Effect of foliar nutrition with $CuSO_4$ on growth and yield of wheat grown under different levels of nitrogen fertilization.

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Abstract: Two field experiments were conducted during 2006/2007 and 2007/ 2008 seasons at the Experimental Farm of Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to study the effect of the foliar nutrition with 0, 100, 200 and 400 ppm $CuSO_4$ after 45 and 60 days from sowing on wheat cv Sakha 94 grown under three levels of nitrogen fertilizer i.e. 35, 70 and 105 kg N/fad at newly reclaimed sandy soil conditions. It was found that increasing the level of soil applied N increased number of leaves, tillers and photosynthetic pigments content. Dry matter accumulation and yield of grains were also increased. Under each nitrogen level, $CuSO_4$ spray treatments resulted further increases in plant growth, dry matter accumulation and chlorophyll content. $CuSO_4$ treatment increased the yield of grains rather than of straw. The highest yield of grains was obtained when wheat plants were soil fertilized with 105 kg N/fad and foliar sprayed with 200 ppm $CuSO_4$. It is worthy to mention that foliar nutrition with 200 ppm $CuSO_4$ and soil fertilization with the medium level of N (70 kg N/fad) increased significantly grain, straw and biological yields of wheat crop than those obtained from wheat plants fertilized with the highest N level alone (105 kg N/fad). This means that wheat crop can utilize N fertilizer more efficiently when wheat plants sprayed with $CuSO_4$.

Keywords: Yield components, Cu foliar nutrition, N levels, new reclaimed soil.

INTRODUCTION

Wheat crop is one of the most important cereal crops in Egypt and acreage about 2.7 million faddan (1 fad= 0.42 ha) with total seed production about 8 million tons in 2007 season. Due to tremendous increasing in population in Egypt, its production is insufficient to meet local consumption and the wheat imports reached about 6 million tons. In this respect, increasing cultivated area as well as increasing production per unit area are main objectives for reducing the gap between wheat production and consumption. Therefore, wheat should be extended cultivation in more areas particularly in the newly reclaimed lands such as El-Salam Canal project (600000 fad, 200000 west of Suez Canal and 400000 east of it in Sinai), which is considered the most important area for land reclamation in the following few years. Increasing wheat's production per unit area by applying the most suitable cultural practices on such areas, is considered main goal for researchers. As most of the areas in the newly reclaimed soil are sandy soil, nitrogen fertilization and foliar spraying with micronutrients can be considered among the most important cultural practices for increasing wheat productivity. Many investigators concluded that N fertilization increased growth, yield and yield components of wheat crop (Moursi *et al.*, 1976*b*, Ashour *et al.*, 1982*a*, Yakout *et al.*, 1998, Avijit-Sen *et al.*, 2003, Tammam and Tawfils, 2004, Allam, 2005, Abu-Grab *et al.*, 2006, El-Sayed and Hammad, 2007 and El-Hag, 2008). Also, few reports showed that the growth and yield of cereals in general and wheat in particular positively responded to Cu nutrition (Anspok, 1967, Grundon, 1980, Yakout *et al.*, 1980, Ashour *et al.*, 1982*b*, Karamanos *et al.*, 1986, Brennan, 1990, Kumar *et al.*, 1990, Javadi *et al.*, 1991, Tong *et al.*, 1995, Karamanos *et al.*, 2004 and Rehm, 2008). In general a greater demand for micronutrients such as Cu seemed to be of great importance under high levels nitrogen to increase growth and yield of wheat (Borchman and Fibian, 1971, Potarzycki, 2004 and Korzeniowska, 2008).

So, the aim of this work was to study the effect of foliar nutrition with $CuSO_4$ on growth, chlorophyll content and yield of wheat plants grown under different levels of nitrogen fertilizer.

MATERIALS AND METHODS

Two field experiments were conducted during 2006/2007 and 2007/2008 seasons at the Experimental Farm of the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to study the effect of the foliar nutrition with $CuSO_4$ on growth, yield and yield components of wheat crop grown under different levels of nitrogen fertilizer at newly reclaimed sandy soil conditions. Chemical and physical properties of the experimental soil are presented in Table (1).

Each experiment consisted of 12 treatments which were the combination of three levels of nitrogen fertilizer applied to the soil i.e. 35, 70 and 105 kg N/fad and four concentrations of aqueous solution of $CuSO_4$ sprayed twice on the foliage after 45 and 60 days from sowing. The design of each experiment was a complete randomized block design in four replicates. Each experimental plot consisted of 20 rows, 3.5 m in long and 15 cm in width (plot area= 3.5 x 3 = 10.5m^2). Wheat grains were sown in rows 15 cm apart on November 18 and 20 in 2006 and 2007 respectively. Farmyard manure (20 m^3/fad) as well as basal dose of calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at a rate of 200 and 50 kg/fad respectively were applied to the soil for all treatments during preparing of experimental soil. Nitrogen fertilizer in the form of ammonium sulphate (20.5% N) was added at four equal doses, during soil preparation and at 21, 42 and 63 days from sowing respectively. Copper sulphate spray treatments were applied twice

Table (1): Mechanical and chemical analysis of the experimental soil

Mechanical analysis	
Course sand %	63.19
Fine sand %	35.15
Silt and Clay	1.66
Texture Class	Sandy
Chemical analysis	
Organic matter	0.17
CaCo3	1.74
p.H	7.75
E.C. (ds/m)	0.12
Anions and cations (mg/100 gm soil)	
Co_3^{--}	Trace
HCo_3^-	0.15
CL^-	0.30
So_4^{--}	0.13
Ca^{++}	0.15
Mg^{++}	0.15
Na^{++}	0.25
K^+	0.03
Available macro and micronutrients (ppm)	
N	14.00
P	2.20
K	29.00
Cu	0.14
Zn	0.50
Mn	0.44
Fe	4.40

after 45 and 60 days from sowing at a rate of 400 L/fad and Tepool was added as a wetting agent by a concentration of 1 ml/L. The normal cultural practices of growing wheat at Ismailia Governorate were followed.

A sample of 10 guarded plants was taken from each experimental plot after 75 days from sowing for measuring plant height, number of leaves and area of the upper fourth leaf and number of tillers/plant. Then the plants were divided into leaf blades and stem+ sheaths and dried in an air draft oven till constant weight was obtained. Fresh plant samples were taken to determine the content of photosynthetic pigments in the leaves. The pigments were extracted using 85% aqueous acetone solution and its concentration was calculated according to Von Wettestein formula (Von Wettestein, 1957). At harvest time grain yield (ard/fad) and straw yield (ton/fad) were estimated from the central 4 m^2 of each experimental unit.

The obtained results were subjected to the analysis of variance of complete randomized block design as described by Little and Hill (1977). Combined analysis for the two growing seasons was carried out. Duncan's multiple range test, (Duncan, 1955), has been used to indicate treatment differences.

RESULTS AND DISCUSSION

Table 2 represents the growth response of wheat plants to foliar nutrition with $CuSO_4$ under different levels of nitrogen.

It is clear that increasing the level of soil applied nitrogen significantly increased number and area of fourth upper leaf as well as enhanced production of tillers. The dry matter content of the above ground parts also increased with increasing soil applied nitrogen. The differences obtained between 35 and 105 kg N/fad were significant. These results are expected and were in harmony with those obtained by several investigators (Moursi *et al.*, 1976*b*, Ashour *et al.*, 1982*a*, Avisit-Sen *et al.*, 2003, Allam, 2005, Abu-Grab *et al.*, 2006, El-Sayed and Hammad, 2007 and El-Hag, 2008).

At each nitrogen level, foliar nutrition with $CuSO_4$ enhanced the vegetative growth of wheat plants (200-400 ppm). $CuSO_4$ treatment gave the greatest records for dry matter accumulation. However, 200 ppm $CuSO_4$ in general seems to be more effective than 400 ppm $CuSO_4$ on morphological characters. The positive effect of foliar spray with Cu on vegetative growth of wheat was reported by Ashour *et al.* (1982 *b*), and Kumar *et al* (1990) on wheat and by Yakout *et al.* (1980) and Tong *et al.* (1995) on maize.

These results indicate that $CuSO_4$ spray seems to stimulate the dry matter accumulation in wheat plants. Such effects may be mediated indirectly through the direct effect of Cu^{2+} ion on the enzyme activity controlling plant metabolism. Cu^{2+} ion was reported to increases the activity of dehydrogenises (Me Elrey and Nasen, (1954) and nitrogen reductase (Peive and Zhiznevskaya, 1961) as well as synthetic activity of starch phospherylase (Stasouskaite *et al.*, 1963).

Table (3) shows that increasing the level of nitrogen from 35 to 70 kg N/fad increased the content of chlorophyll a + b and carotenoids in the leaves of wheat plants, further increase in nitrogen level seemed to be without effect. The increase in chlorophyll a and

chlorophyll b contents are responsible to the same extent for the increase in total chlorophyll, since chl. a/b ratio was not markedly changed. In addition, there was no differential effect for nitrogen on green and orange pigments, though chl. a+b /caret. ratio was also not changed.

The positive effects of nitrogen nutrition on the accumulation of green pigments in wheat leaves were reported by other investigators (Moursi *et al.*, 1976*a* and Ashour *et al.*, 1982*a*).

At each nitrogen level foliar nutrition with $CuSO_4$ enhanced the accumulation of the photosynthetic pigments in the leaves of wheat plants, 200 and 400 ppm $CuSO_4$ gave the highest effect. However, at the highest nitrogen level the positive effect of $CuSO_4$ nutrition on carotenoids content was diminished by increasing its concentration. In general the ratios of chl. a/b and chl. a+b/carotenoids were not markedly changed due to different treatments. The positive effect of Cu on photosynthetic pigments content was mentioned by Yakout *et al.* (1980), Jasiewicz (1981) and Tong, *et al.* (1995) on maize and by Ashour *et al.* (1982 *b*) and Javadi *et al.* (1991) on wheat.

In this connection it is worthy to note that spraying wheat plants with copper sulphate was found to enhanced the accumulation of chlorophyll in the leaves of wheat plants (Ashour *et al.*, 1982 *b*) and protects it from distraction (Gilbert, 1952). However, it is known that chlorophyll molecule contains no copper, thus it seems that the positive effect of copper on chlorophyll accumulation may be induced indirectly through enhancement of enzyme activity responsible for protein metabolism in the chloroplasts (Ostrovskaya, 1958).

Table (4) shows that as expected, the yield of both grains and straw was increased by increasing the level of soil-applied nitrogen. The ratio of grains/straw also increased by increasing N level indicating more increase in grain than in straw yields. These results were in complete harmony with those obtained by others (Maursi *et al.*, 1976*b*, Ashour *et al.*, 1982*a*, Yakout *et al.*, 1998, Tammam and Tawfils, 2004, Allam, 2005, Abu-Grab *et al.*, 2006, El-Sayed and Hammad, 2007 and El-Hag, 2008).

Table (2): Effect of foliar nutrition with copper sulphate under different levels of soil nitrogen fertilizer on vegetative growth characters of wheat plant.

Nitrogen kg/fad	$CuSO_4$ conc. ppm	Plant height cm	Area of 4th leaf. cm^2	No. of leaf blades/plant	No. of tillers/plant	Dry wt., gm/plant		
						Stems+ sheaths	blades	Shoot
35	0	75.76 ^{a}	36.2 ^{a}	19.2 ^{a}	4.4 ^{ab}	1.87 ^{a}	1.30 ^{a}	3.17 ^{a}
	100	78.0 ^{bc}	40.4 ^{b}	20.1 ^{abc}	4.3 ^{a}	2.12 ^{c}	1.43 ^{b}	3.55 ^{c}
	200	77.2 ^{ab}	42.7 ^{bcd}	21.8 ^{de}	4.7 ^{bcd}	2.38 ^{d}	1.55 ^{cd}	3.93 ^{f}
	400	76.5 ^{ab}	43.0 ^{bcd}	20.5 ^{bc}	4.7 ^{bcd}	2.75 ^{f}	1.47 ^{bc}	4.22 ^{gf}
70	0	76.0 ^{a}	44.7 ^{bcde}	19.5 ^{ab}	4.6 ^{abc}	1.90 ^{a}	1.40 ^{b}	3.30 ^{b}
	100	77.8 ^{bc}	47.1 ^{de}	22.0 ^{def}	5.0 ^{de}	2.38 ^{d}	1.82 ^{f}	4.20 ^{gf}
	200	77.8 ^{bc}	48.0 ^{e}	22.4 ^{ef}	5.0 ^{de}	2.50 ^{e}	1.65 ^{de}	4.15 ^{g}
	400	81.0 ^{e}	45.3 ^{cde}	23.1 ^{fg}	4.7 ^{bcd}	2.70 ^{f}	1.57 ^{d}	4.27 ^{f}
105	0	77.6 ^{ab}	46.6 ^{de}	20.6 ^{bc}	5.0 ^{de}	2.00 ^{b}	1.65 ^{de}	3.65 ^{d}
	100	81.0 ^{e}	48.6 ^{e}	20.8 ^{cd}	4.9 ^{cd}	2.05 ^{bc}	1.73 ^{ef}	3.78 ^{e}
	200	79.0 ^{cd}	44.8 ^{bcde}	23.7 ^{gh}	5.3 ^{ef}	2.72 ^{f}	1.73 ^{ef}	4.45 ^{g}
	400	79.8 ^{de}	41.4 ^{bc}	24.2 ^{h}	5.6 ^{f}	2.98 ^{g}	1.70 ^{c}	4.68 ^{h}

Table (3): Effect of foliar nutrition with copper sulphate under different levels of nitrogen fertilizer on photosynthetic pigments content in the leaves of wheat plants, mg/dm^2.

Nitrogen kg/fad.	$CuSO_4$ conc. ppm	Chl. a	Chl. b	Chl. a+b	Carotenoids	Chl. a/b	Chl. a+b/carot.
35	0	2.48 ^{a}	0.57 ^{a}	3.05 ^{a}	1.34 ^{a}	4.35	2.28
	100	2.48 ^{a}	0.64 ^{ab}	3.12 ^{ab}	1.34 ^{a}	3.88	2.33
	200	2.58 ^{b}	0.69 ^{b}	3.27 ^{ab}	1.40 ^{b}	3.74	2.34
	400	2.57 ^{b}	0.63 ^{ab}	3.20 ^{bc}	1.41 ^{b}	4.08	2.27
70	0	2.70 ^{c}	0.60 ^{a}	3.30 ^{cde}	1.48 ^{c}	4.50	2.23
	100	2.73 ^{cd}	0.63 ^{ab}	3.36 ^{de}	1.47 ^{c}	4.33	2.29
	200	2.92 ^{e}	0.77 ^{c}	3.69 ^{f}	1.59 ^{d}	3.79	2.32
	400	2.91 ^{e}	0.76 ^{c}	3.67 ^{f}	1.61 ^{d}	3.83	2.28
105	0	2.70 ^{c}	0.68 ^{b}	3.38 ^{de}	1.48 ^{c}	3.97	2.28
	100	2.80 ^{d}	0.64 ^{ab}	3.44 ^{e}	1.69 ^{e}	4.37	2.04
	200	2.93 ^{ef}	0.77 ^{c}	3.70 ^{f}	1.76 ^{f}	3.81	2.10
	400	3.00 ^{f}	0.79 ^{c}	3.79 ^{f}	1.61 ^{d}	3.80	2.36

Table (4): Effect of foliar nutrition with copper sulphate under different levels of soil nitrogen fertilizer on yield of wheat plants.

Nitrogen kg/fad.	$CuSO_4$ conc. (ppm)	Grain yield/fad ard	Grain yield/fad ton	Straw yield ton/fad	Biological yield ton/fad	Grains/straw %
35	0	11.50 [a]	1.73 [a]	4.38 [a]	6.11 [a]	39.5
	100	13.35 [b]	2.00 [b]	4.51 [b]	6.51 [b]	44.3
	200	14.25 [c]	2.14 [c]	4.52 [b]	6.66 [b]	47.3
	400	12.50 [b]	1.88 [b]	4.97 [c]	6.85 [b]	37.8
70	0	17.60 [d]	2.64 [d]	5.16 [d]	7.80 [d]	51.2
	100	17.90 [d]	2.68 [d]	5.05 [cd]	7.73 [c]	53.0
	200	21.40 [e]	3.21 [e]	5.70 [g]	8.91 [f]	56.3
	400	17.15 [d]	2.57 [d]	5.52 [f]	8.09 [de]	46.5
105	0	19.35 [e]	2.90 [e]	5.53 [f]	8.43 [e]	52.4
	100	20.15 [e]	3.02 [e]	5.38 [e]	8.40 [e]	56.1
	200	27.50 [g]	4.13 [g]	6.76 [h]	10.89 [g]	61.1
	400	18.10 [d]	2.71 [d]	5.47 [ef]	8.18 [e]	49.5

At 35 N/fad all tested concentrations of $CuSO_4$ had positive effect on the yield of both grains and straw of wheat plants. At more higher nitrogen levels, 70 and 105 kg N/fad foliar nutrition with 200 ppm $CuSO_4$ gave the highest yield. Other $CuSO_4$ concentrations seemed to be un effective. The same picture was obtained with regard to the total biological yield. The observed increase in the ratio of grains/straw due to foliar nutrition with 100-200 ppm $CuSO_4$ indicates that yield of grains was increased more than that of straw. In this connection several investigators reported that the yield of wheat responded positively to $CuSO_4$ treatments. (Anspok, 1967, Grundon, 1980, Ashour *et al.*, 1982 *b*, Karamanos *et al.*, 1986, Brennan, 1990, Kumar, 1990, Javadi *et al.*, 1991, Karamanos *et al.*, 2004 and Rehm, 2008).

The increase in the yield of grains may be attributed partially to the increase in number of tillers and green leaves as well as chlorophyll content which may induce an increase in the photosynthetic productivity of the plants. Such effect was reflected as high accumulation of dry matter in the treated plants.

The role of Cu in increasing the activity of several enzyme systems (Nicholas, 1975) as well as the role of Plastocyanin, the Cu-containing protein of chloroplasts which is known to be an electron carrier in the process of photosynthesis (Beardman, 1975) lead to an increase in photosynthetic activity, consequently enhanced carbohydrate metabolism and lead to high accumulation of dry matter. Also, the stimulatory effect of Cu^{+2} on synthetic and hydrolytic activities of starch phosphorylase (Stasouskaite *et al.*, 1963) may be also of great importance for carbohydrate translocation from the vegetative parts to the yielded grains.

It is obvious from the data in (Table 4) that foliar nutrition with 200 ppm $CuSO_4$ and soil fertilization with the medium level of N (70 kg N/fad) increased significantly grain, straw and biological yields of wheat crop than those obtained from wheat plants fertilized with the highest N level alone (105 kg N/fad). This means that wheat crop can utilize N fertilizer more efficiently when wheat plants sprayed with $CuSO_4$. Confirming results were obtained by Potarzycki (2004) who mentioned that utilization of the nitrogen from fertilizaer was more intensive in plants receiving copper. He added that with copper fertilization it was found that the plants more efficiently translocated nitrogen from leaves and stems to grain.

The highest yield from grains, straw and biological yields was obtained from wheat plants soil fertilized with the highest N level (105 kg N/fad) and sprayed with 200 ppm $CuSO_4$ (Table 4). These results are in agreement with those obtained by Kocurik (1967) and Borchman and Fibian (1971) who mentioned that foliar spraying with Cu in combination with high nitrogen fertility was found to have positive effects on plant productivity.

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تأثير الرش الورقى بكبريتات النحاس على نمو محصول القمح المنزرع تحت مستويات مختلفة من التسميد النتروجيني

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** مدير برنامج الزراعة- جامعة القدس المفتوحة - فلسطين.

أجريت تجربتان حقليتان خلال الموسمين ٢٠٠٧/٢٠٠٦ ، ٢٠٠٨/٢٠٠٧ فى محطة التجارب الزراعية- كلية الزراعة- جامعة قناة السويس- الإسماعيلية- مصر بهدف دراسة تأثير التغذية الورقية بكبريتات النحاس بتركيزات ٠ ، ١٠٠ ، ٢٠٠ ، ٤٠٠ جزء فى المليون مع الرش مرتين بعد ٤٥ ، ٦٠ يوما من الزراعة وذلك تحت ثلاثة مستويات من التسميد النتروجينى (٣٥ ، ٧٠ ، ١٠٥ كجم ن/فدان).

أوضحت النتائج أن زيادة معدل التسميد الأرضى بالنيتروجين أدى إلى زيادة عدد أوراق واشطاء النبات وكذلك محتوى صبغات التمثيل الضوئى. كما أدى ذلك أيضا إلى زيادة تراكم المادة الجافة ومحصول الحبوب. كما انه تحت كل مستوى من النيتروجين أدى الرش بكبريتات النحاس إلى زيادة اكبر فى الصفات السابقة. ولقد كانت استجابة محصول الحبوب للرش بكبريتات النحاس اعلى من محصول القش. وسجلت المعاملة بالمستوى الأعلى من النيتروجين (١٠٥ كجم ن/ فدان) مع الرش بكبريتات النحاس بتركيز ٢٠٠ جزء فى المليون اعلى محصول من الحبوب (٤,١٣ طن/فدان) ومن الجدير بالذكر ان التسميد بالمعدل المتوسط من النيتروجين (٧٥ كجم ن/ فدان) مع الرش بكبريتات النحاس بتركيز ٢٠٠ جزء فى المليون تفوق معنويا فى محصول الحبوب والقش والمحصول البيولوجى عن ذلك الناتج من التسميد بأعلى معدل من النتروجين (١٠٥ كجم ن/ فدان).