron sulfate spraying on yield and some qualitative characteristics of three wheat cultivars, this experiment was conducted at Kamalvand area in Khorram Abad with an altitude of 33˚26′, a longitude of 48˚17′, and a height of 1147.8 meters above sea level in the crop year 2011-2012. There are 285,000 hectares of annual farmlands in Lorestan, of which 196,000 hectares is allocated to dryland farming. The precipitation rate was 298.1 mm in the crop year in which the experiment was conducted. After providing the required farmland for this research, the pilot map of the split plot in the form of random complete block design (RCBD) with twelve treatments and three replications was prepared by cultivating three dryland wheat cultivars (Azar 2, Kouhdasht, and Zagros). The main plot (M) of the spraying treatment of micronutrient elements was at four levels of marker (m1), as well as spraying with such concentrations as 2/1000 (m2), 4/1000 (m3), and 6/1000 (m4). The dissolved fertilizer type containing iron was prepared by using iron sulfate resources with such ratios as 2/1000, 4/1000, and 6/1000, and was consumed during development. The treatment sub-plot (V) of wheat cultivar was at such three levels of Azar 2 (v1), Kouhdasht (v2) and Zagros (v3).

In order to provide and reinforce the elements required by wheat, the amounts of the consumed fertilizers were determined based on the results of soil test and critical limit of nutrient elements. The needed rates of phosphate, potash, and nitrogen fertilizers were used according to the suggestion proposed by the Iranian Institute of Soil and Water Research. All the phosphate and potash fertilizers, as well as one-third of nitrogen fertilizer, were used before cultivation and two-thirds of the remained nitrogen fertilizer was used as surplus on condition of moisture at the tillering stage. The seeds, in mother category and in treated form, were provided from the Institute for Research, Registration and Certification of Seed and Seedling at Lorestan Province Research Center for Agriculture and Natural Resources affiliated with Lorestan Province Agricultural Jihad Organization. MSTATC computer software was used for analyzing the data variance and comparing their mean (by Duncan Test), and the diagrams were drawn by Excel software.

Table 1:Results of the chemical analysis of experiment site soil before cultivation

Total Nitrogen (%)	Organic Carbon (%)	Available Phosphorus (P.P.m)	Available Potassium (P.P.m)	Fe- P.P.m	Mn- P.P.m	Zn- P.P.m
0.12	1.16	9.8	330	8	7.4	0.7
Cu- P.P.m	**pH**	**Ec**	**Neutralized Matters percent (lime)**	**Soil Particles Percent (clay, sediment, sand)**	**Soil texture**	
0.62	7.8	0.67	25.2	21, 46, 33	Clay loam	

RESULTS AND DISCUSSION

The results from variance analysis and comparing the means of the grains' yield influenced by concentrations of spraying with iron sulfate and wheat cultivars show that it has a positive effect on grain's yield, and has become significant at one percent level (Table 2).

The results of comparing the means of spraying and wheat cultivar interactions on grain yield showed that maximum grain yield belongs to m4v3 treatment with a concentration of 6/1000, and Zagros cultivar (m4v3), being 8125 kg/ha, having 3761 kg/ha yield increase compared to the marker treatment (Table 4). The results correspond with those obtained by Tandon (1995), Cakmack *et al*. (1996), and Yilmaz *et al*. (1997). It appears that iron sulfate spraying, with a concentration of 6/1000, has increased grain yield by increasing the photosynthetic activity of leaves, and more dry matter accumulation, and positive effect on 1000-grain weight.

Mohammad Aref *et al*. (2006) reported that maximum wheat grain yield is obtained by spraying with micronutrient elements having different concentrations, which corresponds with the results of this research.

The results of variance analysis and comparing the means showed that biological yield characteristic is influenced by different concentrations of spraying with iron sulfate and has a significant difference at one percent level. In this study, interactions of spraying and wheat cultivar for biological yield showed that maximum yield, being 181.2 kg/ha, belongs to spraying with a concentration of 6/1000 and Zagros cultivar (m4v3), and minimum biological yield, being 116.6 kg/ha, belongs to the marker treatment and Azar 2 cultivar (m1v1) (Tables 2 and 4).

Mohammad Aref *et al*. (2006) in an experiment showed that maximum biological yield, 1,333 kg/ha, compared to the marker treatment, having a very significant increase, was obtained because of spraying trace elements in wheat at maturation stage.

The results of variance analysis and comparing the means showed that straw yield characteristic influenced by different concentrations of spraying with iron sulfate is positive and significant at one percent level (Table 2). The results of comparing the interactions of spraying and wheat cultivar on straw yield showed that maximum straw yield, 100 kg/ha, belongs to spraying with a concentration of 6/1000 and Zagros cultivar (m4v3), and minimum straw yield, 73.02 kg/ha, belongs to the marker treatment and Azar 2 cultivar (m1v1) (Table 4). Baibourdi and Malakouti (2003) , conducting an experiment, stated that maximum straw yield was obtained by consuming 18kg/ha iron sulfate and 21 kg/ha manganese.

Studies have showed that grain yield, iron concentration in wheat grain and stubble, and protein percentage significantly increase by consuming the fertilizers containing iron [20, 3]. The researchers, in their experiments, concluded that using iron and manganese in soil as well as their spraying and simultaneous application in wheat leads to yield components increase, their concentration increase in grain and stubble, and protein percentage increase [16, 15]. The percent and quality of protein and gluten is one of the most important internal characteristics in wheat grain. Although wheat is usually known as a grain containing starch, its proteins are considered as the most important biological and metabolic compounds. On the one hand, proteins are source of required nitrogen and amino acids during embryo sprouting. They are, on the other hand, regarded as a significant factor in baking mechanism and bread's nutritional value. In time of wheat harvest, increasing the amount of wheat is considered as its quantitative improvement, and increasing the amount of proteins and their types as its qualitative improvement. Generally, it is more likely that as grain's yield (quantitative improvement) increases, crop's quality, that is, the rate protein deposit and its amount also increase (qualitative improvement).

The results of variance analysis and comparing the means showed that grain's protein influenced by different concentrations of spraying with iron sulfate was positive and significant at one percent level. Comparing the means of grain's protein for different spraying treatment showed that maximum protein percent belongs to spraying treatment with a concentration of 6/1000 (14.61 %), which has increased 4 percent compared to the marker. In addition, the highest protein percentages belong to Zagros, Kouhdasht, and Azar 2 cultivars, being 13.75, 12.83, and 11.50 percent, respectively (Table 3).

Today, it is proved that wheat genotype (cultivar) is an important factor in determining the amount of protein so that different wheat cultivars have different protein rates at similar environmental conditions. This indicates the effect of heredity factor on protein percentage in wheat grain. Moreover, grain protein is influenced by climatic conditions. Research has proved that dryland wheat has more protein than wetland wheat. In addition, wheat grains in warm regions are more enriched in protein sources than those cultivated in cold areas (8 to 20 percent).

Gluten is another important biological and metabolic compound in wheat grain. The amount of wheat's gluten, effective in baking bread, is a function of total soil nitrogen. However, gluten's biochemical compound and the rate of its amino acids mainly depend on wheat genotype. Wheat nutritional value and quality is determined by the amount of grain's protein; therefore, gluten plays an important role in this connection. Gluten is composed of gliadin and glutenin [13]. The amount of gluten, in the first phase, depends on climatic conditions as well as the rate of soil nitrogen, and its quality is a function of genetic factors.

Miezan *et al*. (1997) stated that late nitrogen application increases grain's protein. However, there is no significant change in its vegetative growth. Research results, therefore, showed that protein rate has increased 0.7 to 2.1 percent, and gluten 4.7 to 6.5 percent [13]. Nitrogen fertilizers mainly increase the quantity of gliadin [11].

The quality of plant gluten is largely determined by its genetic record. Gluten's quality cannot change due to variations in environmental conditions or the use of fertilizers. Higher protein levels mainly causing to increase the quality of bakeries are indicative of gluten's quality. It is the rate of wheat gluten which determines its quality. In spring and autumn, hard red wheat has more gluten; therefore, it has a high nutritional value to make bread. The amount of wheat gluten largely depends upon climatic conditions. However, its quantity may be increased by breeding wheat seeds. Grain's gluten is influenced by climate to 70 percent, and by cultivar up to 30 percent.

The results of variance analysis and comparing the means showed that grain's gluten has become positive and significant at one percent level, influenced by the concentrations of spraying with iron sulfate (Table 2).

In this study, interactions of spraying and wheat cultivar on the above-mentioned trait showed that maximum grains gluten (28 percent) belongs to spraying with a concentration of 6/1000 and Zagros cultivar (m4v4), and minimum grain's gluten (20.83 percent) belongs to the marker treatment and Azar 2 cultivar (m1v1) (Table 4).

Harvest index is obtained by the ratio of grain's economic yield to its biological yield [6]. Harvest index is known as important physiological criteria in crops. This component shows the efficiency, especially the economic one, of the produced matters in various organs. This trait is largely influenced by environmental changes, and its application may be useful only when its variation from one environment to another is parallel to yield variations [9].

The results of variance analysis and comparing the means showed that harvest index, influenced by spraying with different concentration of iron sulfate had a significant difference between different treatments. In this study, the results of interactions showed that maximum harvest index (45.18 percent) belongs to spraying treatment with a concentration of 4/1000 and Azar 2 cultivar (m3v1), and minimum harvest index (37.40 percent) belongs to the marker treatment and Azar 2 cultivar (m1v1) (Table 2 and 4). It seems that spraying treatment with a concentration of 4/1000 has a green level and lower photosynthetic activity due to spraying with lower concentration. In other words, plant tissues have a lower vegetative growth; therefore, they have a lower biological yield and a higher harvest index.

Table 2: Variance analysis of yield and qualitative characteristics in 3 dryland wheat cultivars influenced by spraying with iron sulfate

Mean Squares (MS)							
Variation Resources	**Rate of Freedom**	**Grain Yield**	**Biological Yield**	**Straw Yield**	**Grain's Protein**	**Grain's Gluten**	**Harvest Index**
Replication	2	0.489 ns	1.108 ns	1.338 ns	1.174 ns	0.271 ns	0.093ns
Spraying (A)	3	758.875**	1614.737**	203.217**	26.324**	16.481**	62.080**
Error a	6	0.548	9.712	2.412	0.164	0.558	0.325
Cultivar (B)	2	687.160**	4578.830**	1710.536**	15.361**	60.896**	3.115**
Interaction (A×B)	6	9.726**	29.674**	35.209**	0.102 ns	0.294**	8.367**
Error b	16	0.463	6.663	0.885	0.125	0.069	0.225
Variations Coefficient		1.07%	1.71%	1.08%	2.79%	1.07%	1.12%

*ns, *, ** are insignificant, significant at probability levels of 5 and 1 percent, respectively.*

Table 3: Comparison of mean yield and qualitative characteristics in 3 wheat cultivars influenced by spraying with iron sulfate

Treatment	Grain Yield (kg/ha)	Biological Yield (kg/ha)	Straw Yield (kg/ha)	Grain's Protein (%)	Grain's Gluten (%)	Harvest Index (%)
m1 (marker)	51.35 d	134.3 d	83.02 b	10.61 d	23.26 c	38.23 c
m2 (2/1000)	62.75 c	145.6 c	82.88 b	12.17 c	24.28 b	43.09 b
m3 (4/1000)	66.99 b	157.4 b	90.44 a	13.39 b	25.06 b	42.56 b
m4 (6/1000)	73.12 a	164.9 a	91.81 a	14.61 a	26.28 a	44.34 a
v1 (Azar 2)	55.43 c	129.1 c	73.74 c	11.50 c	22.13 c	42.93 a
v2 (Kouhdasht)	64.84 b	155.3 b	90.52 b	12.83 b	25.46 b	41.75 b
v3 (Zagros)	70.39 a	167.2 a	96.84 a	13.75 a	26.42 a	42.09 b

Means of each characteristic in each group with at least one letter in common have no significant difference at 5% probability level.

Table 4: Comparing the mean interactions of spraying and cultivars on yield and qualitative characteristics in 3 dryland wheat cultivars with Duncan test

Treatment	Grain Yield (kg/ha)	Biological Yield (kg/ha)	Straw Yield (kg/ha)	Grain's Protein (%)	Grain's Gluten (%)	Harvest Index (%)
m1v1	43.64 j	116.66 k	73.02 i	9.50 h	20.83 g	37.40 f
m1v2	53.12 i	137.50 h	84.38 g	10.67 g	23.67 e	38.63 e
m1v3	57.29 h	148.96 f	91.67 e	11.67 ef	24.67 d	38.45 e
m2v1	56.25 h	125.00 j	68.75 j	11.17 fg	21.83 f	45.00 a
m2v2	61.87 f	149.16 e	87.29 f	12.33 d	25.00 d	41.47 d
m2v3	70.12 d	162.70 d	92.58 de	13.00 c	26.00 c	43.09 c
m3v1	59.31 g	131.25 i	71.94 i	12.00 de	22.00 f	45.18 a
m3v2	68.75 e	165.00 d	96.25 c	13.50 c	26.17 c	41.66 d
m3v3	72.91 c	176.01 b	103.10 a	14.67 b	27.00 b	41.42 d
m4v1	62.50 f	143.75 g	81.25 h	13.33 c	23.83 e	43.47 c
m4v2	75.62 b	169.79 c	94.17 d	14.83 b	27.00 b	44.53 b
m4v3	81.25 a	181.25 a	100.00 b	15.67 a	28.00 a	44.82 b

Means of each characteristic in each group with at least one letter in common have no significant difference at 5% probability level.

CONCLUSION

According to the results from variance analysis of the data obtained from iron sulfate spraying with different concentrations at wheat growth stages during a year of conducting the experiment, it was witnessed that spraying treatments have influenced grain yield, yield components and qualitative characteristics in grain's protein and gluten, having become significant at 1% level. All spraying treatments have showed higher yield in comparison with the marker. Maximum yield increase in treatments under spraying with iron sulfate has belonged to spraying treatment with a concentration of 6/1000 and Zagros cultivar (m4v3). This treatment, with a yield mean of 7312 kg/ha, has had a yield increase of 2177 kg/ha compared to the marker. It seems that this concentration of spraying may increase grain yield by increasing leaf photosynthetic activity and ultimately more dry matter accumulation and positive effect on 1,000-grain weight increase. Grain's protein and gluten have been among qualitative characteristics under study in this research. The results of correlation between these two characteristics with other ones cannot be a reason for their quality increase. A high percent of grain's protein and gluten is determined by genetic properties and environmental conditions. However, strides may be taken to improve the quality of such characteristics by breeding. Because the application of spraying the trace elements leads to maximum yield and efficiency of the resources, and their use, in sporadic or compound forms, causes some changes in grain yield, it is predicated that the yield of these elements, when used in sporadic form, is more than their compound form. It is suggested that the compound forms of these micronutrient elements be applied to prove this factor. As micronutrient elements are not insufficient everywhere, it is advised that soil test become generalized for suggesting the solution.

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