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Effects of potassium and manure fertilizers on concentration of micro elements in leaf and grain of wheat under water stress

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ABSTRACT

In order to study the effect of potassium and manure fertilizer on yield and water use efficiency in wheat (N-81-18 cultivar) under drought stress, a pot experiment was conducted in split plot based on completely randomized design with four replications in 2009-2010 crop year. The main factor included irrigation after depletion of 75, 50 and 25 percent available plant water and the subsidiary factor was potassium in three levels (0, 300 and 600 kg/ha potassium sulfate fertilizer) and manure fertilizer in three levels (0, 20 and 40 ton/ha). Result indicated that irrigation treatment had significant effect on concentration of iron, zinc, copper and manganese in leaf and grain. The manure treatment had significant effect on concentration of iron, zinc, copper and manganese in grain at $p<0.01$ and on concentration of iron in leaf at $p<0.05$. Potassium treatment was significant ($p<0.01$) only on concentration of copper in leaf and grain. Interaction effect of irrigation and manure fertilizer treatments were significant on concentration of all micro element in leaf and grain and interaction effect of potassium and manure fertilizer was significant ($p<0.05$) only on concentration of iron. The most concentration of iron and manganese in leaf of wheat were observed in irrigation treatment after depletion of 75% of available plant water and maximum amount of zinc in irrigation treatment after depletion of 25% of available plant water and consumption of 20 tons of manure fertilizer ha^{-1}. Also, maximum amount of copper in leaf of wheat was obtained in irrigation treatment after depletion of 25% of available plant water and consumption of 40 tons of manure fertilizer ha^{-1}. Concentration of iron, manganese and copper in grain of wheat enriched to maximum in irrigation treatment after depletion of 50% of available plant water and consumption of 40 tons of manure fertilizer ha^{-1} and zinc of grain in irrigation treatment after depletion of 75% of available plant water without consumption of manure fertilizer.

Keywords: potassium; manure fertilizer; water stress; micro elements.

INTRODUCTION

Water is the main constituent of plant cells. It affects the metabolic reactions such as photosynthesis, respiration and nutrient uptake, transport, cell division, growth and increased cell turnover, differentiation and formation of organs and tissues and many other processes [1]. Absorption of the active elements in the soil under wet condition, good air conditioning and heat be enhanced [2].

Drought stress is the most important environmental stress factors that reduce growth and yield of many crops especially in arid and semiarid regions of the world. Reduced amount of photosynthesis due to stomatal closure, reduced plant growth, lack of photosynthesis materials needed for grain filing and reduced grain filing period are among the important effect of drought on plants [7]. Another effect of drought is disrupting the nutritional balance in plants [18, 19].

During the incidence of stress due to increase concentration of soluble salts in the root environment and consequently increased the osmotic potential of soil, nutrient uptake is greatly reduced [21]. Nasri et al [20], for example, reported that due to water shortage, the concentration of zinc was reduced in plant.

Organic resources such as manure fertilizer in combination with chemical fertilizer can lead to soil fertility and crop production because these systems provide most of nutrition needs of plant and increase output of nutrient uptake by the crop [17]. Manure application increases the concentration of zinc, copper and manganese in the plant and iron concentration in the shoots of plants in soli treated with manure compared to the control [10, 16].

Organic fertilizers especially animal fertilizers, compared to chemical fertilizers contain large amounts of organic matter and can be considered as rich sources of nutrients. Animal frtilizers can provide these elements for plants repeatedly, however, they cannot resolve all nutrotional requirements of plants, of course with improvement of soil physical structure they can bring about balance in soil chemical parts [4].

In addition to in increasing yield and grain quality in wheat, K plays a significant role in the uptake of nutrient [13]. Brohi et al [6] showed that using different amounts of potassium sulfate reduced copper and increased iron and zinc in straw. Potassium sulfate had no effect on the amount of iron in rice grains while it significantly affected copper, zinc and manganese. The effect of potassium on plant nutrient may be due to its effect on enzyme activity in the plant and increasing transportation and restoration of protein synthesis [11].

MATERIALS AND METHODS

The experiment was designed in split plot based randomized complete design with four replications in the greenhouse of Sari Agricultural Sciences and Natural Resources University. The main factor included irrigation in three levels I_1: irrigation after depletion of 75% available plant water, I_2: irrigation after depletion of 50% available plant water and I_3: irrigation after depletion of 25% available plant water, which were applied during plant growth. The subsidiary factor was potassium sulfate in three levels K_0: no consumption of potassium sulfate fertilizer, K_1: 300 kg/ha potassium sulfate fertilizer and K_2: 600 kg of potassium sulfate fertilizer consumption per hectare and cattle manure at three levels M_0: no consumption of manure fertilizer, M_1: 20 tons/ha consumption of manure fertilizer and M_2: 40 tons/ha consumption of manure fertilizer that were mixed with pot soil.

Before the experiment, soil samples were taken and some of its chemical and physical properties were measured [12, 13]. Also some of the characteristics of the manure were measured (Table 1). According to soil test the base fertilizer was added. After the addition of fertilizer treatments and base fertilizer to pot soil, 30 seeds of wheat cultivar N-81-19 were planted in pots and before tillering stage 6 plants per pot were kept. Irrigation treatments were applied during plant growth. In April, the flag leaf samples were gathered and after drying in the oven were milled. To determine the concentration of micro-elements, including iron, zinc, copper and manganese, 0.5 gram plant samples was weighed and placed and were in at 550 ° C in oven and then after cooling with hydrochloric acid (2 normal) extraction, the samples were brought to the volume of 50 cc and extracts were read by atomic absorption. In mid-June, wheat plants were harvested from the bottom of the pots and samples of grain were prepared, milled and extracted in the same way and were read by atomic absorption. The final data were analyzed using SPSS and MSTATC statistical software.

RESULTS AND DISCUSSION

Amounts of micro element concentrations in wheat leaves: Accordance to the analysis of variances preempted in Table 2, the effect of irrigation treatment (at $p<0.01$) on concentration of iron, zinc, copper and manganese was significant. The manure treatments had significant effects on the concentration of iron at p<0/05 and concentration of copper at $p<0.01$ and potassium treatment only had significant effect at $p<0.01$ on concentration Cu (Table 2). The highest concentration of copper was obtained in leaves of wheat with consumption 600 kg/ha of potassium sulfate fertilizer (Table 6). The interaction of irrigation and manure fertilizer was significant at $p<0.01$ on concentration of each of four elements (Table 2). The highest amount of iron was observed in irrigation after depletion of 75% available plant water and no consumption of manure fertilizer, which was statistically similar to I_1M_1, I_1M_2 and I_3M_1 treatments the highest amount of zinc was observed in the irrigation treatment after depletion of 25% available plant water and consumption of 20 tons/ha of manure fertilizer, which was similar to I_3M_0, I_3M_2 and I_1M_0 treatments. The maximum concentration of copper was observed in irrigation treatment after depletion of 25% available plant water and consumption of 40 tons/ha of manure fertilizer and the most amount of manganese was obtained from irrigation after depletion of 75% available plant water and no consumption of manure fertilizer which were in a similar statistical level with I_1M_1, I_1M_2 and I_2M_1 treatments (Table 3). The interaction between irrigation and potassium sulfate treatments on concentration of micro element was not significant and the interaction between manure fertilizer and potassium sulfate was only significant on concentration of iron at p<0.05 (Table 2). The highest concentration of iron was obtained in the treatment of consumption of 40 tons/ha of manure fertilizer and 600 kg/ha potassium sulfate (figure 1). In wheat leave, the level of stress in concentration of iron, zinc and manganese was in high level that may be possible due to reduction of leaf biomass caused by the reduced water availability [9]. Increasing the concentration of micro elements such as iron, manganese and zinc intake of animal manure have been reported by Tavassoli et al [8].

Amount of micro element concentrations in wheat grain: Results of experiment showed that the effect of irrigation treatment on the concentration of all four elements (iron, zinc, copper and manganese) was significant at p<0.01 and the effect of manure on the concentration of these elements in grain except for zinc, was significant at p<0.01, potassium treatments was significant on the copper concentration at p<0.01 (Table 2). The maximum concentration of copper in the grain of wheat was obtained with consumption of 300 kg/ha potassium sulfates (Table 5). Interaction between irrigation and manure fertilizer treatment was significant on the concentration of iron, copper, zinc and manganese concentrations at p<0.05 and p<0.01 levels (Table 2). The highest concentration of iron was obtained in the water treatment after depletion of 50% available plant water and consumption of 40 tons/ha of manure, which statistically was similar to I_2M_0 treatment. The maximum concentration of zinc was observed in irrigation treatment after the depletion of 25% available plant water and consumption of 20 tons/ha of manure fertilizer, which was similar to I_1M_0, I_3M_0 and I_3M_2 treatments. The highest concentration of copper was observed in irrigation treatment after depletion of 25% available plant water and consumption of 40 tons/ha of manure fertilizer, which was in the same statistical group to I_2M_2 treatment. Similar to iron the most amount of manganese concentration was obtained in irrigation treatment after depletion of 50% available plant water and consumption of 40 tons/ha manure and I_1M_2 I_1M_1 treatments were statistically similar to this treatment. According Babaeian et al [14], water stress at the reproductive stage limits the transition of iron and manganese to seed. Also Babaeian et al [15] during their study on sunflower reported that water stress had significant effect on the concentration of iron, zinc and manganese in sunflower seeds and the maximum amount of iron and zinc was observed in irrigation treatment control and water stress treatment at grain filling stage. The study also found that with increasing use of water and manure application, the concentrations of Fe, Cu and Mn in the grain increased. Mirlohi et al [5] have reported that the use of animal fertilizers increases iron, manganese and zinc in soil.

Table 1 - Some physical and chemical properties of soil and manure

Properties	soil	Cattle manure
FC (percent)	24	-
PWP (percent)	10	-
Soil texture	loam	-
pH	7.65	7.3
EC (dS/m)	0.7	9.68
OC (percent)	1.85	9.85
Fe (mg/kg)	20.3	1368
Zn (mg/kg)	1.13	88.65
Cu (mg/kg)	2.69	211.66
Mn (mg/kg)	5.48	38.78

Table 2 - Analysis of variances based on mean squares (MS) of micro-elements in the leaf and grain

		leaf				grain			
Sources of changes	df	Fe	Zn	Cu	Mn	Fe	Zn	Cu	Mn
I (irrigation)	2	9736.37**	792.62**	0.37**	3236.81**	491.36**	518.67**	102.77**	91.49**
Error I	9	64.33	32.34	0.002	42.88	54.5	12.69	2.69	5.75
M (manure fertilizer)	2	853.8*	26.48ns	0.46**	400.17ns	426.82**	26.56ns	89.12**	41.28**
K (potassium)	2	312.99ns	5.85ns	0.007**	218.62ns	59.62ns	12.98ns	11.22**	5.64ns
I*M	4	798.11**	147.03**	0.006**	844.58**	172.73*	169.63**	6.63*	20.99**
I*K	4	394.26ns	82.65ns	0.001ns	279.26ns	99.34ns	30.49ns	4.73ns	9.42ns
M*K	4	455.56*	54.68ns	0.001ns	210.48ns	24.13ns	36.71ns	0.61ns	2.33ns
I*M*K	8	538.73**	74.71**	0.002ns	343.39*	23.49ns	36.15*	3.31ns	7.11ns
residual error	72	181.42	35.41	0.001	125.76	51.23	16.66	2.21	5.21
C.V	-	15.95	26.29	0.45	16.59	15.57	19.37	8.64	7.50

***, * and ns, respectively, significant at p<0.01 and 0.05 and no significant difference*

Table 3 - Interaction between irrigation and manure fertilizer treatments on the micro element concentration in wheat leaf (mg / kg)

Irrigation	Manure fertilizer	Fe	Zn	Cu	Mn
I_1	M_0	102.97^{a}	25.51^{ab}	6.76^{h}	80.07^{a}
	M_1	101.75^{a}	21.86^{bc}	6.91^{g}	77.46^{a}
	M_2	92.17^{ab}	17.66^{cd}	7.03^{d}	75.4^{a}
I_2	M_0	53.26^{e}	14.01^{f}	6.94^{f}	63.72^{b}
	M_1	76.15^{cd}	17.84^{cd}	7.04^{d}	79.7^{a}
	M_2	70.35^{d}	20^{c}	7.15^{b}	55.69^{b}
I_3	M_0	89.04^{b}	27.1^{a}	6.99^{c}	55.69^{b}
	M_1	92.31^{ab}	27.84^{a}	7.1^{c}	56.9^{b}
	M_2	82.04^{bc}	25.04^{ab}	7.19^{a}	63.81^{b}

In each column, means that have at least a common letter, do not differ significantly at p<0.05 level of LSD test.

Table 4 - Interaction between irrigation and manure fertilizer treatments on the micro element concentrations in wheat grain (mg / kg)

Irrigation	Manure fertilizer	Fe	Zn	Cu	Mn
I_1	M_0	45.07^{bcd}	25.51^{a}	8.73^{d}	30.98^{b}
	M_1	44.03^{cd}	20.79^{b}	10.7^{c}	31.83^{ab}
	M_2	48.37^{bc}	16.25^{cd}	13.01^{b}	32.65^{ab}
I_2	M_0	50.8^{ab}	14.01^{d}	12.86^{b}	28.36^{d}
	M_1	41.87^{d}	19.02^{bc}	12.39^{b}	30.89^{bc}
	M_2	56.52^{a}	19.11^{bc}	15.14^{a}	33.23^{a}
I_3	M_0	44.79^{cd}	24.19^{a}	13.33^{b}	29.11^{cd}
	M_1	40.56^{d}	25.66^{a}	13.05^{b}	28.07^{d}
	M_2	41.69^{d}	25.04^{a}	15.49^{a}	28.92^{d}

In each column, mean that have at least a common letter, do not differ significantly at p<0.05 level of LSD test.

Table 5 - Effect of potassium sulfate fertilizer on the concentration of copper (Cu) in leaf and grain of wheat (mg/kg)

potassium	Cu (flag)	Cu (grain)
K_0	6.99^{b}	12.11^{b}
K_1	7.01^{a}	13.13^{a}
K_2	7.02^{a}	13^{a}

In each column means that have at least a common letter differ significantly at p<0.05 level of LSD test.

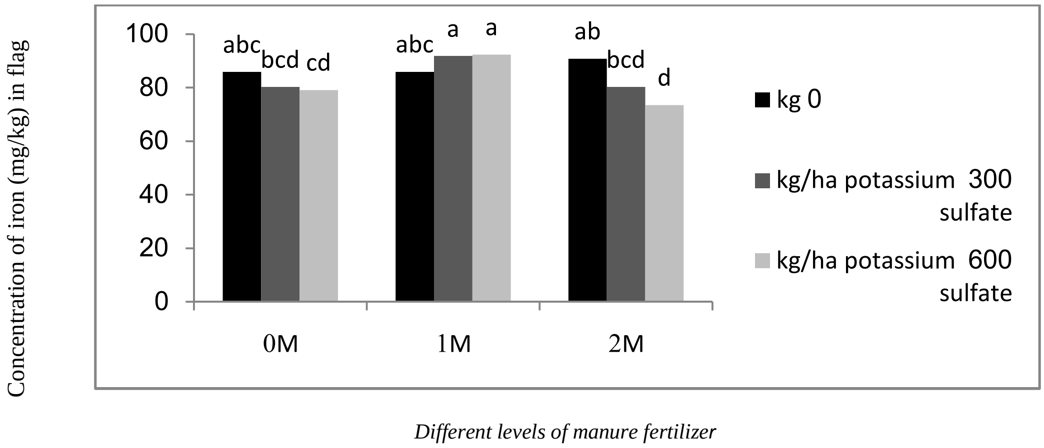

Figure 1 - Interaction between manure and potassium sulfate fertilizer on concentration of iron (mg / kg) in wheat flag leaf

CONCLUTION

To reduce water consumption, Iron and manganese concentrations increased in wheat leaves and zinc and copper concentrations decreased .But in the grain, concentration of these elements increased with increasing water and manure fertilizer. The reason for increasing concentrations of iron and manganese in treated water stress can be because the transmission of these elements to seed is reduced due to stress and the reduction of leaf surface.

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