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Research Article

RESPONSE OF DURUM WHEAT (*Triticum aestivum* L.) TO FOLIAR APPLICATION OF MICRONUTRIENTS IN SALTED AND CALCAREOUS SOIL

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ABSTRACT

The alkaline nature of arid regions soil usually posses a reduction in solubility and assimilability of micronutrient in soil. A study has been carried out to focus-on the effect of foliar spraying of micronutrients (Fe, Zn, Cu, Mn, Mo) on wheat cultivation- in a saline and calcareous soil. The studied growth parameters are: stem length, yield, weight of 1000 seeds and weight of dry matter. According to ANOVA at 5% the following results were obtained: the Zn+Cu 87.67cm, Cu+Mn 83.63cm, Fe+Zn+Cu+Mo 83.53cm treatments exerted the best lengths in succession. For dry matter, the best treatments reported are Zn+Cu+Mo 12396.00Kg/ha, Fe+Mn+Mo11614.67Kg/ha and Fe+Zn+Cu+Mn 11415.67Kg/ha. The results of the weight of 1000 seeds are arranged as follows: Cu+Mo 44.62g was the greatest followed by, Zn+Mo 42.97g, and then by Zn+Cu+Mn+Mo 42.85g. The to pranked treatments in the yield parameter are Fe+Mo 3480.00 Kg/ha, followed by Fe+Zn+Cu+Mn 3451.00 Kg/ha, and then Mn+Mo 3442.20 Kg/ha.

Keywords: foliar spraying; micronutrients; Salted calcareous soils; Wheat; pH; alkaline reaction.

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop source of staple food and thus the most important crop in food security [1]. It's widely grown over wide range of latitude [2], when the cultivated area and total production in 2014 was more than 218 million hectares of farmlands and 771 million tons respectively [3].According to [4 - 9] the importance of wheat is remarked in the huge consummation of this product by the population because it's represent the major source of dietary calories, proteins and minerals. Crop yield is culmination of several rate processes one of which is nutrient uptake [10]. Crops need 17 nutrients to complete their life cycle under ideal conditions [11]. According to [12,13] micronutrients are less required relative to macronutrients and their total content in the soil is too small, but the importance of some micronutrients for plants was not detected until the 21st century. Several researches achieve by [4,14-20] conducted on the importance of micronutrients on plant development, finding an increasing crop yield by the positive effect on the cell physiology and grain quality for human nutrition but also for the nutrition of the next generation seedling. Thus only a few of those elements are known and they are irreplaceable: Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B) and Molybdenum (Mo). Root uptake contributes up to 86% micronutrients accumulation in the grain [21-23, 16,7] are reported that : the micronutrients deficiency has become a major yield limiting factor that may either be primary due to their low total contents or secondary caused by the soil physio-chemical characteristics that reduces their availability to plants. According to [24 - 26] nutritional disorders creating deficiency symptoms can be affected by other factors such as poor drainage, soil salinity and unbalanced fertilizer application also the availability of micronutrients such as Fe, Mn and Zn is much affected by pH and $CaCO_3$ due to low organic matter content, usually micronutrients-deficiency problems are bound in calcareous soil of arid and semi-arid regions. However, soil application of micronutrients is therefore not very effective to recover these deficiencies in calcareous and alkaline soils [27]. Foliar spray of these micronutrients has been reported to be 6 – 20 time more efficient than the soil application, depending on soil type [23]. Foliar application lead to increase in grain yield components and protein percentage in seed [28,29]. In Algeria, wheat is critical product in the

country's economy and in the consumption of the Algerian people. Soils in this region are particularly predominated by calcareous and salted soils which reduces the bioavailability of micronutrients for crops. Therefore, our study aims to use these elements in foliar spraying and thus facilitate their absorption by leaves of plants in order to compensate the hortage of plant needs to trace elements.

2. RESULTS AND DISCUSSION

2.1. Stem lenght

The result of foliar application of micronutrients and their combination (**Fig.1.**) showed significant effect ($p \leq 0.05$) on the stem length (**Table 1.**).

Table 1. Variance analysis results of foliar application of micronutrients on the stem length

Source	DDL	Sum squares	Square average	F	Pr > F
Template	31	3375.676	108.893	6.740	< 0.0001
Error	64	1034.002	16.156		
Adjusted Total	95	4409.677			

When the results range from: 64.17 cm to 87.67 cm and the best treatments are: Zn+Cu, Cu+Mn, Fe+Zn+Cu+Mo with stem lengths: 87.67cm, 83.63 cm, 83.58 cm respectively.

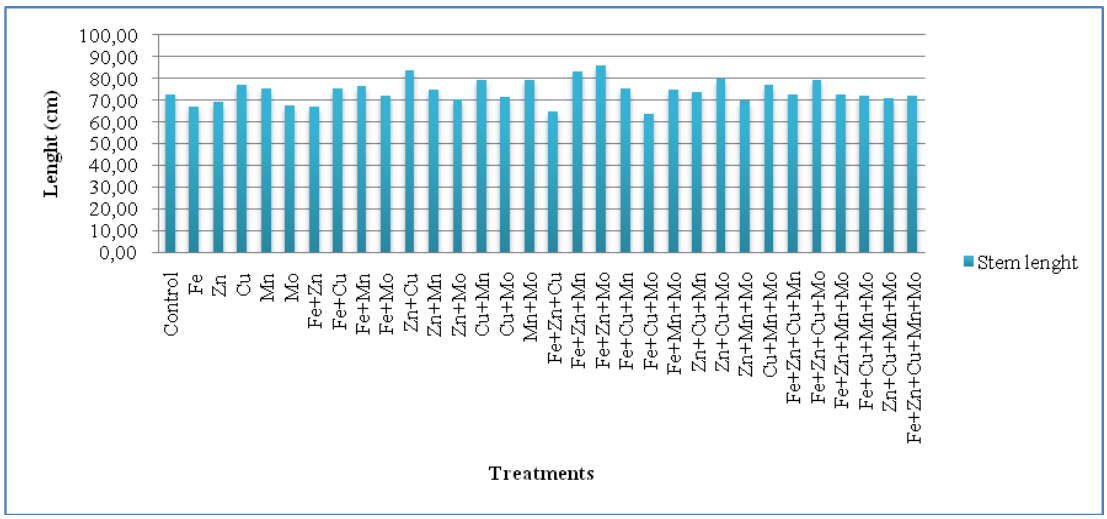

Fig.1. Stem length relative to the foliar application treatments on wheat cultivation

We can say that the foliar spray of micronutrients Zn, Cu, Fe, Mn, and Mo or in combination generally increase the wheat stem length due to the involvement of micronutrients in different physiological process like enzyme activation, electron transport, chlorophyll formation and stomat a regulation [1]. These results are similar to that was obtained by [30,16,1,19-20].

2.2. WEIGHT OF DRAY MATTER

The weight of dry matter is significantly affected ($p \leq 0.05$) by the foliar feeding of micronutrients (**Table 2.**).

Table 2. Variance analysis results of foliar application of micronutrients on dry matter.

Source	DDL	Sum squares	Square average	F	Pr > F
Template	31	28399.573	916.114	26.750	< 0.0001
Error	64	2191.818	34.247		
Adjusted Total	95	30591.335			

Which varies between 7322.67 Kg/ha and 12396.00 Kg/ha, the best reported treatments are: Zn+Cu+Mo 12396.00 Kg/ha, Fe+Mn+Mo 11614.67 Kg/ha and Fe+Zn+Cu+Mn 11415.67 Kg/ha (**Fig.2.**).

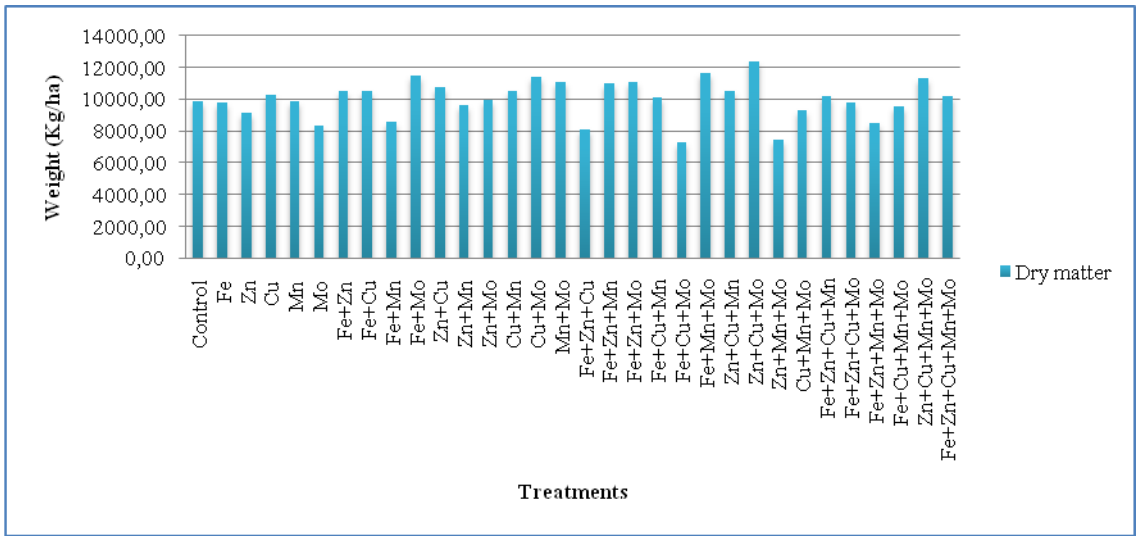

Fig.2. Weight of dry matter relative to the foliar application treatments on wheat cultivation

The foliar application of micronutrients increases the biological yield [23], this may be due to better crop nutrition through foliar application of the applied nutrients which may result in improved crop growth and [1] mention that more than one foliar spray of micronutrients mixture starting at tillering improve the biological yield. The same results were affirmed by another research achieved by [4,14,31].

2.3. Grain yield

The result of foliar application of micronutrients and their combination showed significant effect ($p \leq 0.05$) on grain yield (**Table 3.**).

Table 3. variance analysis results of foliar application of micronutrients on grain yield

Source	DDL	Sum squares	Square average	F	Pr > F
Template	31	2141.004	69.065	5.807	< 0.0001
Error	64	761.136	11.893		
Adjusted Total	95	2902.140			

The marked yield ranges from 1116.13Kg/ha to 3480.00Kg/ha, the top-ranked treatments were: Fe+Mo (3480.00 Kg/ha), Fe+Zn+Cu+Mn (3451.00 Kg/ha), Mn+Mo (3442.20 Kg/ha).

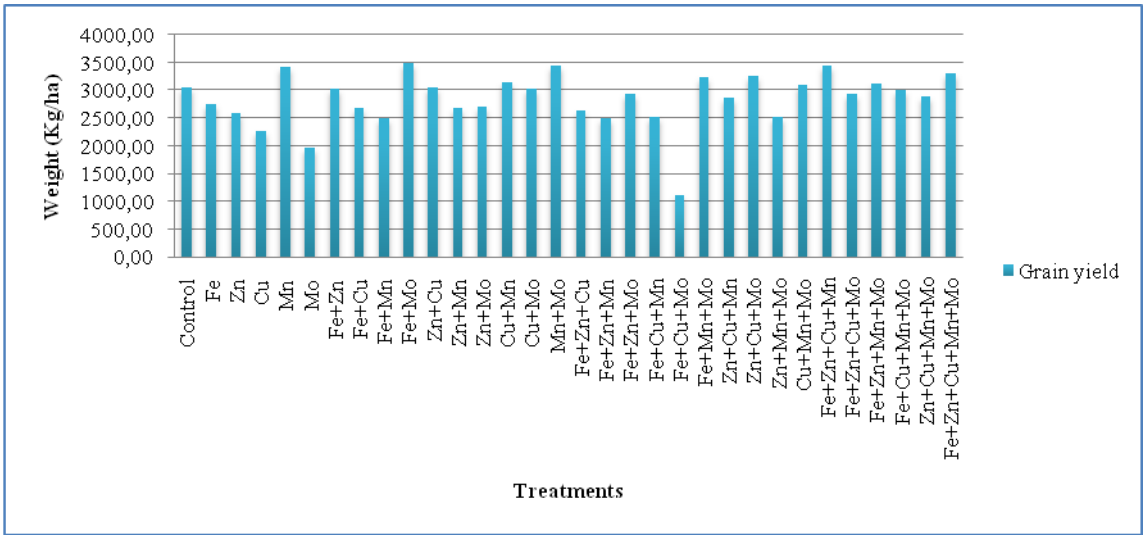

Fig.3. Grain yield relative to the foliar application treatments on wheat cultivation

These results are similar to the results mentioned by [14,23] also they reported that micronutrients application to leaves of growing crops will ensure better crop nutrition at an

thesis and grain filling stage which in turn may result in increased grain yield. This increased grain yield is the direct result of improvement in yield component, grain size and number of grains per spike had positive correlation with grain yield so highest grain yield might be the direct effect of improvement in grain size and number of grains per spike and many reports indicate the positive correlation of foliar spray of micronutrients with grain yield in wheat [1].

2.4. 1000 Seeds weight

The result of foliar application of micronutrients and their combination showed significant effect ($p \leq 0.05$) on 1000 seeds weight (**Table 4.**).

Table 4. Variance results of foliar application of micronutrients on seeds weight

Source	DDL	Sum squares	Square average	F	Pr > F
Template	31	544.435	17.562	2.663	< 0.000
Error	64	422.043	6.594		
Adjusted Total	95	966.477			

The weight of 1000 seeds (**Fig.4.**) is focused between 32.68 g to 44.62 g. the first three treatments are arranged as follows: Cu+Mo, Zn+Mo, and Zn+Cu+Mn+Mo and results recorded are mentioned respectively : 44.62g, 42.97 and 42.85 g however the first treatments differs significantly from other groups.

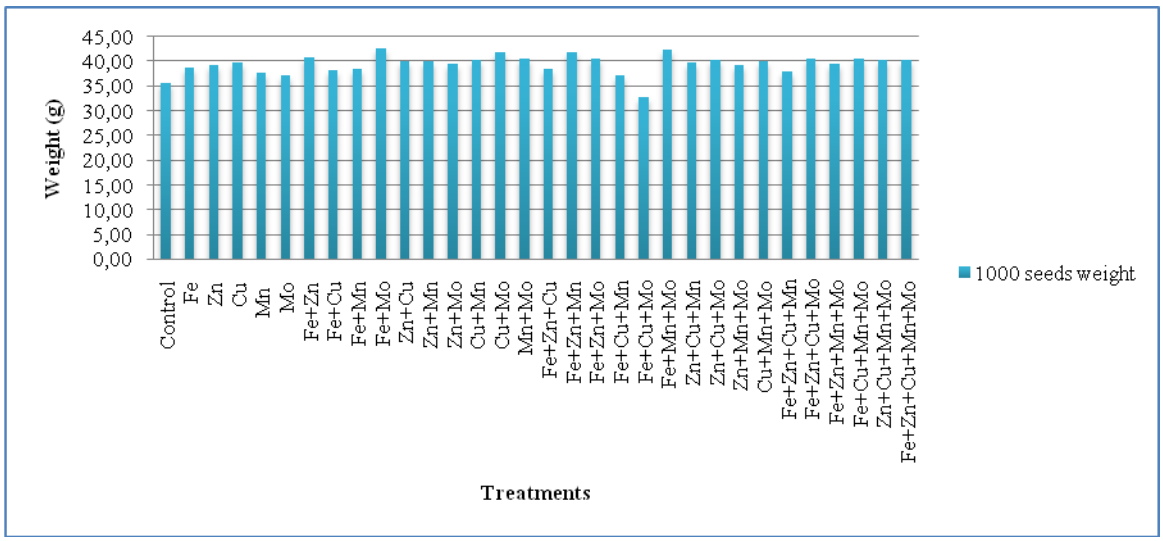

Fig.4. Weight of 1000 seeds relative to foliar application treatments on wheat cultivation

The increase of 1000 seeds weight due to involvement of the sprayed micronutrients in enzyme activation, membrane integrity, chlorophyll formation, stomata regulation and starch utilization at early stages, while enhance accumulation of assimilation in the grains, which result heavier grain wheat at later stages [1]. The results are in the same line with [32-34], a significant increase in 1000 grain weight of wheat with foliar application micronutrients.

3. EXPERIMENTAL

We conducted our study in the experimental site of agricultural sciences department, Biskra Algeria. The wheat cultivation (*Triticum aestivum* L.) was performed. In order to achieve our work, we put 7 Litters of soil in agricultural pots where percentage of $CaCO_3$ is 40.85 %, EC is 4.1 dS/m and pH is 7.3. Before planting, we brought: 1.3 g super simple phosphate (18%), 0.3 g of potassium sulfate (50%) and 0.9 g of urea (46%) this fertilizer was added in fraction way in different vegetative stages (0.3×3).

The Iron sulfate, Manganese sulfate, Zinc sulfate, Copper sulfate and Molybdic acid solutions concentrations (**Table 5.**) are prepared according to [12].

Table 5. Micronutrients treatment concentrations

$FeSO_4$ (ppm)	**$MnSO_4$ (ppm)**	**$ZnSO_4$ (ppm)**	**$CuSO_4$ (ppm)**	**$MoO_3 \cdot H_2O$ (ppm)**
6000	2000	3000	1000	200

This application has been carried out in two different stages tillering and booting under a favorable climatic and optimal water conditions. Where the maximum grain yield was recorded for two foliar sprays which were statistically similar to the three foliar sprays [14].Our experimental site is structured as follows 3 blocks; distributed according to completely randomized block design, each one consisting of 32 foliar spraying treatments which are mentioned in the **Table 6** below:

Table 6. Foliar spray treatments

Control	Fe	Zn	Cu	Mn
Mo	Fe + Zn	Fe + Cu	Fe + Mn	Fe + Mo
Zn + Cu	Zn + Mn	Zn + Mo	Cu + Mn	Cu + Mo
Mn + Mo	Fe +Zn + Cu	Fe +Zn + Mn	Fe + Zn + Mo	Fe + Cu + Mn
Fe + Cu + Mo	Fe + Mn + Mo	Zn + Cu + Mn	Zn + Cu + Mo	Zn + Mn + Mo
Cu + Mn + Mo	Fe + Zn+ Cu + Mn	Fe + Zn + Cu + Mo	Fe + Zn + Mn + Mo	Fe + Cu + Mn+ Mo
Zn + Cu + Mn + Mo	Fe + Zn + Cu + Mn + Mo			

During the culture cycle, the measurements and weighing were carried out including: stem length (cm), weight of dry matter (Kg/ha), grain yield (Kg/ha) and weight of 1000 seeds (g).

Statistical analysis

Analyze of data collected throughout the culture cycle in 3 blocks was done by using analysis of variance technique (ANOVA). For this purpose, software XLSTAT (2009) was used and arithmetic means were compared by using least significant difference (LSD) test.

4. CONCLUSION

The effectiveness of the micronutrients application on wheat to increase the stem length, biological yield, grain yield and 1000 seeds weight was remarked by the application of foliar micronutrients treatments combination. And also, we have noticed a positive effect of Zn because it was present in all the best combination treatments.

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