ISSN 1110-0419

*Annals Of Agric. Sc., Moshtohor,*
*Vol. 42(4): 2101-2113, (2004).*

# GROWTH ENHANCEMENT OF WHEAT BY SUPPLEMENTATION OF N, Fe, Mn, AND Zn.

**BY**

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## ABSTRACT

Effect of applying N-fertilizers (soluble and slow release) to wheat grown on a calcareous soil in presence of Fe or Mn or Zn (mineral and chelated forms) was studied. Assessment included response of dry weight of plant, N, Fe, Mn and Zn uptake. Seven sources of N were used, urea "N1", ammonium sulphate "N2", sulphur coated urea "N3", urea-form (ureaformaldehyde) "N4", calcium nitrate "N5"and ammonium sulphate + N-serve "N6". two sources [ mineral and chelated ] of Fe, Mn, and Zn were used.

Under conditions of mineral or chelated Fe, dry weight of wheat plants was significantly increased by an average of 53% with application of N-fertilizer, Application of N as N2 or N6 showed the highest N-uptake giving increases averaging 334.8% and 363.2%, respectively. The highest Fe-uptake occurred with N2 and N1. Treatments of N2 and N6 showed the highest Mn-uptake. The results of Zn-uptake were rather similar to those of Mn-uptake.

In case of mineral and chelated Mn application, N-sources significantly increased dry weight of plant with a mean percentage increase of 30.9%. All N-sources positively affected N, Fe, Mn, and Zn uptake by plants by an average of 108.8, 12.3, 100.0, and 23.9%, respectively.

Under conditions of mineral or chelated Zn dry weight of plants responded positively to N application in any form exhibiting an average increase of 44.6%. Application of N-sources significantly increased N, Fe, and Zn uptake by wheat plants with averages of 176.4, 22.4, and 93.3%, respectively. Most N-sources increased Mn uptake.

## INTRODUCTION

Nutrient disorders relating to micronutrient deficiency; especially, Fe and Zn are widespread, and are an important limiting factor in arid and semi arid areas (Sillanpää, 1982 and 1995). Zinc uptake was generally decreased with the application of high rates of $FeSO_4$ (Mortvedt and Kelesoe 1988). Hammed (1997) concluded that application of different sources and concentrations of Fe to maize caused a progressive decrease in Zn concentration especially when added as Fe-EDTA at high rates. Iron concentration and uptake were decreased with increasing Zn-application. (Mohamed, 1998). Several mechanisms were proposed to explain the effect of Fe application in inducing Mn deficiency and causing a number of other phenomena (Romero, 1988).

Iron increases plant growth and may decrease manganese concentrations in tops to deficient levels through the "dilution effect" without decreasing Mn uptake. On the other hand, manganese deficiency may induce Fe toxicity by decreasing growth without decreasing the accumulation of Fe. Ali *et al*. (1998) found that excessively high Fe levels induces symptoms of manganese deficiency and decreases concentration of Mn in leaf blades. El-Headek (2000) found that Fe-EDTA application to calcareous and non-calcareous soils showed a relative reduction in Mn concentration in barley straw and grains. Kalyanaraman and Sivagurunathan (1994) concluded that the excess of accumulation of Zn in the plant induced a reduction in content of Mn levels in plant.

The antagonistic effect of Zn on the concentration of Mn may be also explained on the basis of competitive inhibition of Zn on Mn. Basyouny (1996) and Rateb (2000) demonstrated that application of Zn under saline and non-saline conditions reduced Mn concentration and its uptake by wheat plant.

The impact of soil properties on nutrient availability to crops and consequently the nutrient power supply of the soil have reported by several investigators (Amberger, 1991, Sillanpää, 1995 and Nofal *et al*. 1998). Basyouny (1996) showed that iron application, as Fe-EDTA was superior for increasing the Fe content in wheat grown on a non-calcareous soil, whereas Fe-EDDHA was more effective on a calcareous soil, and $FeSO_4$ was inferior to the chelated sources. El-Headek (2000) found that application of Fe-EDTA to a non-calcareous soil resulted in a marked increase in dry weight of grains (24%) and a slight increase in straw (1.62%) of barley as compared with application of $FeSO_4$

Foliar application of chelated micronutrients caused remarkable higher yields (Kriem *et al*, 1991). El-Beshbeshy (1983) reported that foliar application of Mn in chelated form on maize plant increased the concentration and uptake of N, P and Mn in grains. Firgany *et al*. (1983) showed that spraying chelated Mn-EDTA increased grain yield, ear length and weight of 100 kernels whereas number of rows/ear was not affected. Application of Zn fertilizers with or without nitrogen fertilizers increased dry matter, but this increase was more pronounced in the case of nitrogen application and Zn-EDTA was more effective than $ZnSO_4.7H_2O$ (El-Koumey and El-Sayed, 1997).

Rateb (2000) found that the fertilization of wheat by zinc sulphate at 5 Kg Zn/fed with application of ammonium sulphate was of superior effect in increasing dry weight of wheat than under conditions of applying ammonium nitrate.

The objective of this study was to assess the effect of nitrogen source as well as Fe, Mn and Zn sources on nutrient availability to wheat plants.

## MATERIALS AND METHODS

**Soil and methods of analysis:**

The soil used in this experiment was a calcareous one collected from the surface 0-15 cm layer from Marsa Matroh, north of the Western Desert of Egypt. Soil was air-dried, crushed with a wooden roller to pass through a 2 mm sieve and stored for the experimental use. Physical and chemical properties of the soil are shown in Table (1).

Soil pH was determined in a 1:2.5 soil : water suspension; and calcium carbonate was determined by the calcimeter (Piper. 1950). Soil salinity (expressed as EC) and soluble ions were in a saturated soil paste extract; organic matter was determined by the Walkley and Black procedure as outlined by Jackson (1967) and Page *et al*. (1982). Sulfate was determined as the difference between the sum of cations and anions. Particle size distribution was determined using the pipette method (Piper 1950).

Available Fe, Zn and Mn were extracted by ammonium bicarbonate-DTPA [AB-DTPA] according to Soltanpour and Workman (1979).

**Sources of nitrogen fertilizers:**

Six N-sources were used. They were as follows: urea "N1" (46 % N), ammonium sulphate "N2" (20.6% N), sulphur coated urea "N3" (38%N), urea-form (ureaformaldehyde) "N4" (40%N), calcium nitrate "N5" (15,5% N) and ammonium sulphate + N-serve "N6".

**Sources of micronutrient fertilizers:**

Two sources of micronutrients (Fe, Mn and Zn) were used. They were as follows: a mineral sulphate form "F1" [$FeSO_4$. $7H_2O$ for Fe, $ZnSO_4$. $7H_2O$ for Zn and $MnSO_4$ for Mn] and a chelated form (EDTA) "F2".

**Experimental work:**

Pots of 17 cm diameter and 23 cm depth were packed uniformly with 5 kg of the calcareous soil. Basal doses of P and K were added to the soil as Ca-superphosphate and potassium sulphate at rates of 15 and 48 mg of P and K /kg, respectively. Sources of nitrogen fertilizers were applied at a rate of 100 mg N/kg before planting. Fifteen grains of wheat (Triticum aesfivum cv. Sakha 69) were Planted in each pot, irrigated with distilled water to bring the soil moisture content to about 70% of the field capacity, then later the seedlings were thinned to ten plants after seven days from germination.

The experiments were executed each concerned one of the three micronutrients Fe, Mn and Zn, relating its two sources (mineral and chelated) with the six N sources.

**Table (1): Selected chemical and physical properties of the studied soil.**

| Soil propertie | |
|---|---|
| **Particle size distribution:** | |
| Coarse sand % | 16.7 |
| Fine sand % | 47.7 |
| Silt % | 14.6 |
| Clay % | 21.0 |
| Texture | Sandy clay loam |
| pH (1:2.5 soil : water suspension) | 8.16 |
| EC in soil paste extract (dS/m) | 1.90 |
| **Soluble ions (me/L) in soil paste extract:** | |
| $CO_3^{2-}$ | 0.0 |
| $HCO_3^-$ | 12.5 |
| $Cl^-$ | 3.0 |
| $SO_4^{2-}$ | 3.5 |
| $Ca^{2+}$ | 6.0 |
| $Mg^{2+}$ | 4.0 |
| $Na^+$ | 8.4 |
| $K^+$ | 0.6 |
| $CaCO_3$ % | 17.87 |
| Organic matter % | 2.14 |
| Available Fe* (mg/kg) | 4.16 |
| Available Mn* (mg/kg) | 1.74 |
| Available Zn* (mg/kg) | 1.70 |
| Available Cu* (mg/kg) | 0.52 |

* in AB-DTPA (Ammonium bicarbonate-DTPA) extract.

For each experiment, the micronutrients was applied ten days after sowing at a rate of 10 mg/kg. Treatments were in 3 replicates Each experiment was executed in a factorial randomised complete block design.

Plants were harvested after 165 days of planting. The plant materials were then oven dried at 70°C for 72 hours and their dry weights were determined. The dried plant materials were ground and chemically analysed.

Factors of the experiment were two: the first is the sources of micronutrients (2 sources); the second is the source of N (6 sources). A control treatment with no addition of either micronutrient or N was also carried out.

**Plant analysis:**

For analysis of Fe, Zn and Mn, plant materials were digested by means of $H_2SO_4$ + $HClO_4$; for total N, the micro-kjeldahl method was used (Chapman and Pratt,1961); Fe, Zn and Mn in soil as well as plant extracts were assayed by Atomic Absorption Spectrophotometer (Perkin Elmer 3110).

**Statistical analysis:**

Analysis of variance for the obtained data was performed according to the methods described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

Addition of fertilizer N along with any of Fe, Mn, or Zn caused a positive response with regard to plant growth or N, Fe or Zn uptake.

Effect of different nitrogen sources on plant growth and nutrient uptake under conditions of mineral or chelated Fe (Table 2):

**Dry weight:**

Dry weight of wheat plants grown on calcareous soil was significantly increased by an average of 53% with application of N-fertilizer. Ammonium sulphate "AS" N2 either alone or mixed with N-serve N6 gave the highest values of dry weight which increased by averages of 67.6% and 74.9%, respectively. Thus, adding N-serve to N2 increased its efficiency as a fertilizer. Sulpher-coated urea N3 was the least effective N source and caused an increase of 34.1% in dry weight of wheat. Urea-form "UF" was superior to sulpher-coated urea "SCU" only in presence of Fe-EDTA; in presence of $FeSO_4$ both N sources were similar. Comparison between the chelated (EDTA) and the mineral Fe forms shows a superiority of the former. Such superiority was significant in treatments which were fertilized with the slow-release N-sources of urea-forma "UF" as well as the slow calcium mnitrate, i.e. with N4 and N5 sources. These results are similar to those of Awad (1990), Singh *et al.* (1996) and Zeidan and Nofal (2002) who found that different nitrogen sources increased dry matter yield of wheat plants and that applied Fe was more effective on the dry matter in presence of applied N.

**Nitrogen-uptake:**

Application of "AS" either alone "N2" or mixed with N-serve "N6" showed the highest N-uptake giving increases averaging 334.8% and 363.2%, respectively. This trend was similar to that of dry weight. The lowest N-uptake was given by "UF" N4 followed by "SCU" (i.e. the 2 slow-release sources) giving average of 83% and 88% respectively. Such low N uptake given by the slow-release sources was more evident under conditions of fertilization with mineral Fe rather than chelated Fe. The obtained results are in agreement with those of Abbady (1988) in which values of N-uptake by wheat plants significantly increased by application of all N-sources.

**Iron-uptake:**

The highest Fe-uptake occurred with N2 and N1; giving 135.7% and 120% average increases, respectively. The lowest increase was with N4; which gave 62.4% increase. Applying N6 gave 80.5% increase in Fe uptake. The most effective treatment on Fe uptake was N2 Fe2 and the least effective one was N6 Fe1. The superiority of N2 may be attributed to the acidification effect of this source in the rhizospher. As plant absorbs $NH_4^+$ ions it excretes to the growth medium $H^+$ ions which in turn increases iron availability. Chelated Fe releases iron ions more readily in acidic conditions. The positive effect of the chelated source would be suppressed with addition of N serve i.e with presence of N6 source. N-serve inhibits nitrification, this inhibition effect may be the reason of negative effect of N6 on N2. These results are in agreement with those reported by Abd El-Haleem (1985). Application of chelated-Fe form increased Fe-uptake than those caused by the mineral-Fe form with no significant differences. These results agree with those of Abd El-Haleem (1985) in which Fe uptake from the chelated source (Fe-EDTA) was higher than corresponding mineral Fe ($FeSO_4$). Superiority of chelated Fe over mineral Fe in presence of N in all forms.

**Manganese-uptake:**

Treatments of N2 and N6 showed the highest Mn-uptake giving an average of 9.8% increase in the Mn uptake. Treatments N3 and N4 did not significantly affect Mn-uptake. Both of N2 and N6 were more effective under conditions of mineral Fe than chelated Fe. These results are in agreement with those of El-Headek (2000). The superiority of the ammonium forms of N (i.e. N2 and N6) may be due to their acidification effect on the rhizosphere, which in turn would increase Mn availability.

**Zinc-uptake:**

The results of Zn-uptake were rather similar to those of Mn-uptake. N-application increased Zn-uptake in particular when applied as N2 or N6. Application of Fe as mineral was superior than as chalated, the superiority of mineral Fe was more pronounced under conditions of N2 or N6 nitrogen application. The inferiority of chelated Fe effect on Mn and Zn uptake may be partially due to the computing effect of Fe on Mn and Zn uptake. These results are similar to those reported by Hamed (1997).

Results reflect an enhancement effect of ammonium form of fertilizer in a greater uptake of Zn due to applying mineral Fe rather than chelated Fe.

**Effect of different nitrogen sources on plant growth and nutrient uptake under conditions of mineral or chelated Mn (Table 3):**

**Dry weight:**

Application of different N-sources significantly increased dry weight of plant with a mean percentage increase of 30.9%. These results are similar to those obtained by Zeidan and Nofal (2002) who concluded that it is necessary to apply N to maximize the yield of wheat plant receiving micronutrients. The highest increase was obtained when N2 or N6 was the form, giving 47.6% and 44.7% average increases, respectively. Adding N-serve to (AS), i.e. treatment N6gave greater dry weight than (AS) alone, i.e. N2.

This occurred only where chelated-Mn was used. In presence of mineral Mn, N6 gave greater weight than N2. The lowest increase was obtained with sulpher coated urea (SCU); i.e. N3 giving 9.2% average increase. Slow release of N in the forms of (SCU) was not suitable for the rate of growth of the plant. Comparison between chelated and mineral Mn shows superiority of the former with all sources of N.

**Table (2): Effect of applying N and Fe sources on dry weight and uptake of N, Fe, Mn, and Zn by wheat plants.**

| Fe-form "B" | N-sources "A" | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N5 | N6 | |
| | Dry weight g/pot | | | | | | |
| Fe1 | 7.95 | 8.49 | 6.84 | 6.81 | 7.08 | 8.90 | 7.68 |
| Fe2 | 8.01 | 8.61 | 6.84 | 7.50 | 7.68 | 8.94 | 7.93 |
| Mean | 7.98 | 8.55 | 6.84 | 7.16 | 7.38 | 8.92 | |
| L.S.D 0.05 | A= 0.37 B = NS AxB = 0.52 | | | | | | |
| | N-uptake mg/pot | | | | | | |
| Fe1 | 294.93 | 330.26 | 138.17 | 130.07 | 177.00 | 351.93 | 237.06 |
| Fe2 | 300.38 | 332.35 | 147.06 | 148.50 | 219.63 | 354.0 | 250.32 |
| Mean | 297.66 | 331.31 | 142.62 | 139.29 | 198.32 | 352.97 | |
| L.S.D 0.05 | A= 36.7 B = NS AxB = 51.9 | | | | | | |
| | Fe-uptake mg/pot | | | | | | |
| Fe1 | 4.55 | 4.91 | 3.34 | 3.24 | 3.36 | 3.17 | 3.76 |
| Fe2 | 4.69 | 4.99 | 3.55 | 3.58 | 3.69 | 4.4 | 4.15 |
| Mean | 4.62 | 4.95 | 3.45 | 3.41 | 3.53 | 3.79 | |
| L.S.D 0.05 | A= 0.37 B = NS AxB = 0.52 | | | | | | |
| | Mn-uptake mg/pot | | | | | | |
| Fe1 | 0.45 | 0.49 | 0.42 | 0.43 | 0.44 | 0.49 | 0.45 |
| Fe2 | 0.44 | 0.47 | 0.41 | 0.44 | 0.44 | 0.46 | 0.44 |
| Mean | 0.45 | 0.48 | 0.42 | 0.44 | 0.44 | 0.48 | |
| L.S.D 0.05 | A= 0.03 B = NS AxB = 0.04 | | | | | | |
| | Zn-uptake mg/pot | | | | | | |
| Fe1 | 0.33 | 0.42 | 0.36 | 0.37 | 0.37 | 0.43 | 0.38 |
| Fe2 | 0.32 | 0.38 | 0.36 | 0.38 | 0.37 | 0.41 | 0.37 |
| Mean | 0.33 | 0.40 | 0.36 | 0.38 | 0.37 | 0.42 | |
| L.S.D 0.05 | A= 0.013 B = 0.007 AxB = 0.018 | | | | | | |

**Control**: Dry weight 5.1 g/pt–N uptake 76.2 mg/pot–Fe uptake 2.1 mg/pot– Mn uptake 0.41 mg/pot–Zn uptake 0.3 mg/pot
N1= Urea N2= $(NH_4)_2SO_4$ N3= Sulfer coated urea
N4= Urea formaldehyde N5= Calcium mitrate N6= $(NH_4)_2SO_4$ + N serve

**Nitrogen-uptake:**

Generally, all N-sources positively affected N-uptake by plants. The average increase caused by applying N was 108.8%. The highest increase (178.0%) was given by N6. Adding N-serve to (AS) enhanced N uptake since N2 gave greater N-uptake than N6. The least increase (31.5%) was associated with sulpher coated urea N3. The chelated form of applied Mn was superior (by 22.3%) to the mineral form. These results are similar to those obtained by Singh (1990) who stated that applying N and/or Mn increased N and Mn uptake by wheat plants. The least effective N sources were the slow-release forms of N3 and N4 as they provide small quantities of available N to plants.

**Iron-uptake:**

Concerning Fe-uptake data indicate that all N-sources increased Fe uptake significantly. The highest average increase was given by N2 (22.4%) followed by N1 (18.6%). The lowest average increase was caused by N3 (0.9%). Adding N-serve to (AS) i.e. N6 caused a greater N-uptake than applying (AS) alone, i.e. N2; this occurred only in presence of adding mineral Mn. However, in presence of chelated Mn, N6 was superior to N2 i.e. adding N-serve to (AS) was more effective. The chelated form of Mn was accompanied with greater Fe-uptake than the mineral form giving an average 13.1% increase over the mineral form.

**Manganese-uptake**:

Values of Mn-uptake were generally increased by applying N in any form. The average increase caused by applying N was 96.3%. The highest increase of 141% results from using N6. The least increase of 60.9% was found with either N4 or N5. Adding N-serve to (AS) was more effective in presence of chelated MN since N6 was superior to N2 only in presence of chelated Mn. Greater Mn uptake (average 23.6% increase) occurred with chelated Mn than with the mineral Mn. The superiority of chelated Mn as compared with mineral Mn under the condition of calcareous soil may be due to its ability to maintain Mn in availability form for the growing plants. The current results are similar to those obtained by El-Beshbeshy (1983) who found that application of Mn in chelated form increased Mn-uptake by grains of maize plant.

**Zinc-uptake:**

Adding N sources in any form increased Zn uptake by an average of 23.3%. The highest increase of 40% was given by N2 followed by N5 which gave an average increased of 30%. Lower increases of13.3% and 16.6% were given by N1 N3, respectively.

Adding N-serve to AS (i.e. N6) improved its efficiency in increasing Zn-uptake. This occurred particularly under condition of chelated- Mn when N6 was superior to N2, while the opposite happened under mineral Mn form when N2 was superior to N6. The negative effect of adding N serve to (AS) under mineral Mn conditions may be relate to persistence of ammonium and suppression of nitrification in presence of $MnSO_4$. Comparison between chelated and mineral forms of applied Mn, exhibited that, the mineral form was superior to the chelated form where either N2 or N5 was used, while in presence of N6, the chelated form was superior, with the other N-sources the two forms of Mn were similar or not statistically different.

Effect of different nitrogen sources on plant growth and nutrient uptake under conditions of mineral or chelated-Zn (Table 4):

**Dry weight:**

Dry weight of plants responded positively to N application in any form exhibiting an average increase of 44.6% as compared with control treatment. The increases were highest when N2 or N1 was applied as they gave average of 70%

and 55.1% increases, respectively. Adding N-serve to (AS), i.e. N6 decreased dry weight of plant . Application chelated Zn was superior to the mineral form. El-Basioni *et al.*, (1993) and Zeidan and Nofal (2002) reported that Zn fertilizer gave greater positive response in plant growth as compared with other micronutrients, particularly when given in presence of N fertilizers.

**Table (3): Effect of applying N and Mn sources on dry weight and uptake of N, Fe, Mn, and Zn by wheat plants**

| Mn-form "B" | N-sources "A" | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N5 | N6 | |
| | Dry weight g/pot | | | | | | |
| Mn1 | 6.93 | 7.23 | 5.14 | 5.76 | 5.38 | 6.71 | 6.19 |
| Mn2 | 7.35 | 7.83 | 6.00 | 6.30 | 7.50 | 8.04 | 7.17 |
| Mean | 7.14 | 7.53 | 5.57 | 6.03 | 6.44 | 7.38 | |
| L.S.D 0.05 | A= 0.01 | | B = 0.01 | | AxB = 0.02 | | |
| | N-uptake mg/pot | | | | | | |
| Mn1 | 163.58 | 185.81 | 86.33 | 97.92 | 134.50 | 190.56 | 143.12 |
| Mn2 | 176.40 | 224.72 | 114.00 | 107.10 | 195.00 | 233.16 | 175.06 |
| Mean | 169.99 | 205.27 | 100.17 | 102.51 | 164.75 | 211.86 | |
| L.S.D 0.05 | A= NS | | B = NS | | AxB = NS | | |
| | Fe-uptake mg/pot | | | | | | |
| Mn1 | 2.43 | 2.48 | 1.96 | 2.19 | 1.93 | 2.27 | 2.21 |
| Mn2 | 2.54 | 2.65 | 2.28 | 2.31 | 2.54 | 2.68 | 2.50 |
| Mean | 2.49 | 2.57 | 2.12 | 2.25 | 2.24 | 2.48 | |
| L.S.D 0.05 | A= 0.02 | | B = 0.01 | | AxB = 0.03 | | |
| | Mn-uptake mg/pot | | | | | | |
| Mn1 | 0.89 | 0.87 | 0.56 | 0.61 | 0.53 | 0.87 | 0.72 |
| Mn2 | 1.00 | 1.03 | 0.68 | 0.70 | 0.79 | 1.11 | 0.89 |
| Mean | 0.95 | 0.95 | 0.71 | 0.66 | 0.66 | 0.99 | |
| L.S.D 0.05 | A= 0.02 | | B = 0.01 | | AxB = 0.07 | | |
| | Zn-uptake mg/pot | | | | | | |
| Mn1 | 0.34 | 0.45 | 0.34 | 0.37 | 0.44 | 0.28 | 0.37 |
| Mn2 | 0.34 | 0.39 | 0.36 | 0.37 | 0.33 | 0.44 | 0.37 |
| Mean | 0.34 | 0.42 | 0.35 | 0.37 | 0.39 | 0.36 | |
| L.S.D 0.05 | A= 0.03 | | B = NS | | AxB = 0.04 | | |
| **Control**: Dry weight 5.1 g/pt–N uptake 76.2 mg/pot–Fe uptake 2.1 mg/pot–Mn uptake 0.41 mg/pot–Zn uptake 0.3 mg/pot | | | | | | | |

See footnote of Table (2).

**Nitrogen-uptake:**

Application of any N-source significantly increased N-uptake by wheat plants. The highest increase of 268.3% was caused by N6 followed by N1which gave an average increase of 267.4%, while N4 gave the lowest increase of 56.4%.

Using N3 and N5 treatments gave increases of 109.6% and 109.4%. Adding N-serve to AS, (i.e. N6) raised its efficiency as a fertilizer particularly under mineral form of Zn. The chelated form was superior to the mineral form of Zn, except when N2 or N6 were applied where the mineral form was the superior one.

**Table (4): Effect of applying N and Zn sources on dry weight and uptake of N, Fe, Mn, and Zn by wheat plants.**

| Zn-form "B" | N-sources "A" | | | | | | Mean |
|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N5 | N6 | |
| | Dry weight g/pot | | | | | | |
| Zn1 | 7.80 | 8.40 | 6.45 | 6.09 | 6.39 | 8.07 | 7.20 |
| Zn2 | 8.01 | 8.94 | 6.78 | 6.42 | 6.45 | 8.70 | 7.55 |
| Mean | 7.91 | 8.67 | 6.62 | 6.26 | 6.42 | 8.70 | |
| L.S.D 0.05 | A= 0.76 | | B = NS | | AxB = 0.07 | | |
| | N-uptake mg/pot | | | | | | |
| Zn1 | 263.64 | 269.64 | 129.00 | 116.32 | 156.56 | 295.80 | 205.16 |
| Zn2 | 296.37 | 259.26 | 190.52 | 121.98 | 162.54 | 265.44 | 216.02 |
| Mean | 280.00 | 264.45 | 159.76 | 119.15 | 159.55 | 280.62 | |
| L.S.D 0.05 | A= 2.0 | | B = 1.2 | | AxB = 2.3 | | |
| | Fe-uptake mg/pot | | | | | | |
| Zn1 | 2.64 | 2.90 | 2.30 | 2.19 | 2.31 | 2.92 | 2.54 |
| Zn2 | 2.67 | 3.04 | 2.37 | 2.28 | 2.32 | 2.89 | 2.60 |
| Mean | 2.66 | 2.97 | 2.34 | 2.24 | 2.32 | 2.91 | |
| L.S.D 0.05 | A= 0.01 | | B = 0.01 | | AxB = 0.02 | | |
| | Mn-uptake mg/pot | | | | | | |
| Zn1 | 0.48 | 0.53 | 0.45 | 0.41 | 0.36 | 0.52 | 0.46 |
| Zn2 | 0.46 | 0.54 | 0.41 | 0.41 | 0.39 | 0.57 | 0.46 |
| Mean | 0.47 | 0.54 | 0.43 | 0.41 | 0.38 | 0.55 | |
| L.S.D 0.05 | A= 0.01 | | B = NS | | AxB = 0.01 | | |
| | Zn-uptake mg/pot | | | | | | |
| Zn1 | 0.62 | 0.66 | 0.46 | 0.44 | 0.47 | 0.70 | 0.56 |
| Zn2 | 0.66 | 0.74 | 0.49 | 0.48 | 0.48 | 0.73 | 0.60 |
| Mean | 0.64 | 0.70 | 0.48 | 0.46 | 0.48 | 0.72 | |
| L.S.D 0.05 | A= 0.02 | | B = 0.01 | | AxB = 0.03 | | |
| **Control**: Dry weight 5.1 g/pt–N uptake 76.2 mg/pot–Fe uptake 2.1 mg/pot–Mn uptake 0.41 mg/pot–Zn uptake 0.3 mg/pot | | | | | | | |

See footnote of (Table) 2.

**Iron-uptake:**

Fe-uptake by plants was positively affected by nitrogen application with an average increase of 22.4%. The most effective N source was N2 which gave an average increase of 41.4% followed by N6 which gave an average increase of

38.6%. Adding N-serve to AS, (i.e. N6) gave greater Fe uptake as compared with (AS) alone, i.e. N2 particularly those which received the mineral form of Zn. However, Fe-uptake by plants of N6 under conditions of chelated form of Zn was lower than those of N2. Thus, the effect of $(NH_4)_2SO_4$ + N- serve on Fe uptake was positive. Chelated Zn was superior to mineral Zn except where N6 was applied when the reverse occurred.

**Manganese-uptake:**

Most N-sources increased Mn uptake particularly N6 and N2 giving averages of 34.1% and 31.7% increases respectively. N5 caused a slight decrease, N6 gave greater Mn uptake over N2 indicating enhancement of N-serve to the effect of ammonium sulphate source. This occurred particularly under conditions of chelated addition of Zn. The chelated form was superior to the mineral form under conditions of N5 and N6 in particular; under conditions of N1 and N3 the reverse occurred; under conditions of N2, and N4 both Zn sources were similar.

**Zinc-uptake:**

All sources of N increased Zn-uptake. The highest increase occurred with N6 (an average of 140% increase) followed by N2 (an average of 133.3% increase). N-serve showed no marked effect to the efficiency of ammonium sulphat under chelated Zn, but under mineral-Zn condition it enhanced its efficiency. Comparing the two forms of applied Zn, results show that the chelated form was superior to the mineral form particularly in presence of N1 or N2.

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## تعزيز نموالقمح عن طريق إضافة النتروجين ، الحديد ، المنجنيز والزنك

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** قسم تغذية النبات – المركز القومي للبحوث – الجيزة – مصر.

تم إجراء تجربة زراعة حقلية لدراسة تاثير إضافة الأسمدة النتروجينية ( الذائبة وبطيئة التيسر) فى وجود عناصر الحديد ، المنجنيز ، والزنك ( في الصورتين المعدنية أوالمخلبية) على الوزن الجاف لنباتات القمح وكذلك على إمتصاص نباتات القمح للعناصر محل الدراسة تحت ظروف الأراضي الجيرية. ٧ مصادر للنتروجين تم إستخدامها فى الدراسة وهى اليوريا N1 وسلفات الأمونيوم N2 واليوريا المغطاة بالكبريت N3 واليوريا فورمالدهيد N4 ونترات الكالسيوم N5 وسلفات الأمونيم + N-serve N6. تحت ظروف إضافة الحديد بصورتيه لوحظ زيادة فى الوزن الجاف لنباتات القمح عند إضافة النتروجين وكان متوسط الزيادة ٥٣%. حدثت زيادة فى معدل إمتصاص النتروجين والحديد والمنجنير والزنك بواسطة نباتات القمح. فى حالة إضافة المنجنيز بصورتيه لوحظ زيادة معنوية فى الورن الجاف بمتوسط ٣٩,٩% عند إضافة النتروجين وكذلك حدثت زيادة فى معدل إمتصاص النتروجين والحديد والمنجنيز والزنك بمتوسط ١٠٨,٨و١٢,٣و١٠٠,٠ و ٢٣,٩ % على التوالى. عند إستخدام الزنك بصورتيه حدثت زيادة فى الوزن الجاف بمعدل ٤٤,٦% عند إضافة النتروجين ولوحظ زيادة فى معدل إمتصاص النتروجين والحديد والزنك بمتوسط ١٧٦,٣ و ٢٢,٤ و ٩٣,٣ % علي التوالى. معظم مصادر النتروجين المستخدمة سببت زيادة فى معدل إمتصاص المنجننيز.