Influence of Magnesium and Copper Foliar Application on Wheat Yield and Quality of Grains under Sandy Soil Conditions

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ABSTRACT: Two field experiments were conducted during the winter seasons of 2007/2008 and 2008/2009 at Ismailia Experimental Station, Agriculture Research Center, Ismailia Governorate, to study the influence of foliar feeding with magnesium , copper either as single nutrient or in combination on yield ;yield components and grains quality of wheat (*Triticum aestivum* L.) cv. Sakha 94. Nine treatments were applied: two levels of Mg, two levels of Cu and four combined treatments (Mg + Cu), in addition to control treatment. Results showed that positive significant effect on plant height (cm), tillers number/m^2, spike number/m^2, spike length (cm), spike weight (g), grains number/spike, grains weight /spike (g), 1000-grain weight (g), grains yield/fed. and straw yield/fed. were achieved by spraying the of copper and magnesium treatments. However, the highest significant increment in grain yield was obtained by spraying the highest Cu level (1.68 kg Cu/fed.), while spraying the lowest Cu level (0.84 kg Cu/fed.) gave the highest straw yield. On the other hand, combination treatment (6.72 kg Mg + 1.68 kg Cu/fed.) showed the highest values for protein, N, Mg, Cu and Zn contents. However, spraying wheat plants with low Cu level (0.84 kg Cu/fed.) gave the highest value of grain carbohydrate percentage.

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1. Introduction

Wheat (*Triticum aesitivum L.*) is cultivated worldwide primarily as a food commodity. Because of its importance in the Egyptian diet. Wheat is considered a strategic commodity. Calderini and Slafer (1998) noticed that only 3 of 21 countries (Egypt, Germany and India) exhibited a clear continuous increase in wheat yield (per unit area) during the last decade. Cropping intensity in Egypt accompanied with shortage in fertilization led to a serious depletion of both macro- and micronutrients from soil, especially sandy soil.

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 indicated that 15 to 30% of the total magnesium in plants is associated with the chlorophyll molecule. Magnesium has functions in protein synthesis that can affect the size, structure, and function of chloroplasts (Marschner 1995). Hanna and Abdel Mottaleb (1998) concluded that the magnesium fertilization as foliar application tended to increase grain, straw yield and 1000-kernel weight, number of grains/spike and grain content of Mg , P, K, and crude protein. El-Amry *et al.* (2001) reported that maximum grain yield and chemical composition (protein, ash, oil, fiber, total carbohydrate, and phytic acid) of wheat were obtained by application of Mg with 5 or 10 kg /feddan.

Copper is an essential micronutrient for higher plants that required for the functioning of more than 30 enzymes, all of which are either redox catalysts (e.g., cytochrome oxidase, nitrate reductase) or dioxygen carriers (*e.g.*, haemocyanin). Consequently, their importance is pronounced on the health and diseases of plants, animals, and human being, as they are dependent on trace elements needed from food (Mohamed and Taha, 2003). Dobermann and Fairhurst (2000) found that copper affected metabolic processes like photosynthesis and respiration reduction in pollen viability and increase in spikelet sterility and many unfilled grains. El-Magid et al. (2000) reported that the application of Fe, Cu, Zn and Mn increased grain and straw yields of wheat. Zeidan and Nofal (2003) showed that application of micronutrients only (iron, manganese, zinc and copper) or with adding 1% urea on growth and yield of wheat caused significant increases in wheat grain protein content, yield and quality of wheat. El-Maghraby (2004) found that application of micronutrients in wheat plants had

highly significant effects on the uptake of macronutrients (N and K) and micronutrients (Fe, Mn, Zn and Cu) by straw and had highly significant effects on the uptake of macronutrients (N, P an K) and micronutrients (Fe, Mn and Zn) by grains. Karamanos *et al.* (2004**)** reported that maximum grain yield of wheat was obtained by foliar Cu application.

The purpose of this study was to explore the response of wheat to magnesium and copper levels either alone or in combination to acheive the highest values of yield and its components as well as grains quality under sandy soil condition.

2. Material and Methods

Two field experiments were carried out in Ismailia Experimental Farm, Agricultural Research Center, Ismailia governorate, during the 2007/2008 and 2008/2009 growing seasons to study the influence of copper, magnesium and their interaction on yield and its components and quality of grain. The experimental design was randomize complete block (RCBD) with six replicates and nine treatments.

Treatments

The experiment contained nine foliar spray treatments as follows:

1- control (water spray)
2- 3.36 kg Mg/feddan
3- 6.72 kg Mg/feddan
4- 0.84 kg Cu/feddan
5- 1.68 kg Cu/feddan
6- 3.36 kg Mg + 0.84 kg Cu/feddan
7- 3.36 kg Mg + 1.68 kg Cu/feddan
8- 6.72 kg Mg + 0.84 kg Cu/feddan
9- 6.72 kg Mg + 1.68 kg Cu/feddan

Wheat plants were sprayed with the aforementioned treatments two times, the first was 45 and the second was 60 days after planting. The sprayed solution volume was 350 and 400 L/fed. in the first and second spray, respectively.

Soil was ploughed using a chisel plough and divided into experimental units, 2.0 m long and 3.0 m wide. Every plot contained 15 rows each of 20 cm width. Wheat grains were sown on November 22 th and 13 th in 2007/2008 and 2008/2009 seasons; respectively at the rate of 60 kg/feddan by hand drilling in rows.

Soil Analysis:

Representative soil samples were taken after soil preparation and before fertilization from the experimental sites (0-30 cm depth) for physico-chemical characteristics (Table 1).

Nitrogen, phosphorus and potassium were added at rate of 106 kg N/fed, 37 kg P_2O_5/fed., and 24 kg K_2O/fed.. Nitrogen was applied as ammonium sulfate (20.6 % N) in three equal splits (at planting, 30 and 50 days after sowing) in both seasons. Phosphorus was applied as a single super phosphate (15.5 % P_2O_5) during soil preparation. Potassium was applied as Potassium sulphate (50 % K_2O) at 30 days after sowing. The whole experimental plots were also sprayed with mixed iron, manganese and zinc in EDTA form two times (45 and 60 days after planting) at rate of 0.5 g/L. from each nutrient.

Table 1: Physico-chemical characteristics of soil (0 – 30 cm) in 2007/2008 and 2008/2009 seasons.

Characteristics	2007/2008	2008/2009
Physical Properties		
Sand (%)	88.4	90
Silt (%)	4.0	3.2
Clay (%)	7.6	6.8
Texture	Sand	Sand
E.C dS/m	0.20*	0.35*
pH	8.95****	9.15****
Chemical Properties		
$CaCO_3$ %	1.20*	1.84*
Organic Matter %	0.54*	0.09*
Exchangeable macronutrients (mg / 100 g soil)		
P	0.36*	0.62*
K	7.6*	4.24*
Na	18.0*	41.4***

Ca	240	308
Mg	9.0*	3.64*
Determined micronutrients (ppm)		
Fe	3.7*	3.83*
Mn	2.8*	1.13*
Zn	0.22*	0.15*
Cu	0.1*	0.25*

*** = low ** = Adequate *** = High **** = Very high**

Data of soil analysis was evaluated according to Ankerman and Large (1974); texture according to Bauyoucos (1954); pH & E.C according to Jackson (1973); $CaCO_3$ according to Black (1965); Organic matter according to Walkely and Black (1934) ;K, Na, Ca & Mg according to Jackson (1973); P according to Olsen *et al*. (1954) and Fe, Mn, Zn & Cu Lindsay and Norvell (1978)

Plants were irrigated at 6 days interval using sprinkler system.Weeds were controlled by hoeing.

Plant sampling

Wheat grains after harvest were taken to determine macro- and micronutrients, protein and carbohydrate. Grains were washed in sequence with tap water, 0.01 N HCl- acidified distilled water and distilled water, and then dried in a ventilated oven at 70 ^{o}C till constant weight was obtained.

Yield and its components:

At maturity, i.e. 160 days after planting the plants were harvested. Samples from wheat were taken to determine the following characteristics: Plant height (cm), tillers number/m^2, number of spikes per m^2, number of grains per spike, spike length, in (cm), 1000 grains weight (g), Grain yield [ardab /fedden, (one Ardab = 150 kg.)] and straw yield (tons /feddan). Grain and straw yields were determined in one m^2 then, converted to feddan.

Measurements and determinations:

Nitrogen was determined using Micro – Kjelahl method (Markaham, 1942), using boric acid modification as described by Ma and Zuazage (1942), and distillation was done using Gerhardt apparatus. Phosphorus was photometrical determined using the molybdate-vanadate method Jackson (1973). Potassium, sodium and calcium were measured using Dr. Lang -M8D Flame-photometer. Magnesium, Fe, Mn, Zn and Cu were determined using the Atomic Absorption Spectrophotometer (Perkin-Elmer 100 B). Protein calculated as (N %) × 6.25. Carbohydrate percentage in grains was determined according to the method adapted by Shaffer and Hartmann (1921).

Statistical analysis:

Collected data were subjected to the proper statistical analysis with the methods described by Snedecor and Cochoran (1967). Since the data in both seasons took similar trends and variances were homogeneous according to Bartllets test, the combined analysis of both seasons was done. LSD test was applied at 5 % level for comparing the numerical averages Waller and Duncan (1969).

3. Results and Discussion

Yield and its components:

Foliar application with the applied magnesium and/or copper had a significant effect on plant height (cm), tillers number/m^2, spike number/m^2, spike length (cm), spike weight (g), grains number/spike, grains weight /spike (g), 1000-grain weight (g), grains yield ardab/fed. and straw yield ton/fed. (Table 2). Spraying wheat plants with 3.36 kg Mg + 0.84 kg Cu /fed. produced the greatest increase for tillers number/m^2, spike length and spike weight as compared with control and other treatments. While, the highest values for grains number/spike, grains weight /spike and 1000-grain weight were determined by the magnesium and copper application of 6.72 kg Mg + 0.84 kg Cu /fed. Moreover, foliar application with 6.72 kg Mg/fed. and 1.68 kg Cu/fed. gave the highest value for plant height. Moreover, high level of copper (1.68 kg/fed.) produced the greatest increase for grains yield, while the lowest level of Cu (0.84 kg/fed.) gave the highest value for straw yield but, the differences between treatments did not reach to the level significance. The lowest values of grain and straw yields and yield components were resulted from the

untreated treatment (control). Such effects of foliar application with Mg and/or Cu might be due to their critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus, their importance in achieving higher yields. These results are similar to those obtained with copper application on wheat plants by El-Badry (1995), Negm (1998), Zeidan and Nofal (2003), El-Maghraby (2004) and Kumar *et al.* (2009). On the other hand, Hanna and Abdel Mottaleb (1998), El-Amry *et al.* (2001), and Hussain *et al.* (2005) showed that grains yield of wheat plants was affected positively by application of magnesium.

Grain chemical compositions:

Chemical composition of grains i. e, N, Mg, Cu and Zn concentrations showed significant response to magnesium and copper foliar application treatments (Table 3). Foliar application with high level of magnesium (6.72 kg/fed.) mixed with high level of copper (1.68 kg/fed.) gave the highest value of wheat grains N, Mg, Cu and Zn concentration compared with other treatments and control. This might be in part attributed to the favorable effect of copper and magnesium to form vegetative plant materials which in turn increase N, Mg, Cu and Zn uptake by plants (Marschner, 1995). In this respect, Hanna and Abdel Mottaleb (1998) concluded that magnesium fertilization as a foliar application tended to increase grain content of Mg , P and K. Also, Negm (1998) showed that N and Cu contents of wheat grains were significantly increased by foliar application of copper at 100 ppm, while Zn grain content was not affected by copper treatments.

Table(2): Plant height (cm), tillers number, yield and yield components of wheat plant as affected by copper and magnesium foliar applications (combined analysis of 2007/2008 and 2008/2009 seasons)

Parameters / Treatments	Plant height (cm)	Tillers no./m^2	Spike no./m^2	Spike length (cm)	Spike weight (g)	Grains no./ spike	Grains weight /spike (g)	Grains weight /m^2 (g)	1000- grains weight (g)	Grain yield ardab /fed.	Straw yield ton/fed
Control (water foliar spray)	84.50	693.3	581.30	7.72	1.67	22.33	0.77	280.5	30.63	7.86	2.63
3.36 kg Mg /fed.	88.00	690.7	621.30	8.77	2.33	31.50	1.15	363.5	32.97	10.16	4.35
6.72 kg Mg /fed.	89.33	734.0	680.50	9.17	2.45	33.50	1.27	384.4	36.23	10.77	4.59
0.84 kg Cu /fed.	87.67	767.3	733.30	9.03	2.30	29.83	1.18	467.9	39.10	13.09	5.01
1.68 kg Cu /fed.	89.50	826.7	773.30	8.80	2.53	36.50	1.25	518.3	40.38	14.51	4.45
3.36 kg Mg + 0.84 kg Cu /fed.	90.33	840.0	768.00	9.13	3.02	35.67	1.40	469.7	37.02	13.15	4.70
3.36 kg Mg + 1.68 kg Cu /fed.	90.83	778.3	678.00	9.13	2.60	34.83	1.13	441.0	37.57	12.35	4.80
6.72 kg Mg + 0.84 kg Cu /fed.	89.83	757.0	691.20	9.08	2.62	36.50	1.45	435.4	41.12	12.19	4.32
6.72 kg Mg + 1.68 kg Cu /fed.	94.83	826.7	757.30	8.90	2.58	32.67	1.25	494.3	40.93	13.83	4.78
LSD at 0.05	3.40	77.38	48.93	0.75	0.49	3.84	0.20	67.3	3.81	1.88	0.91

Grain quality:

Quality parameters of wheat grains (protein and carbohydrates) showed significant response to magnesium and/or copper foliar application treatments (Table 3).

Spraying wheat plants with mixture of magnesium and copper at rate of 6.72 kg Mg + 1.68 kg Cu/feddan resulted in the highest significant value of grain protein content (16.65 %) compared with other foliar application treatments. Magnesium has functions in protein synthesis that can affect the size, structure, and function of chloroplasts (Marschner, 1995). But, magnesium and copper sufficient levels increased protein content indirectly through its role in nutrients balance in plant tissues. The present results are in the same direction with those reported by Zeidan and Nofal (2003) with copper application on wheat plants. Moreover, Hanna and Abdel Mottaleb (1998) and El-Amry *et al.* (2001) found that grain protein of wheat increased markedly by Mg application.

Also, the results in Table (3) indicated that 0.84 kg Cu /fed. gave the highest carbohydrate in grains (69.33 %) as compared with untreated plants and other treatments. This indicates that there is no value to increase copper and magnesium level more than 0.84 kg Cu and 3.36 kg Mg/fed. for obtaining high carbohydrate content of grains. Even it is contributed in photosynthesis and enzymes controlling carbohydrate formation, the minimum requirements of copper and magnesium were enough to accumulate suitable carbohydrate contents. Migahid and Sadek (1994) they found that carbohydrate content in wheat plants was significantly increased by copper application. Also, El-Amry *et al.* (2001) reported that maximum grain total carbohydrate of wheat was obtained by application of Mg with 5 or 10 kg /feddan.

Table (3): Protein (%), carbohydrate (%), N (%), Mg (%), Cu (ppm) and Zn (ppm) in grains of wheat plant as affected by copper and magnesium foliar applications (combined analysis of 2007/2008 and 2008/2009 seasons)

Parameters / Treatments	Protein %	Carbohydrate %	N%	Mg%	Cu ppm	Zn ppm
Control (water foliar spray)	6.9	61.7	1.1	0.26	3.3	34.8
3.36 kg Mg /fed.	12.8	63.7	2.1	0.27	4.4	39.7
6.72 kg Mg /fed.	13.8	65.3	2.2	0.29	4.5	42.4
0.84 kg Cu /fed.	13.0	69.3	2.0	0.29	5.3	45.8
1.68 kg Cu /fed.	13.8	68.2	2.2	0.29	7.2	48.7
3.36 kg Mg + 0.84 kg Cu /fed.	14.6	67.8	2.3	0.32	5.4	46.9
3.36 kg Mg + 1.68 kg Cu /fed.	15.2	67.3	2.4	0.33	7.5	48.3
6.72 kg Mg + 0.84 kg Cu /fed.	16.2	67.2	2.6	0.35	5.6	50.9
6.72 kg Mg + 1.68 kg Cu /fed.	16.7	67.3	2.7	0.35	7.9	54.4
LSD at 0.05	0.5	0.8	0.2	0.01	1.0	3.6

It could be concluded that under sandy soil condition foliar application of magnesium and copper with 6.72 kg Mg/feddan and 1.68 or 0.84 kg Cu/feddan could be used to obtain high yield and yield components of wheat plants. Also, to obtained wheat grains with high N, Mg, Cu, Zn and cured protein percentage, magnesium and copper application should be applied at 6.72 kg Mg/feddan in combination with 1.68 kg Cu/feddan as foliar application. While, to obtained wheat grains with high carbohydrate percentage copper application should be applied in 0.84 kg Cu/feddan as foliar application.

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References

1. Ankerman D. and Large L. (1974). Soil and Plant Analysis, Technical Bulletin, A&L Agricultural Laboratories Inc. USA, 82 pp.
2. Bouyoucos, H. H. (1954). A recalibration of the hydrometer for making mechanical analysis of soils. Agron. J., 43: 434-438.
3. Black C. A. (1965). Methods of Soil Analysis. 1st Edition, American Society Agronomy, Madison, WI., USA.
4. Calderini, F. D. and G. A. Slafer (1998). Changes in yield and yield stability in wheat during the 20th century. Field Crop Res., 57; 335-347.
5. Chapman, H. D. and Pratt, P. F. (1978). Methods of Analysis for Soils, Plants and Water, Univ. of California, Dept. of Agric. Sci., USA, 320 P.
6. Dobermann, A. and T. Fairhurst. (2000). Rice: Nutrient Disorders & Nutrient Management IRRI, Potash and Phosphate Institute/Potash & Phosphate Institute of Canada. ISBN 981-04 - 2742-5. 192p.
7. El-Amry, H.G; A. M. Mahdy and S. M. A. Salam (2001). Efficacy of combination between Mg and N fertilization on the chemical composition and technological properties of wheat grains. Egyptian-Journal-of-Agricultural-Research.; 79(3): 1085-1098.
8. El-Badry, O. Z. (1995). Effect of nitrogen and copper fertilization on yield and quality of wheat. Annals of Agric. Sci, Moshtohor. 33(3): 1017-1024.
9. El-Maghraby, T.A (2004). Effect of wheat grain soaking in some micronutrient solutions on crop production under rainfall condition. Egyptian Journal of Soil Science. 44(3): 429-440.
10. El-Magid, A.A.A; R.E. Knany and H.G.A. El-Fotoh (2000). Effect of foliar application of some micronutrients on wheat yield and quality. Annals of Agricultural Science Cairo. 1(Special): 301-313.
11. Hanna, N. S. and F. A., Abdel Mottaleb (1998). Response to magnesium fertilization under different nitrogen fertilizer levels in wheat (*Triticum aesitivum* L). Egypt. J. Appl. Sci; 13(5)168-177.
12. Hussein, S. M. A. (2005). Effect of supplemental irrigations, seeding rates and foliar application of potassium and macro-micro elements on wheat productivity under rainfed conditions. Bulletin of Faculty of Agriculture, Cairo University. 6(3): 431-453.
13. Jackson, M. I. (1973). Soil Chemical Analysis. Prentice Hall Inc. N. J., U. D. A.
14. Karamanos, R. E.; Q. Pomarenski; T. B. Goh; N. A. Flore (2004). The effect of foliar copper application on grain yield and quality of wheat. Canadian Journal of Plant Science, 84 (1) 47-56.
15. Kumar, R; N.K. Mehrotra; B.D. Nautiyal, P. Kumar and P.K. Singh (2009). Effect of copper on growth, yield and concentration of Fe, Mn, Zn and Cu in wheat plants (*Triticum aestivum* L.). Journal of Environmental Biology. 30(4) 485-488.
16. Lindsay, W. L. and Norvell, W. A. (1978). Development of a DTPA micronutrients soil test. Soil. Sci. Society. Amer. J. 42: 421-428.
17. Ma, T. S. and Zuazage, C. (1942). Micro-Kjeldahl determination of nitrogen a new indicator and an improved repaid method. Industr. Eng. Chem. Anal. Ed. 14, 280.
18. Markaham, R. (1942). A steam distillation apparatus for micro-Kjeldahl analysis. Biochemical J. 36: 790.
19. Marschner H. (1995) Mineral Nutrition of Higher Plants, Academic Press, London, UK, 680 pp.
20. Migahid, M. M. and L.A. Sadek (1994). Effect of presoaking with trace elements on salt tolerance of three cultivars of wheat. Alexandria Journal of Agric. Res. 39(3): 501-515.
21. Mohamed, A.E. and G. M. Taha (2003). Levels of trace elements in different varieties of wheat determined by atomic absorption spectroscopy. The Arabian Journal for Science and Engineering, 28, (2A): 163-171.
22. Negm, A. Y. (1998). Foliar application of ascorbic acid and copper to wheat plants grown on sandy soils. Egypt. J. Appl. Sci; 13(5): 312-319.
23. Olsen, S. R. ; Colu, S. V. ; Watanabe, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with bicarbonate. U. S. Dept. Circ. 939.
24. Shaffer, D. A. and Hartmann, A. F. (1921). The iodometric determination of copper and its use in sugar analysis. 1. Method for the determination of reducing sugars in blood, urine , milk and other solution . J. Boil. Chem. 45, 365.
25. Snedecor, G. W. and Cochran, W. G. (1967). Statistical Methods, 6th Edition The Iowa State College, Ames Iowa, U. S. A.
26. Walkely, A. and Black, I. A. (1934). An examination of the Degtjareff method for

determining soil organic matter , and a proposed modification of the chromic acid titration method . Soil Sci., 37:29-38.
27. Waller, R. A. and Duncan, D. B. (1969). A bays rule for the symmetric multiple comparisons problem. Am. Stat. Assoc. J. December. 1485.
28. Zeidan, M.S and Nofal, O.A. (2003). Effect of urea on the efficiency of spraying iron, manganese, zinc and copper on wheat. Egyptian-Journal-of-Agronomy.; 24: 121-131.

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