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ORIGINAL ARTICLE

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The Impact of Manganese Sulfate on Increasing Grain Yield, Protein and Manganese Content of Wheat Cultivars in Semi Arid Region

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Wheat is the most important staple food crop in the world. Micronutrients are vital components for balances both growth and development in plants. An experiment was designed in order to survey the effects of manganese sulfate on yield and quality parameters of wheat cultivars in Isfahan in 2017. A split plot layout with a randomized complete block design with four replications was conducted. Main plots were manganese sulfate (contains 28% pure manganese) (20, 40 and 60 kg/ha), and sub-plots were winter wheat cultivars (Pishtaz, Shiraz and Marvdasth). Manganese sulfate influence was meaningful on the number of fertile spikes, the number of grains in spike, a thousand grain weight, grain yield, protein and manganese contents of grain. Cultivar had significant influence on number of fertile spikes, a thousand grain weight, grain yield and protein content. The highest values of fertile spike, number of grain, a thousand grain weight, harvest index, grain yield, grain protein and the content of grain manganese was achieved in application of 60 kg manganese sulfate per ha. In addition, the highest number of fertile spikes, number of grains per spike, grain yield and the content of grain manganese was related to Marvdasht cultivar. On the basis of the results, cultivation of Marvdasht cultivar and application of 60 kg Mn sulfate per ha is recommended for the semi-arid region of Isfahan.

Key words: Manganese sulfate, Grain protein, Wheat, Manganese content of grain, stress

Wheat *(Triticum aestivum* L.) is one of the most important stable food in the world, especially in Iran (Shahrajabian *et al.*, 2013; Shahrajabian *et al.*, 2017a,b). It plays a special role in nutrition of people (Riaziat *et al.*, 2012; Shahrajabian *et al.*, 2017c; Soleymani and Shahrajabian, 2017). Small amounts of Cu, Zn, B, Fe, Mo and Mn are essential for growth and quality of the crop as they control most of the physiological activities of the crop by interrupting the level of chlorophyll content in leaves, which ultimately influence the photosynthetic activity of the plant (Kanwar and Randhawa, 1967; Graham *et al.*, 2001). Manganese (Mn) is an important micronutrient in most organisms. In plants, it plays a vital role in the structure of photosynthetic, proteins and enzymes. Its deficit is dangerous for chloroplasts as it affects the water splitting system of photosystem II (PSII), which provides the necessary electrons for photosynthesis (Buchanan *et al.*, 2000). But, its excess may also lead to damage the photosynthetic apparatus (Mukhopadhyay and Sharma, 1991). Micronutrient elements are needed relatively small quantities for adequate plant growth and plant production (El-Shazly and Dris, 2004). El-Shazly and Dris (2004) reported that Mn foliar application gives the best result to obtain suitable yield. Sainju *et al.* (2003) found that the deficiency of tomato can be reduced by spraying $MnSO_4$ at 6 kg ha^{-1} several times during tomato growth. Application of manganese sulfate positively affects thousand seed weight of sunflower (Farzanian *et al.*, 2010). Setia and Sharma (2004) conclude that the use of fertilizer is a good agronomical strategy for achieving the object of enhanced productivity. Mn has two roles in the plant metabolic processes: as an essential micronutrient and as a toxic element when it is in excess (Kochian *et al.*, 2004; Ducic and Polle, 2005). In this research, our goal was to determine the effects of application of manganese sulfate on yield and quality parameters of wheat in semi-arid part of Isfahan.

MATERIALS AND METHODS

An experiment was designed in order to survey the effects of manganese sulfate on yield and quality parameters of wheat cultivars in Mahmoodabad Experimental Field in Isfahan in 2017 (Latitude 32°40′ N, longitude 51°48′ E, and 1570 m elevation). A split plot layout with a randomized complete block design with four replications was used. Main plots were manganese sulfate (contains 28% pure manganese) (20, 40 and 60 kg/ha), and sub-plots were winter wheat cultivars (Pishtaz, Shiraz and Marvdasth). One week before sowing, soil sample was taken at 0 to 30 cm. The soil texture was clay loam (Table 1). Long term average precipitation was 150 mm. Seed plantation was done on Nov 1th in 2017. On the basis of soil analysis, 80 kg per ha, potassium sulfate, 60 kg per ha ammonium phosphate, 40 kg per ha Zn sulfate, 40 kg per ha Fe sulfate and 20 kg per ha Cu sulfate before seed plantation was used. Each experimental plot had 10 rows with 6 m length. The plant density was 400 plants per m^2. 120 kg N per has from urea source at tiller stage and 120 kg N per ha at stem elongation was used. The protein content was calculated after the determination of the total nitrogen according to the Kjeldahl method. Mn content was determined according to Carter (1993). Analysis of variance of the data was carried out using MSTAT-C software. Duncan ،s test was applied to compare means of each trait at $p<0.05$.

RESULTS AND DISCUSSION

The influence of manganese sulfate was significant on the number fertile spikes, the number of grains per spike, a thousand grain weight, grain yield, grain protein and manganese content of grain. Cultivar had significant influence on the number of fertile spike, the number of grain weight, grain yield and grain protein. The number of fertile spikes and number of grains per spike were significantly increased from application of 20 to 60 kg N/ ha. There was no significant difference between three treatments of manganese sulfate application. The highest grain yield and grain protein were obtained in application 60 kg manganese sulfate per ha. The direct effects of grain yield with the number of fertile spikes were positive, indicating that increasing number of fertile spikes directly associated with increase in number of spikes. Manganese content of grains also significantly increased by application of manganese sulfate fertilizer (Table 2).Temiz *et al.* (2009) noted that crop production can be improved through improving nutritional status of crop plants. Marvdasht had obtained the highest number

of fertile spikes. Marvdasht cultivars obtained the maximum number of grains per spike, and there were significant differences between all experimental cutlviars. It may therefore be concluded that number of grains per spike is a reliable measure of higher yield and can be used as a criteria for selecting the appropriate cultivar (Mohsin *et al.*, 2009). The maximum and minimum of a thousand grain weight was related to Pishtaz and Marvdasht cultivars, respectively. There was no significant difference between cultivars in harvest index. The highest grain yield and grain protein was related to Marvdasht and Shirza, respectively, and there were no meaningful differences in manganese content of grain between all cultivars.

Table 1- Soil analysis of experimental station at 0-30 cm.

S (%)	K a.v.a (mg/kg)	P a.v.a (mg/kg)	N (%)	OC (%)	TNV (%)	pH	EC (ds/m^{-1})	SP	Soil texture
47	397	40.2	0.09	0.89	38	7.65	1.0	55	Clay loam

Table 2 Mean comparison of experimental characteristics.

Treatment	Number of fertile spikes per m^2	Number of grains per spike	A Thousand grain weight (g)	Harvest index (%)	Grain yield (kg/ha)	Grain protein (%)	Manganese content of grain (ppm)
Manganese sulfate (kg/ha)							
20	560.3c	38.67c	38.8c	45.66a	8150c	9.78c	56.33a
40	579.3b	39.92b	39.8b	45.86a	8799b	11.54b	63.92a
60	609.8a	41.58a	41a	46.16a	9604a	12.91a	76.92a
Cultivar							
Pishtaz	588.83b	36.3c	42.5a	47.22a	9039b	11.45b	60.92a
Shiraz	553.42a	39.5b	40.17b	46.54a	8316c	11.95a	65.42a
Marvdasth	609.55c	44.4a	37c	46.99a	9791a	11.12c	65.72a

Common letters within each column do not differ significantly.

CONCLUSION

The nutritional values of wheat is extremely important, as it takes an important place among crop species, being extensively grown as stable food sources. The results of this trial clearly shown that application of manganese sulfate fertilizer resulted high values of a thousand grain weight, harvest index, grain yield, grain protein and manganese content of grain. Besides, it is clear that selecting appropriate wheat cultivar gave best result in achieving appropriate grain yield and grain protein. It is recommended to use Marvdasht cultivar and application of 60 kg mn sulfate per had for semi-arid region of experimental station.

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