Response of Wheat to Magnesium and Copper Foliar Feeding under Sandy Soil Condition

EL-Metwally, A.E.[1]; F.E. Abdalla[2]; A.M. El-Saady[2]; S.A. Safina[1] and Sara S. EI-Sawy[2]

[1.] Agronomy Dept., Fac. of Agric., Cairo University, Cairo Egypt
[2]. Fertilization Technology Dept., National Research Centre (NRC), Dokki – Cairo Egypt

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 (Mg), copper (Cu) either as single nutrient or in combination on growth of wheat (*Triticum aestivum* L.) cv. Sakha 94. Nine treatments were applied: two levels of Mg, two levels of Cu and four combined treatment (Mg + Cu), in addition to control treatment. Results showed that the highest positive significant effect on flag leaf area, chlorophyll contents and dry matter/m^2 were achieved by spraying the highest Mg level + the highest Cu level (6.72 kg Mg + 1.68 kg Cu/fed.) Results also, showed that most of both macro and micronutrients content increased markedly due to the same previous treatment.

[EL-Metwally, A.E.; F.E. Abdalla; A.M. El-Saady; S.A. Safina and Sara S. EI-Sawy. **Response of Wheat to Magnesium and Copper Foliar Feeding under Sandy Soil Condition**. Journal of American Science 2010;6(12):818-823]. (ISSN: 1545-1003). http://www.americanscience.org.

Keywords: Wheat, *Triticum aestivum* L., Magnesium, Copper and Sandy soil.

1. Introduction:

Wheat (*Triticum aestivum L.*) is the most important cereal crop in the world. Wheat ranks as the first among all cultivated cereals in Egypt. Its cultivated area reached to about 1.2 million hectare in year 2008, produced about 7.9 million tons (FAO, 2008). However, this production did not meet consumption party due to crop leakage for other misused and as well as the over growing population and hence, consumption. It is clear that there is a great shortage in the production of wheat in Egypt. This reflects the size of the problem that shows the need of increasing both of vertical and horizontal expansion in old alluvial soils and new desert area. Sandy soils predominate in most newly cultivated area. These soils suffer from very low soil fertility level and as well very low water holding and nutrients retention capacity.

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 (Marschner 1995).

Copper is an essential micronutrient that requires for the functioning of more than 30 enzymes, all of which are either redox catalysts (e.g., cytochrome oxidase and nitrate reductase) or dioxygen carriers (e.g., haemocyanin). El-Magid *et al*. (2000) recorded that, spraying wheat plant with Fe, Zn, Mn or B increased shoot height, while Cu had little effect on this parameter. Spraying such nutrients increased the number of tillers per plant and shoot weight. It was found also that spraying Cu and B reduced N content, while spraying Zn, Mn, B, Fe and Cu increased wheat plant P and K contents. Ziaeian and Malakouti (2001) reported that copper as well as the other micronutrient application led to significantly increase in their concentration and uptake in grain and flag leaf. Such nutrient application increased significantly grain protein content. Shaaban (2002) showed that foliar fertilizer feeding containing 5.2 % Mn, 0.65 % Zn and 0.65 % Cu increased the concentration of Mg, Ca, Fe, Mn, Zn and Cu in the leaves of wheat.

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**.** Korzeniowska (2008) found that wheat plants after Cu application showed higher N concentration than control plants. Moreover, high correlation between Cu and N concentration in wheat shoots were obtained.

The purpose of this work is to study the response of wheat cultivar Sakha 94 to magnesium and copper levels either alone or in combination to induce the highest values of growth parameters as well as nutritional status of plants under sandy soil condition.

2. Materials and methods

Two field experiments were carried out at Ismailia Experimental Station, Agric. Res. Center, Ismailia Governorate, during 2007/2008 and 2008/2009 winter seasons to study the influence of magnesium, copper and either alone or in combinations on growth and nutritional of wheat cv. Sakha 94. The experimental design was randomize complete block with six replicates 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
4- 68 kg Cu/feddan
5- .36 kg Mg + 0.84 kg Cu/feddan
6- 3.36 kg Mg + 1.68 kg Cu/feddan
7- 6.72 kg Mg + 0.84 kg Cu/feddan
8- .72 kg Mg + 1.68 kg Cu/feddan

Wheat plants were sprayed with the aforementioned treatment 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 13th 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).

The samples were air-dried and passed through 2mm sieve pores. Soil fractions were determined using the hydrometer method (Bauyoucos, 1954). E.C. and pH were determined in soil/water extract (1:2.5) according to Jackson (1973). $CaCO_3$ was determined using the calcimeter method according to Black (1965). Organic matter was determined using the potassium dichromate method according to Walkely and Black (1934). Soil phosphorus was extracted using sodium bicarbonate (Olsen *et al*., 1954). Potassium, sodium and magnesium were extracted using ammonium acetate (Jackson, 1973). Iron, manganese, zinc and copper were extracted using DTPA-solution (Lindsay and Norvell, 1978).

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

Characteristics	2007/2008	!008/2009
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/100g 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

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

Plant samples:

Wheat shoots at 75 days after the second spray, were taken to determine the dry weight (g/m^2). The samples were washed with tap water (0.01 N HCl) and bi-distilled water, then oven dried at 70º C for 24 hours and ground. The ground material was dry-ashed in a muffle furnace at 550º C for 6 hours. The residue then suspended in 0.3 N HCl.

Recorded Data:

A sample of 25 x 25 cm2/plot was randomly taken at 75 days after sowing to determine dry weight per plant, shoot macro and micronutrients concentration. Flag leaf area (cm^2) per plant was also calculated using formula (Length x maximum width x 0.79) according to Voldeng and Simpson (1967).

Nutrients Determination:

Total nitrogen was determined in the dried plant shoots based on Micro-Kjeldahl method (Ma and Zauzage, 1942). Phosphorus was photometrical determined using the molybdate-vanadate (Jackson, 1973). Potassium, Ca, Fe, Mn, Zn and Cu were determined according to Chapman and Pratt (1978). Dr. Lang -M8D Flame-photometer was used for K and Ca, while Atomic Absorption Spectrophotometer (Perkin-Elmer 100 B) was used for Fe, Mn, Zn and Cu.

Statistical analysis:

Collected data were subjected to the proper statistical analysis with the method 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' data was done. LSD test at 5 % level was used for comparing the numerical averages according to Waller and Duncan (1969).

3. Results and Discussion:

Experimental soil presentation:

Data in Table (1) showed that the experiment soil was sand in texture, very high alkalinily in reaction, had low content of macro and micronutrients. The soil was poor in organic matter, without any salinity problems. Soil evaluation was according to Ankerman and Large, 1974.

Effect of magnesium and copper foliar application on wheat growth:

Data in Table 2 showed that all magnesium and/or copper foliar application significantly affected wheat growth parameters. (i.e. flag leaf area, chlorophyll and total dry weight $/m^2$ at 70 days after sowing.

The increment ranged between 19-31% in flag leaf area, 7-29% in chlorophyll content and 22-88% in total dry weight, over control treatment. The highest increment recorded for the aforementioned parameters was due to spraying plants with the treatment contains the high level of both magnesium and copper (i.e. 6.72 kg Mg + 1.68 kg Cu/fed).

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). El-Magid (2000) reported that application of Cu at 0.1% with other micronutrients increased the shoot wheat plants. Kumar *et al.* (2009) found in a pot experiment that production of wheat dry matter enhanced with increasing Cu levels and reached to the maximum at 1.5 mg kg^{-1}.

Table (2): Effect of magnesium and copper on growth characteristics of wheat plants at 70 days after sowing (combined of 2007/2008 and 2008/2009 seasons).

Treatment	Growth characteristic		
	Flag leaf area (cm^2)	Chlorophyll (mg/g)	Total dry weight(g/m^2) (gm / m^2)
0 Cu + 0 Mg	19.23	2.22	463.4
3.36 kg Mg /fed.	22.85	2.38	567.3
6.72 kg Mg /fed.	24.00	2.52	604.6
0.84 kg Cu /fed.	23.25	2.55	577.3
1.68 kg Cu /fed.	24.23	2.60	632.0
3.36 kg Mg + 0.84 kg Cu /fed.	24.42	2.57	686.4
3.36 kg Mg + 1.68 kg Cu /fed.	24.53	2.70	766.8
6.72 kg Mg + 0.84 kg Cu /fed.	24.07	2.78	810.4
6.72 kg Mg + 1.68 kg Cu /fed.	25.13	2.85	871.8
LSD at 0.05	1.78	0.15	40. 5

Macronutrients Status:

Concentration of macronutrients in wheat shoots as affected by different treatments of magnesium and/or copper are shown in Table 4. It is obvious that nitrogen concentration was significantly increased as a response to application of magnesium and copperas compared with control.

Table (3): Effect of magnesium and copper on macronutrient contents (%) of wheat shoots at 70 days after sowing (combined of 2007/2008 and 2008/2009 seasons).

Treatment	Macronutrient (%)				
	(N)	(P)	(K)	(Mg)	(Ca)
0 Cu + 0 Mg	1.73	0.21	2.70	0.14	0.32
3.36 kg Mg /fed.	2.49	0.24	3.32	0.15	0.35
6.72 kg Mg /fed.	2.70	0.28	3.94	0.17	0.44
0.84 kg Cu /fed.	2.55	0.26	3.67	0.14	0.41
1.68 kg Cu /fed.	2.71	0.26	3.95	0.14	0.45
3.36 kg Mg + 0.84 kg Cu /fed.	2.40	0.29	3.26	0.16	0.50
3.36 kg Mg + 1.68 kg Cu /fed.	2.68	0.29	3.57	0.16	0.50
6.72 kg Mg + 0.84 kg Cu /fed.	2.85	0.29	3.47	0.18	0.51
6.72 kg Mg + 1.68 kg Cu /fed.	3.06	0.30	3.84	0.18	0.51
LSD at 0.05	0.07	0.01	0.35	0.01	0.06

Phosphorus concentration determined in wheat shoots significantly increased with foliar application of 6.72 kg Mg + 1.68 kg Cu/fed.

Concerning potassium content, it was found that either spraying plants with the highest level of magnesium or the highest level of copper or their combination gave the highest content, 3.94, 3.95, and 3.84, respectively. 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 (Marschner 1995). These results are in agreement with the results of El-Magid (2000), Brohi *et al*. (2000), Shaaban (2002), El-Maghraby (2004) and Korzeniowska (2008).

Micronutrients Status:

Micronutrient concentrations in wheat shoots were differed significantly with different treatments (Table 4).

Table (4): Effect of magnesium and copper on micronutrient contents (%) of wheat shoots at 70 days after sowing (combined of 2007/2008 and 2008/2009 seasons).

Treatment	Micronutrient (ppm)			
	(Fe)	(Zn)	(Mn)	(Cu)
Control (0 Cu+0 Mg)	114.0	31.2	18.0	5.2
3.36 kg Mg /fed.	139.6	38.4	21.2	6.0
6.72 kg Mg /fed.	153.0	40.4	25.3	6.3
0.84 kg Cu /fed.	135.4	38.6	23.5	10.6
1.68 kg Cu /fed.	155.7	40.8	24.8	17.1
3.36 kg Mg + 0.84 kg Cu /fed.	156.9	41.9	25.2	12.1
3.36 kg Mg + 1.68 kg Cu /fed.	163.8	48.2	25.7	19.3
6.72 kg Mg + 0.84 kg Cu /fed.	164.5	48.0	26.3	12.5
6.72 kg Mg + 1.68 kg Cu /fed.	176.5	50.0	27.0	18.9
LSD at 0.05	7.6	6.7	2.4	1.5

It is obvious that the highest Fe, Mn, Zn and Cu concentrations were obtained by spraying wheat plants with 6.72 kg Mg + 1.68 kg Cu/fed. Sicene, the fertilizer contains relatively higher concentrations of nutrients than other treatments which mostly absorbed by the plant shoots and raise their concentrations in the shoot tissues (Kassab et al. 2004). The same trend was found by Brohi et al. (2000) who determined the effect of Mg fertilization on the rice yield grown on artificial siltation soil and N, P, K, Fe, Cu, Zn and Mn contents. The uptake of all nutrients in straw was increased with Mg treatment. El-Maghraby (2004) found that the soaking of wheat grains in Fe (FeSO4), Mn (MnSO4), Zn (ZnSO4) and Cu (CuSO4) had highly significant effects on the uptake of micronutrients (Fe, Mn, Zn and Cu) by straw.

4. Conclusions

It could be concluded that:

1. Magnesium and copper fertilization is very important for the growth of winter wheat plants under sandy soil condition.
2. Combined treatments (Mg + Cu) under experiment conditions could improve growth and nutritional status of wheat.
3. Spraying wheat plants with 6.72 kg Mg + 1.68 kg Cu/fed. Is highly recommended to achieve maximum growth and nutritional status value.

Acknowledgements:

This work was carried out as a part of the activities of the Egypto-German Project" Micronutrients and other Plant Nutrition Problems in Egypt" conducted by National Research Centre, Cairo (Coordinator: Prof. Dr. M.M. El-Fouly) and the Institute of Plant Nutrition, Technical University of Munich (Prof. Dr. A. Amberger).

Corresponding author

EL-Metwally, A.E

Agronomy Dept., Fac. of Agric., Cairo University, Cairo, Egypt

5. References:

1. Amberger, A. (1974). Micronutrients, dynamics in the soil and function in plant metabolism. IV. Copper. Proc. Egypt Botany Society. Workshop 1, Cairo. pp 113-120.
2. Ankerman D. and Large L. (1974). Soil and Plant Analysis, Technical Bulletin, A&L Agricultural Laboratories Inc. USA, 82 pp.
3. Black, C.A. (1965). Methods of soil analysis. 1st Ed., American Society Agronomy, Madison, WI., USA.
4. Brohi, A.R; M.R. Karaman; M.T. Topbas; A. Aktas and E. Savasli (2000). Effect of potassium and magnesium fertilization on yield and nutrient content of rice crop grown on artificial siltation soil. Turk Journal Agriculture, 24: 429-435.
5. Bouyoucos, H.H. (1954). A recalibration of the hydrometer for making mechanical analysis of soils. Agronomy Journal, 43: 434.
6. Chapman, H.D. and P.F. Pratt (1978). Methods of Analysis for Soils, Plants and Water, University California, Department Agriculture Science USA, 320 P.
7. 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.
8. 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.
9. FAO, (2008) Food and Agriculture Organization of the United Nation, Economic and Social Department.
10. Jackson, M.I. (1973). Soil Chemical Analysis. Prentice Hall of India, New Delhi.
11. Kassab, O.M.; H.A.E. Zeiny and M.M. Ibrahim (2004). Effect of water deficit and micronutrients foliar application on the productivity of wheat plants. Minufiya Journal Agriculture Research, 29: 925-932.
12. Korzeniowska, J. (2008). Winter wheat response to copper application under different cultivation technologies and nitrogen fertilization. Ecological Chemistry and Engineering, 15(1, 2):81-88.
13. 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.
14. Lindsay, W.L. and W.A. Norvell (1978). Development of a DTPA micronutrients soil test. Soil Science Society American Journal, 42: 421-428.
15. Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd ed. New York: Academic Press, Harcourt Brace Jovanovich, Published 674 P.
16. Ma, T.S. and C. Zauzage (1942). Micro-kjeldahl determination of nitrogen, a new indicator and improved rapid method. Industry Engineering Chemistry Annals Ed., 14: 280-286.
17. Olsen, S.R.; S.V. Colu; F.S. Watanabe and L. A. Dean (1954). Estimation of available phosphorus in soil by extraction with bicarbonate. U. S. Dept. Circ. 939.
18. Shaaban, M.M. (2002). Effect of trace-nutrient foliar fertilizer on nutrient balance, growth, yield and yield components of two cereal crops. Pakistan Journal of Biological Sciences, 7(4): 770-774.
19. Snedecor, G. W. and Cochran, W. G. (1967). Statistical Methods, 6 th Edition The Iowa State College, Ames Iowa, U. S. A.
20. Tan, K.; W.G. Keltjens and G. R. Findenegg (1992). Acid soil damage in sorghum genotypes:

Role of magnesium deficiency and root impairment. Plant and Soil 139: 149-155.

21. Voldeng, H.D. and G.M. Simpson (1967). Leaf area as an indicator of potential grain yield in wheat. Canadian Journal Plant Science 47: 359-365.
22. Walkely, A. and I.A. Black (1934). An examination of the degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37:29-38.
23. Waller, R.A. and D.B. Duncan (1969). A bays rule for the symmetric multiple comparisons problem. American Stat. Associated Journal December. 1485.
24. Ziaeian, A.H. and M.J. Malakouti (2001). Effects of Fe, Mn, Zn and Cu fertilization on the yield and grain quality of wheat in the calcareous soils of Iran. Plant Nutrition - Food security and sustainability of agro-ecosystem, 92: 840-841.

10/2/2010