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Assessment Effect of Spray Different level of Zinc and Magnesium on Crop Production and Agrophysiological Characteristics of Wheat

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ABSTRACT

BACKGROUND: Suitable and useful usage of different kind of fertilizers is the main way for reformation and potential of soil fertility and increasing of crops yield. Microelements are the critical elements for plants; also play the important role in crop productivity where it is used in low rate. Optimum plant nutrition and maximum yield is achieved when nutrient elements are available for plant during the growing season.

OBJECTIVES: This research was carried out to evaluate response of seed yield, materials redistribution and current photosynthesis of wheat under apply different level of microelements (Zinc and Manganese).

METHODS: Current study was conducted according factorial experiment based on randomized complete blocks design with three replications along 2018 year. The first factor included spray different level of Zinc (0, 2.5, 5 and 10 $kg.ha^{-1}$) and second factor consisted spray Manganese at three level (0, 2 and 4 $gr.1000L^{-1}$).

RESULT: Evaluation of analysis of variance indicated effect of different level of zinc on all measured traits was significant, also effect different level of Manganese (instead contribution and efficiency of redistribution) and interaction effect of treatments (instead efficiency of current photosynthesis) on all measured traits had similar result. Mean comparison result of different level of zinc revealed the maximum amount of seed yield (5258 $kg.ha^{-1}$), rate of redistribution (150.2 $gr.m^{-2}$), contribution of redistribution (28.5%), efficiency of redistribution (12.6 $gr.gr^{-1}$), rate of current photosynthesis (375 $gr.m^{-2}$), efficiency of current photosynthesis (48.5%) was noted for 10 $kg.ha^{-1}$ zinc fertilizer. Also compare different level of manganese and interaction effect of treatments showed similar result.

CONCLUSION: Finally according result of current study the highest of amount of crop production and agrophysiological traits belonged to spray 10 $kg.ha^{-1}$ zinc and 4 $gr.1000L^{-1}$ manganese micronutrient and under studied region it can be advised to farmers.

KEYWORDS: *Current photosynthesis, Fertilizer, Nutrition, Redistribution, Seed yield.*

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1. BACKGROUND

Wheat is considered as a chief source of food of all over the world. Under optimum management practices it has the capability to provide food and feed for rapidly growing humans and animals (Khalil *et al*., 2011). Nutrients play a very important role in chemical, biochemical, physiological, metabolic, geochemical, biogeochemical, and enzymatic processes. Magnesium has major physiological and molecular roles in plants, such as being a component of the chlorophyll molecule, a cofactor for many enzymatic processes associated with phosphorylation, dephosphorylation, and the hydrolysis of various compounds, and as a structural stabilizer for various nucleotides. Studies indicate that 15 to 30% of the total magnesium in plants is associated with the chlorophyll molecule (EL-Metwally *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, the use of chemical fertilizers containing this element improves the nutritional conditions of plants and removes many nutritional disorders (Khald Barin and Islamzade, 2001). Zinc is one of the most functional micronutrients in plants, animals and humans and plays an important physiological role in their growth and development (Cakmak, 2008). Zinc deficiency is common in both crop plants and human beings, causing various serious health complications such as stunting, increased susceptibility to infectious diseases, impaired brain function and mental development, poor birth outcomes and anemia (Fraga, 2005). It is estimated that more than one third of the population is affected by Zn deficiency, particularly children and pregnant women and low dietary intake of Zn has been discussed as a major reason (White and Broadley, 2009). Enrichment of cereal crops with zinc is an important global challenge and a high priority research area. Zinc is required for the growth and grain nutritional quality of wheat, a staple food in a number of developing countries in the world and essential to ensure food safety and healthy diet (Pfeiffer and Clafferty, 2007). It has been reported that Zn concentration in wheat grains is different among wheat cultivars and subjects to the regulation of the environment and cultivation measures (Cakmak *et al*., 2010; Jiang *et al*., 2008). El-Maghraby (2004) found that the soaking of wheat grains in $FeSO_4$, $MnSO_4$, $ZnSO_4$ and $CuSO_4$ had highly significant effects on the uptake of N, K, Fe, Mn, Zn and Cu in straw. The treatments had highly significant effects on the uptake of N, P, K, Fe, Mn and Zn by grains. Sadeghi (2017) reported the effect of zinc sulfate showed that 60 kg zinc sulfate had the best effect on the traits under investigation. The effect of this treatment on two important traits (i.e., yield and grain protein percent) with 7.10 tons per hectare and 12.05% was higher (about 115 and 103%, respectively), as compared with the control treatment. Effect of magnesium sulfate levels on the traits showed that the treatment of 210 kg per hectare of magnesium sulfate was the superior treatment. The effects of the above-mentioned treatment on yield (7.84 tons per hectare) and grain protein (11.89 percent) were higher than the control treatment, which was 124 and 101.5%, respectively. Given the number of field nutrients and the wheat needs for these elements, the treatments of 20 $kg.ha^{-1}$ of zinc sulfate and 140 $kg.ha^{-1}$ of magnesium sulfate were better than other treatments and economically speaking, are very cost-effective and are thus recommended. Pahlavan-Rad *et al* (2011) reported zinc sulphate increased the Leaf Area Index, the total number of fertile tillers m^{-2}, number of spikelet, spike length, grain $spike^{-2}$, thousand grain weight, grain yield, straw yield and biological yield and decreased harvest index. All applications of zinc sulphate gave economic increases in margins over costs but the application of 5 $kg.ha^{-2}$ gave the highest marginal rate of return. It is recommended that under such calcareous soil conditions growers can expect good returns from the application of 5 kg zinc sulphate ha^{-2} at the time of sowing but if the grain price were to increase or the price of zinc sulphate were reduced economic responses could be expected from higher levels of zinc sulphate. Baji *et al.* (2001) stated that the application of manganese would cause the production of various enzymes in plant would increase the transfer of assimilates and elements into seed and would increase the weight of 1000-seed.

2. OBJECTIVES

This research was carried out to evaluation effect of different level of microelements (Zinc and Manganese) on seed yield and agrophysiological characteristics of bread wheat under warm and dry climate condition.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

Current study was conducted according factorial experiment based on randomized complete blocks design with three replications along 2018 year. Place of research was located in Ahvaz city at longitude 48°32'E and latitude 32°22'N in Khuzestan province (at South west of Iran). The first factor included spray different level of Zinc microelement (0, 2.5, 5 and 10 $kg.ha^{-1}$) and second factor consisted spray Manganese at three level (0, 2 and 4 $gr.1000L^{-1}$). This experiment had 27 plots. Each plot consisted of 6 lines with a distance of 60 cm and 6 meters length. The distance between the shrubs on every row was 10 cm. The climate of Khuzestan province is subtropical, with hot and dry summers and rainy and humid winters. Most of the winds are south, southwest to north, northeast. The sunshine totals over 2700 hours per year and evaporates to over 2400 mm. According to the Do marten climate classification mentioned region is part of the semi-arid region, but according to the Amberjeh classification, it has warm climates. The average annual rainfall, temperature, and evaporation in the region are 242 mm, 24°C and 3000 mm, respectively.

3.2. Farm Management

After ground preparation, the soil feeding process was carried out based on the results of soil sample analysis in the laboratory. Nitrogen fertilizer from urea source was consumed at 252 g per plot. One-third deduction was applied before planting as basal, next section at end of tillering and final one-third deduction used at spike emergence stage. Phosphorus (P_2O_5) was obtained from triple super phosphate source and was applied in amount 120 gram per plot at pre-planting. Potassium fertilizer was applied from potassium sulfate source at 120 gr per plot. To combat broadleaf and narrow leaf weeds, Duplosan Super (2.5 $L.ha^{-1}$) and topic (1 $L.ha^{-1}$) herbicides was used at the end of tillage and before application of topdressing fertilizer, respectively. The physical and chemical properties of studied soil mentioned in table 1.

Table 1. Physical and chemical properties of studied field

Sand (%)	**Silt** (%)	**Clay** (%)	**Potassium** ($mg.kg^{-1}$)	**Phosphorus** ($mg.kg^{-1}$)	**Nitrogen** ($mg.kg^{-1}$)	**pH**	**EC** ($ds.m^{-1}$)
28	36	36	110	7.2	39	6.6	1.51

3.3. Measured Traits

In order to determine the seed yield two planting lines from each plot harvested and after the removal of marginal effect were carried to the laboratory and were placed in the oven device at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighed and finally the total dry yield was measured. Also in order to evaluate remobilization efficiency and contribution and current photosynthesis seven days after flowering stage from each plot after removing the effects of lateral margin, five plants were harvested and total dry weight was measured. At the end of plant growth grain yield and related characteristics were calculated using the relationship. Agrophysiological traits were calculated by the following equations (Papakosta and Gagianas, 1991):

Equ.1. $R = Y_2 - Y_1$

R= Remobilization of storage material ($gr.m^{-2}$)

Y_2= Dry weight of vegetative organs at anthesis ($gr.m^{-2}$)

Y_1= Dry weight of vegetative organs at Maturity

Equ.2. Redistribution efficiency= R/Y_2

Equ.3. Redistribution Contribution= R/seed yield

Equ.4. Current photosynthesis= seed yield-redistribution of storage material

Equ.5. Current photosynthesis efficiency= Rate of current photosynthesis/dry weight of vegetative organs at anthesis.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done according MSTAT-C software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Seed yield

Result of analysis of variance revealed effect of different level of zinc, manganese and interaction effect of treatments on seed yield was significant at 1% probability level (Table 2). According mean comparison result of different level of zinc the maximum seed yield (5258 $kg.ha^{-1}$) was observed in 10 $kg.ha^{-1}$ and the lowest one (3363 $kg.ha^{-1}$) was found in control treatments (Table 3). Between different levels of manganese highest value of seed yield was belonged to the 4 $kg.ha^{-1}$ treatment (5251 $kg.ha^{-1}$ $kg.ha^{-1}$) and the lowest one was found in the control treatment as 3341 $kg.ha^{-1}$ (Table 4).

Table 2. Result analysis of variance of measured traits

S.O.V	df	Seed yield	Rate of redistribution	Contribution of redistribution
Replication	2	614.22^{ns}	8.7^{ns}	1.4^{ns}
Zinc (Zn)	2	5320114.22**	4102**	23.7*
Manganese (Mn)	2	4304781.33**	3501**	1.7^{ns}
Zn × Mn	4	6108450.22**	5842**	13.08*
Error	16	483	9.6	0.76
CV (%)	-	10.55	7.5	7.8

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Continue Table 2.

S.O.V	df	Efficiency of redistribution	Rate of current photosynthesis	Efficiency of current photosynthesis
Replication	2	0.9^{ns}	31.3^{ns}	5.5^{ns}
Zinc (Zn)	2	19.3*	3681**	102*
Manganese (Mn)	2	0.1^{ns}	2580**	98.2*
Zn × Mn	4	53.88*	4501**	2.11^{ns}
Error	16	0.13	18.5	1.27
CV (%)	-	8.3	6.3	7.5

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (6191 $kg.ha^{-1}$) was noted for 10 $kg.ha^{-1}$ zinc and 4 $kg.ha^{-1}$ manganese and lowest one (2430 $kg.ha^{-1}$) belonged to control treatment (Table 5). Positive effect of magnesium and copper foliar application on studied wheat growth parameters can be attributed to the important function of copper in plant metabolism since copper participates in photosynthesis and chloroplast development (Amberger, 1974). Since, magnesium is the central atom in the chlorophyll molecule. This makes it essential for photosynthesis. It also plays other critical roles in plant growth (Marschner, 1995). The same trend was found with Mg application on twelve sorghum genotypes (Tan *et al*., 1992).

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 26% growth.

4.2. Rate of redistribution

Sources of photosynthetic material for grain filling include current photosynthesis, re-transfer of photosynthetic materials stored in vegetative organs before pollination and redistribution of stored materials in vegetative organs from pollination stage to beginning of linear growth grains (Naderi, 2001). According result of analysis of variance effect of different level of zinc, manganese and interaction effect of treatments on rate of redistribution was significant at 1% probability level (Table 2). Mean comparison result of different level of zinc indicated that maximum rate of redistribution (150.2 $gr.m^{-2}$) was noted for 10 $kg.ha^{-1}$ zinc and minimum of that (70.4 $gr.m^{-2}$) belonged to control treatment (Table 3). As for Duncan classification made with respect to different level of manganese maximum and minimum amount of rate of redistribution belonged to 4 $kg.ha^{-1}$ (137 $gr.m^{-2}$) and control (87 $gr.m^{-2}$) (Table 4).

Table 3. Mean comparison effect of different level of zinc on measured traits

Zinc ($kg.ha^{-1}$)	Seed yield ($kg.ha^{-1}$)	Rate of redistribution ($gr.m^{-2}$)	Contribution of redistribution (%)
Control	3363^{c}	70.4^{c}	20.9^{c}
5	4739^{b}	116.5^{b}	24.8^{b}
10	5258^{a}	150.2^{a}	28.5^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Continue Table 3.

Zinc ($kg.ha^{-1}$)	Efficiency of redistribution ($gr.gr^{-1}$)	Rate of current photosynthesis ($gr.m^{-2}$)	Efficiency of current photosynthesis (%)
Control	8.7^{c}	266^{c}	41.7^{c}
5	10.9^{b}	357^{b}	44.4^{b}
10	12.6^{a}	375^{a}	48.5^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Assessment mean comparison result of interaction effect of treatments indicated maximum rate of redistribution (177 $gr.m^{-2}$) was noted for 10 $kg.ha^{-1}$ zinc and 4 $kg.ha^{-1}$ manganese and lowest one (51 $gr.m^{-2}$) belonged to control treatment (Table 5). Ziaeian and Malakouti (1999) observed that the consumption of 20 $kg.ha^{-1}$ of manganese sulfate would increase the number of fertile spike as much as 12%. High photosynthetic capacity of the plants under treatment assimilates transfer to the seed and productions of dry matter are the factors that influence the number of fertile spikes. Adding micronutrients to the soil at sensitive growth stages of plant especially at the tillering stage and stem elongation stage will increase the number of spikes per square meter and consequently will enhance the yield (Gastillo *et al*., 1992). Hu and Schmidhalter (2001) reported that the consumption of micronutrients such as iron and manganese would increase crop production. Pahlavan Rad *et al*. (2008) stated that foliar application of manganese sulfate with concentration of 0.5% in two stages increased the number of seeds per spike as much as 8%. 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 with other treatments due to better use of environmental conditions and more potential to produce dry matter, leaf, and stem.

4.3. Contribution of redistribution

Schneider (1993) stated that two types of carbohydrate sources are providing photosynthetic material at grain filling period. Current photosynthetic products that are transferred directly to the grain and redistribute the photosynthetic materials stored in the stored tissues. Result of analysis of variance revealed effect of different level of zinc and interaction effect of treatments on contribution of redistribution was significant at 5% probability level but effect of manganese was not significant (Table 2). According result of mean comparison maximum of contribution of redistribution (28.5%) was obtained for 10 $kg.ha^{-1}$ zinc and minimum of that (20.9%) was for control treatment (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum contribution of redistribution (29.9%) was noted for 10 $kg.ha^{-1}$ zinc and 4 $kg.ha^{-1}$ manganese and lowest one (21.1%) belonged to control treatment (Table 5).

Table 4. Mean comparison effect of different level of Manganese on measured traits

Manganese ($gr.1000L^{-1}$)	Seed yield ($kg.ha^{-1}$)	Rate of redistribution ($gr.m^{-2}$)	Rate of current photosynthesis ($gr.m^{-2}$)	Efficiency of current photosynthesis (%)
Control	3341^{c}	87^{c}	247^{c}	39.9^{c}
2	4525^{b}	111^{b}	341^{b}	44.3^{b}
4	5251^{a}	137^{a}	398^{a}	47.2^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

4.4. Efficiency of redistribution

According result of analysis of variance effect of different level of zinc and interaction effect of treatments on efficiency of redistribution was significant at 5% probability level but effect of manganese was not significant (Table 2). Result of mean comparison maximum of efficiency of redistribution (12.6 $gr.gr^{-1}$) was obtained for 10 $kg.ha^{-1}$ zinc and minimum of that (8.7 $gr.gr^{-1}$) was for control treatment (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum efficiency of redistribution (13.7 $gr.gr^{-1}$) was noted for 10 $kg.ha^{-1}$ zinc and 4 $kg.ha^{-1}$ manganese and lowest one (8.3 $gr.gr^{-1}$) belonged to control treatment (Table 5).

4.5. Rate of current photosynthesis

Result of analysis of variance showed effect of different level of zinc, manganese and interaction effect of treatments on rate of current photosynthesis was significant at 1% probability level (Table 2). Evaluation mean comparison result revealed in different level of zinc the maximum rate of current photosynthesis (375 $gr.m^{-2}$) was noted for 10 $kg.ha^{-1}$ and minimum of that (266 $gr.m^{-2}$) belonged to control treatment (Table 3). Between different levels of manganese the maximum rate of current photosynthesis (398 $gr.m^{-2}$) was observed in 4 $kg.ha^{-1}$ and the lowest one (247 $gr.m^{-2}$) was found in control treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum rate of current photosynthesis (451 $gr.m^{-2}$) was noted for 10 $kg.ha^{-1}$ zinc and 4 $kg.ha^{-1}$ manganese and lowest one (188 $gr.m^{-2}$) belonged to control treatment (Table 5). Saeedin (2016) evaluated the correlation between biological yield and seed yield of cowpea and reported a positive and significant correlation between mentioned traits. Its seem biological yield increased because of accumulation of photosynthetic products (source products) and high potential of seeds (reservoir) for absorption and accumulation of dry matter. Therefore, any increases in seed yield also increases the biological yield. However, less dry matter is accumulated in case of micronutrient deficiency, which decreases the biological yield.

4.6. Efficiency of current photosynthesis

Result of analysis of variance revealed effect of different level of zinc and manganese on efficiency of current photosynthesis was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of zinc indicated the maximum and the minimum amount of efficiency of current photosynthesis belonged to 10 $kg.ha^{-1}$ (48.5%) and control treatment (41.7%) (Table 3). Among different level of manganese the maximum efficiency of current photosynthesis (47.2%) was obtained for 4 $kg.ha^{-1}$ and minimum of that (39.9%) was for control treatment (Table 4). Soleymani and Shahrajabian (2016) reported that application of zinc fertilizer treatment led to the highest biological yield and seed yield due to the positive effect of zinc on biosynthesis of auxin and positive effect of iron on photosynthesis and improved plant growth.

Table 5. Mean comparison interaction effect of treatments on measured traits

Zinc ($kg.ha^{-1}$)	Manganese ($gr.1000L^{-1}$)	Seed yield ($kg.ha^{-1}$)	Rate of redistribution ($gr.m^{-2}$)	Contribution of redistribution (%)
Control	Control	2430^{g}	51^{g}	21.1^{e}
	2	3131^{f}	54^{g}	22.3^{c}
	4	3475^{e}	72^{f}	22.7^{c}
5	Control	4184^{d}	102^{e}	23.3^{b}
	2	4824^{c}	121^{cd}	26.5^{ab}
	4	5403^{b}	131^{c}	28.1^{a}
10	Control	4760^{c}	114^{d}	24.5^{b}
	2	5834^{ab}	152^{b}	28.6^{ab}
	4	6191^{a}	177^{a}	29.9^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Continue Table 5.

Zinc ($kg.ha^{-1}$)	Manganese ($gr.1000L^{-1}$)	Efficiency of redistribution ($gr.gr^{-1}$)	Rate of current photosynthesis ($gr.m^{-2}$)
Control	Control	8.3^{e}	188^{g}
	2	9.6^{d}	236^{f}
	4	9.9^{d}	277^{e}
5	Control	10.5^{c}	331^{d}
	2	10.9^{c}	369^{bc}
	4	11.7^{b}	388^{b}
10	Control	10.7^{c}	344^{c}
	2	12.5^{ab}	441^{ab}
	4	13.7^{a}	451^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

5. CONCLUSION

Finally according result of current study the highest of amount of crop production and agrophysiological traits belonged to spray 10 $kg.ha^{-1}$ zinc and 4 $gr.1000L^{-1}$ manganese micronutrient and under studied region it can be advised to farmers.

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FOOTNOTES

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