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The Effect of Trace Elements Spraying on the Yield and Yield Components of Dryland Wheat in Khorram Abad, Iran

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ABSTRACT

In order to study the effects of iron sulfate spraying on the yield and yield components 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 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, 4/1000, and 6/1000, and the sub-plot of the wheat cultivar was at such three levels as Azar 2, Kouhdasht, and Zagros. Variance analysis was conducted for wheatear length, wheatear weight, number of wheatears per square meter, number of grains per wheatear, and 1000-grain weight. Moreover, their means were compared by Duncan test. Data analysis showed that spraying treatment has a significant effect on grain yield, and proves significant at one percent level. The maximum grain yield is 8125 kg/ha, belonging to the spraying treatment with a concentration of 6/1000 (m4v3), and the minimum grain yield belongs to the marker treatment and Azar 2 cultivar, being 4364 kg/ha. The increase of spraying concentration has positive effect on all the treatments under study, and increases the yield.

Key words: wheat, spraying, micronutrient elements, yield and Yield Components.

INTRODUCTION

Micronutrient elements deficiency, including iron, zinc, and manganese in plants and crops has a worldwide spread. Continuous cultivation, excessive annual consumption of phosphate fertilizers, erosion, leaching, and other conditions of calcareous soils such as excessive calcium bicarbonate, alkaline pH, non-consumption of the fertilizers containing micronutrient elements and organic fertilizers decrease their reserves in soil, and consequently reduce the yield [9].

Iron deficiency has developed in almost 30 percent of the soils under cultivation around the world [1]. In addition, iron absorption decreases in the soils with law organic matters [5]. As the population of the country increases more than one million people every year, demand for foodstuffs also becomes more. Therefore, it is crucial to create a balance in nutrients consumption for quantitative and qualitative increase in agriculture. Law concentrations of micronutrient elements such as iron, zinc, copper, manganese, and boron have become problematic more than foodstuffs, mainly arising from non-consumption of the fertilizers containing micronutrient elements in crops, especially wheat. In developed countries, the fertilizers containing micronutrient elements form 2 to 4 percents of the consumed fertilizers. However, this ratio is quite little in Iran, being almost zero [9]. 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 [9].

Iron is one of the most essential elements for all plants. The most important action of iron is its presence in a plant's enzymatic systems. Iron is necessary for chlorophyll synthesis, because its deficiency causes chlorosis in leaves. The importance of the enzymes containing iron, cytochrome in particular, is evident in plant respiration. Plants absorb iron as ferrous ion (Fe^{2+}). Although this element is abundant in soils, its deficiency is frequently reported. This deficiency emerges in alkaline and acid soils due to the lack of dissolved iron. Moreover, excessive amount of some elements like phosphorus, zinc, copper, manganese, and nickel in soil may help to cause such a deficiency. In case of iron deficiency, chlorophyll is not produced enough in leaf cells, and leaves seem etiolated [9].

Because of its farming values, wheat has a specific position among strategic crops in Iran. Meanwhile, micronutrient elements have a very important role in increasing the yield and improving the qualitative condition of the crops [12].

Canada *et al.* (2002) stated that the effect of complete fertilizer spraying on wheat has such ratios as 0.3%, 0.6%, and 0.9% compared to the mark on vegetative characters, plant height, and number of wheatears, wheatear yield, grain index, and grain yield. The highest effect belongs to spraying with a ratio of 0.9 percent.

Research has showed that, by consuming the fertilizers containing iron, such characters as grain yield, grain's iron concentration, and the number of grains in a wheatear significantly increases [1]. Considering the expensive cost of the fertilizers containing the 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 spraying effects of trace elements on dryland wheat yield and subyield in Khorram Abad in the crop year 2011-2012, an experiment was conducted in this city with an altitude of 33˚26′, a longitude of 48˚ 17', and height of 1147.8 meters above sea level. Khorram Abad is one of the temperate and semi-humid regions in Iran, and its annual crop production is 348 tons. Today, there are more than 110 thousand hectares of farmlands in this city, of which 57 thousand hectares is allocated to dryland and wetland wheat. The precipitation rate was 298.1 mm in the crop year in which the experiment was carried out. Soil test was conducted to determine the amount of nutrient elements applicable by plants. The results are presented in Table 1.

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	

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 the 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 the critical limit of the 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.

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.

Comparing the means of grains' yield for different treatments of spraying presented in Table 3 showed that the highest grain yield belongs to the spraying treatments with a concentration of 6/1000 (m4) and a yield of 7,312 kg/ha, having 2,177 kg/ha yield increase compared to the marker. The grain yield of Zagros cultivar, being 7,039 kg/ha, has been 555 kg/ha and 1,496 kg/ha more than Kouhdasht and Azar 2, respectively. 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 (Table 3).

The results of comparing the means of spraying and wheat cultivar interactions on grain yield showed that the maximum grain yield belongs to the spraying treatment with a concentration of 6/1000, and Zagros cultivar (m4v3), being 8,125 kg/ha, and the minimum grain yield, being 4,364 kg/ha, belongs to the marker treatment and Azar 2 cultivar (Table 4). The results correspond with those obtained by Tandon (1995), Cakmack *et al*. (1996), and Yilmaz *et al*. (1997).

Pahlavan *et al*. (2006) showed that element soil consumption on wheatear increases its grain yield significantly. However, Mohammad Aref *et al*. (2006) reported that the 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 mean wheatears per square meter influenced by the concentrations of spraying with iron sulfate and wheat cultivars show that it has a positive effect on the number of wheatears per square meter, and is significant at one percent level. The mean comparison of the number of wheatears per square meter for different treatments of spraying showed that the maximum number of wheatear belongs to spraying with a concentration of 6/1000 (463.3), and the minimum number of wheatear (355.6) belongs to the marker treatment (Tables 2 and 3). According to the results, it can be inferred that micronutrient elements consumption, including iron sulfate, may have a significant increase in the number of wheatears per square meter, which corresponds with those presented by Yilmaz *et al*. (1997).

Soyler *et al*. (2005) reported a significant increase in the number of wheatears per square meter by spraying different micronutrient elements, in compound and sporadic forms, on wheat. The results of variance analysis and comparing the means showed that wheatear length character has become significant at one percent level influenced by the concentration of spraying with iron sulfate. However, interactions of spraying and boron cultivars have not become significant on this character (Table 2). The mean comparison of wheatear length character for different treatments of spraying showed that the maximum wheatear length belongs to spraying treatments with a concentration of 6/1000 (9.55 cm), having 1.32 cm increase compared with the marker treatment (Table 3).

The results of variance analysis and comparing the means showed that the number of wheatears has become significant at one percent level influenced by the concentrations of spraying with iron sulfate (Table 2). The minimum of the number of wheatear grains belongs to spraying treatment with a concentration of 6/1000 (16.63 grains), and the minimum number of wheatear grains belongs to the marker treatment (11.81 grains). The maximum numbers of wheatear grains obtained were 15.75, 14.25, and 12.59 for Zagros, Kouhdasht and Azar 2 cultivars, respectively (Table 3).

According to the results, it can be inferred that spraying increase may have a positive significant effect on such characteristics as the number of wheatears per square meter, wheatear length, and the number of wheatear grains. However, it cannot have a significant effect on the cultivars under study.

The results of variance analysis and comparing the means showed that wheatear weight characteristic has become significant at one percent level influenced by the concentrations of spraying with iron sulfate (Tables 2 and 4). The results of comparing the interactions of spraying and wheat cultivar on wheatear weight showed that the maximum wheatear weight, being 4.26gr, belongs to the spraying treatment with a concentration of 6/1000 and Zagros cultivar (m4v3), and the minimum wheatear weight, being 2gr, belongs to the marker treatment and Azar 2 cultivar (m1v1) (Table 4).

The third subyield in crops is 1000-grain weight. In fact, 1000-grain weight depends on the speed and durability of a grain's filling. Therefore, any factor that reduces the speed or durability of a grain's filling may decrease 1000-grain weight. The results of variance analysis and comparing the means showed that 1000-grain weight has become significant at one percent level influenced by the concentrations of spraying with micronutrient elements and cultivars. The results of comparing the mean interactions of spraying and wheat cultivar on 1000-grain weight showed that the maximum 1000-grain weight (45.50gr) belongs to the spraying treatment with a concentration of 6/1000 and Zagros cultivar (m4v3), and the minimum 1000-grain weight (32.08gr) belongs to the marker treatment and Azar 2 cultivar (m1v1) (Tables 2 and 4). The increase in 1000-grain weight corresponds with the results presented by Mohammad Aref *et al*. (2006).

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

		Mean Squares (MS)					
Variations Resources	**Rate of Freedom**	**Grain Yield**	**Wheatears per m^2**	**Wheatear Length**	**Number of Wheatears**	**Wheatear Weight**	**1000-Grain Weight**
Replication	2	0.489 ns	0.528 ns	0.026 ns	0.164 ns	0.342 ns	0.030**
Spraying (A)	3	758.875**	187.880**	2.726**	37.945**	329.852**	1.109**
Error a	6	0.548	2.602	0.027	0.558	0.072	0.001
Cultivar (B)	2	687.160**	339.694**	1.302**	29.953**	269.235**	0.509**
Interaction (A×B)	6	9.726**	0.657 ns	0.030 ns	0.96 ns	2.244**	0.036**
Error b	16	0.463	0.667	0.04	1.004	0.118	0.002
Variations Coefficient		1.07%	2.01%	2.23%	7.06%	1.12%	1.11%

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

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

Treatment	**Grain Yield (kg/ha)**	**Number of Wheatears per m^2**	**Wheatear Length (cm)**	**Number of Wheatear Grains**	**Wheatear Weight (gr)**	**1000-Grain Weight (gr)**
m1 (Marker)	51.35 d	355.6 d	8.239 d	11.81 d	2.40 d	33.54 d
m2 (2/1000)	62.75 c	388.9 c	8.917 c	13.46 c	2.84 c	35.12 c
m3 (4/1000)	66.99 b	417.8 b	9.139 b	14.89 b	3.17 b	37.49 b
m4 (6/1000)	73.12 a	463.3 a	9.556 a	16.63 a	3.83 a	41.61 a
v1 (Azar 2)	55.43 c	356.7 c	8.596 c	12.59 c	2.54 c	35.00 c
v2 (Kouhdasht)	64.84 b	400.0 b	9.058 b	14.25 b	3.16 b	36.71 b
v3 (Zagros)	70.39 a	462.5 a	9.233 a	15.75 a	3.48 a	39.10a

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

Table 4: Comparing the interactions of spraying and cultivars on yield and subyield with Duncan test

Treatment	**Grain Yield (kg/ha)**	**Number of Wheatears per m^2**	**Wheatear Length (cm)**	**Number of Wheatear Grains**	**Wheatear Weight (gr)**	**1000-Grain Weight (gr)**
m1v1	43.64 j	306.7 g	7.88 h	10.03 h	2.000 k	32.08 i
m1v2	53.12 i	350.0 f	8.31 g	12.07 fg	2.477 i	33.62 h
m1v3	57.29 h	410.0 d	8.51 fg	13.33 ef	2.727 g	34.93 g
m2v1	56.25 h	343.3 f	8.63 efg	11.33 gh	2.275 j	34.03 h
m2v2	61.87 f	376.7 e	8.91 cde	14.05 cde	2.975 f	34.87 g
m2v3	70.12 d	446.7 c	9.20 bc	15.00 bcde	3.277 e	36.45 f
m3v1	59.31 g	366.7 e	8.80 def	13.67 def	2.558 h	35.43 g
m3v2	68.75 e	410.0 d	9.31 b	15.00 bcde	3.297 e	37.50 e
m3v3	72.91 c	476.7 b	9.30 b	16.00 b	3.358 c	39.53 c
m4v1	62.50 f	410.0 d	9.06 bcd	15.33 bcd	3.363 d	38.47 d
m4v2	75.62 b	463.3 b	9.68 a	15.90 bc	3.890 b	40.85 b
m4v3	81.25 a	516.7 a	9.91 a	18.67 a	4.263 a	45.50 a

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

CONCLUSION

According to the results of data variance analysis from spraying iron sulfate with different concentrations at wheat development stage during the crop year of conducting the experiment, it was observed that spraying treatments have had a positive effect on grain's yield and subyield, and has become significant at one percent level. All the spraying treatments have showed yield increase in comparison with the marker. The maximum yield increase for the treatments under spraying with iron sulfate belongs to the spraying treatment with a concentration of 6/1000 and Zagros cultivar (m4v3). This treatment, with a mean yield of 7,312 kg/ha, has had yield increase compared to the marker with a mean yield of 2,177 kg/ha. The grain yield of Zagros cultivar, 7,039 kg/ha, has become significant at one percent level compared to Kouhdasht cultivar, 6,484 kg/ha, and Azar 2 cultivar, 5,543 kg/ha. It seems that this concentration of spraying with the increase of photosynthetic activity of leaves and finally by more dry matter accumulation, and positive effect on 1000-grain weight raise, has increased grain yield.

The maximum number of wheatear per surface unit belonged to the spraying treatment with a concentration of 6/1000 (m4) and Zagros cultivar (v3), and the maximum number of wheatear grains was also obtained in this treatment. The maximum 1000-grain weight resulted from the interactions of spraying with a concentration of 6/1000 and Zagros cultivar.

Because the application of spraying the trace elements leads to the 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.

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