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EFFECT OF DIFFERENT SOURCES AND RATES OF NITROGEN FERTILIZER ON MAIZE GRAIN YIELD, MACRO- AND MICRONUTRIENTS UPTAKE AT MIDDLE EGYPT REGION

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ABSTRACT: ***A field experiment was carried out during the two successive seasons of 2007 and 2008 at El-Badrasheen, 6 October, governorate, Egypt to study the effect of different nitrogen sources i.e., urea, ammonium sulphate and calcium nitrate at rates (0, 100, 200 kg N/Fed.) and their interaction on growth characters, nutrients content, grain yield and its components of maize plants (Zea mays L. c.v single hybrid 10). The obtained results indicated that the increase of N rates up to 200kg N/fed significantly increased dry weight, grain yield N, P, K, Zn, Fe, and Mn uptake of maize plants with superiority for calcium nitrate fertilizer followed ammonium sulphate and urea and grains were increased significantly as well as Zn, Fe and Mn concentrations in whole plant after 60 days of planting or in maize grains at harvesting significantly increased as a result of applying calcium nitrate or ammonium sulphate followed by urea of both seasons 2007 and 2008. It was notice that the concentrations of Fe, Zn and Mn tended to decrease with increasing N rates. In general, the highest values of vegetative growth and grain yield were obtained when the plants received calcium nitrate followed by ammonium sulphate fertilizer up to 200 kg N/fed, while the lowest ones were obtained by urea treatment at rate of 100 kg N/fed.***

Key words: ***Nitrogen sources & rates, maize, nutrients uptake.***

INTRODUCTION

Maize (*Zea mays*, L) is a great important crop for both human and animal feeding, however, it ranks the third position among cereal crops. In Egypt, it is very important to increase production of maize to cover gab between production and consumption. The highest maize yield production depended on many factors i.e. cultivars, nitrogen and potassium fertilization(El-Bana, and Gomaa, 2000). There, many studies were conducted to increase its yield and improve its quality through proper fertilization. Maize hybrids differed in its productivity as well as its response to nitrogen fertilization.

Nitrogen is usually the most limiting factor for maize production, especially at early growth, grain filling and protein (Khalil, 1994). El-Douby *et al*. (2001) and Said *et al.,* (1996) found also the maize grain yield was significantly increased as N-rate increased and maximum figure was

obtained due to the addition of 140 kg N/fed and each increase N-rate up to 140 Kg N/fed resulted in significant increases in stem diameter, ear leaf area, ear length, ear diameter, 100-grain weight, grain yield, plant and grain yield/fed. El-Bana and Gomaa (2000) found a significant increase in grain yield as a results of increasing nitrogen rates from 100 to 125kg N/fed. Increasing nitrogen fertilization rates led to significant increases in plant height, ear leaf area, ear length, number of kernel/ rows ear weight and grain yield/fed. Also, many investigators such as Atta Allah (1998), Salem (1999), El-Naggar and Amer, (1999)and El-Douby et al., (2001) found that the yield of maize grains increased with nitrogen fertilization using different forms. Moreover, Darwish (2003) found a positive effect of N fertilization on grain yield, straw and whole plant of maize grown in Nile alluvial soil. Also, Abd El-Hamed *et al*. (1996) mentioned that plants fertilized with ammonia gas gave the highest values of vegetative growth, yield and its components, while the lowest values were obtained by urea. Moreover, Sarhan *et al.*(2004) found no significant effect was found for N-sources on Zn concentration in leaves in both seasons in the ear leaf, while Fe and Mn were affected significantly. Also, it was found that the concentration of micronutrients decreased by increasing N rates, they added that use of ammonium sulphate fertilizer gave the highest concentration of Fe and Mn in the ear leaf. This work was carried to evaluate the effects of nitrogen forms applied and with different rates on the yield of maize plants and quality of maize grains.

MATERIALS AND METHODS

A field experiment was carried out at El-Badrasheen, 6 October, governorate in the Middle Egypt region during two successive summer seasons of 2007 and 2008 to study the effect of nitrogen forms and rates on the yield and quality of maize (cv. Singl hybres10). Some physical and chemical properties of the studied soil were determined according to (A.O.A.C) are presented in Table (1). The experiment was carried out in a split plot design with three replicates in each treatment, the area of each plot was 3x3.5 m (1/8 fed.) where N-forms and N-rates represented the main plot and the rates of N application represented the sub-plot. Superphosphate (15 % P_2O_5) and potassium sulphate (48%K_2O) were added to the investigated plots during the tillage of experiment at the recommended rates 100 & 50 kg/fed., respectively. Three nitrogen forms were used; i.e., calcium nitrate (15.5 % N), ammonium sulphate (20.6 % N) and urea (46%N). Plant samples were taken as follows:

- **The first samples were taken after 60 days from sowing, where dry weight (g/plant) and nutrients uptake were determined in collected plant samples.**
- **The second samples were taken at harvest stage, where grain yields were recorded and also subjected to chemical analysis after prepared and oven dried at 70 ºC for 48 hours, then the average dry weights (g) were estimated for each treatment. The dry matter content of samples were analyzed to**

determine their nutrients content. Whereas, at harvest time (120 days after planting) grain weight (kg/plot) and grain yield (ton/fed.) were obtained. Total-N in leaves was determined by the kjldahl method described by Bremner and Mulvaney (1982). Phosphorus, potassium and micronutrients (Fe, Zn and Mn) were determined according to the method described by Cottenie *et al*. (1982).

Statistical analysis :

The data recorded was analyzed statistically by using analysis of variance technique appropriate to randomized complete block design, with split plot arrangement and upon obtaining significant differences. Least Significant Difference (LSD) test was used for comparing the treatment means (Snedecor and Cochran, 1980) using SAS Program.

Table (1): Some physical and chemical properties of the soil under investigation.

a- Particle size distribution

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture class
2.8	12.0	27.6	57.6	Clay

b- Some chemical properties

pH	EC_e (dS/m)	Organic matter %	$CaCO_3$ %	Anions (meq/L)				Cations (meq/L)			
				$CO_3^=$	HCO^-_3	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+
7.30	0.44	2.20	3.90	-	1.84	1.54	0.97	0.84	0.64	2.45	0.42

c- Available elements

Available nutrients (mg/kg soil)						
N	P	K	Fe	Mn	Zn	Mo
74.0	8.9	443.0	0.98	1.69	0.92	0.16

RESULTS AND DISCUSSION

1- Effect of different nitrogen sources, rates and their interaction on dry matter after 60 days of sowing:

a- Effect nitrogen sources :

The application of different nitrogen sources on dry weights of maize plants are presented in Table (2). It was observed that the addition of nitrogen significantly increased dry weight of maize plants as compared with the control treatment. Results also reveal that the application of calcium nitrate followed by ammonium sulphate significantly increased the dry

weight of maize plant as compared with ammonium sulphate and urea. These results indicate the superiority of calcium nitrate, the increases may be due to the noticed reduction in soil pH, an increase in nutrients availability and improved the efficiency of nutrients uptake which increased the amounts of dry yield of plants. Furthermore, the decrease in soil pH are in agreement with those obtained by Norman *et al*. (1987) and Clay *et al*. (1990). Also, Murihead *et al.* (1985), Baldwin (1986) and Sutton *et al*. (1986) found that the yield of maize increased with nitrogen application, however, data show that applying ammonium sulphate increased significantly dry weight of maize plants than urea fertilizers. The high efficiency of ammonium sulphate as compared to urea, could be partly attributed to more volatilization of urea fertilizer which results in a higher losses of N under alkaline soil conditions as reported by Singh *et al.*(1990) and Hassan and Gaballah (2000). Generally, the application of calcium nitrate fertilizer gave the highest value of dry weights about by 140.3, 129.3, 115.3 gm/plant (first season), while about by 138.62, 131.26 and 131.89 gm/plant (second season) for calcium nitrate, ammonium sulphate and urea treatments, respectively.

Table (2): Effect of nitrogen sources and rates on dry matter (g/plant) of maize plant after 60 days from sowing during summer seasons 2007 and 2008.

N Source (A)	rate (kg N/fed) (B)			
	0	100	200	Mean
	First season (Summer season 2007)			
Calcium N.	71.01	171.17	178.73	140.3a
Urea	71.01	139.07	135.91	115.3c
Am. Sulphate	71.01	154.75	162.07	129.3b
Mean	71.01b	154.99a	158.91a	
L.S.D (0.05)	A=4.88	B=4.28	AxB=4.28	
	Second season (Summer season 2008)			
Calcium N.	72.96	163.65	179.24	138.62a*
Urea	72.96	140.24	138.57	131.89b
Am. Sulphate	72.96	157.52	165.18	131.26a
Mean	72.96b	153.80a	160.99a	
L.S.D (0.05)	A=9.74	B=7.84	AxB=7.84	

*** Means with same letters are not significantly different**
NS = Not significant.

a- Effect nitrogen rates :

The obtained data in Table (2) show that increasing nitrogen fertilization rates led to a significant increase in weight of maize as compared with the control treatment. El-Douby *et al* (2001), El-Naggar and Amer (1999) found that maize grain yield was significantly increased by increasing rate of nitrogen and maximum figure was obtained due to addition of 140 kg N/fed. Moreover, it is clear from Table (2) that increasing nitrogen level from 100 to 200 kg N/fed significantly increased dry weight of maize plants compared with other N-rates in two growing seasons except urea application. In average, data in Table (2) show that the highest values of dry weight of maize plants were obtained by using 200 kg N/fed by about 71.0, 154.9 and 158.9 gm/plant (1st season), as well as about 72.9, 153.8 and 160.9 gm/plant (2nd season) in decreasing order for calcium nitrate, ammonium sulphate and urea treatments, respectively.

c- Effect of interaction between nitrogen sources and rates:

All interactions Data in Table (2) for dry matter of maize plants after 60 days from sowing are significantly increased, except rate 0 kg N/fed for the nitrogen sources. The addition of calcium nitrate fertilizer at 200 kg N/fed increased significantly dry weight as compared with urea fertilizer at 200 kg N/fed (Table 2). It important to mention that the best treatment gave the highest dry matter value was the interaction between calcium nitrate treatment at rate 200 kg N/fed followed by ammonium sulphate at the same rate. Similar results were reported by El-Naggar and Amer (1999), Badran (1998), El-Bana and Goomaa (2000), Yakout and Greish (2002), Darwish (2003) and Zohry and Farghaly (2003).

2- Effect of different nitrogen sources, rates and their interaction on macronutrients (N, P and K) after 60 days of sowing:

a- Effect nitrogen sources :

Data in Table (3) show that the mean values of N, P and K were generally significantly increased as increasing of dry matter which affected by sources and rates of N. The higher values of N, P and K concentrations and uptake were found when applying calcium nitrate than the other two sources. So, it could be mentioned here that using of calcium nitrate as nitrogen source increased the nutrition value of maize grain as compared to the other nitrogen forms. These results are in agreement with those obtained by Abd-El-Kader ((2007) and Norman *et al*. (1987). It was found that application of calcium nitrate up to 200 kg N/fed fertilizers. Maize plant gave higher values of N, P and K than ammonium sulphate and urea in decreasing order. In this concern Fayiad ((1989) reported that increasing N Level caused an increase in P concentration and the uptake by wheat plants. The results are in harmony with those obtained by Omar *et al*. (1979) and Kumar *et al*. ((1986).

TABLE 3

Furthermore, it may be interested to observe that the highest P content and uptake at all stage growth of maize ear leaf or straw and grain yield was obtained as result of significant of N x P x K interaction i.e., highest rate of both N and source of N with recommended doses of P and K, the best value of the dry matter of maize plant which recorded the maximum value when plants received calcium nitrate at the rate 200 kg N/fed, while the minimum value recorded by application of urea fertilizer at the rate of 100 kg N/fed.

Generally, data presented in Table (3) show that the highest values of N, P and K uptake by maize plants were obtained when applying of calcium nitrate where the mean corresponding values for N, P and K uptake are 2.51,0.47 and 2.21 g/plant , respectively. While the lowest mean values of N, P and K uptake were found when applying urea fertilizer amounted 1.93, 0.36 and 1.69 g/plant, respectively after 60 days from sowing.

b- Effect of N rates:

The obtained data in Table (3) show that increasing nitrogen fertilizer rates led to a significantly increase in N, P and K uptake by maize plants compared to the control. The application at 200 kg N/fed gave the highest values in all applied rates of N on N, P and K concentrations and uptake by maize plant. These results attributed to that account of the corresponding higher amount of the available of nitrogen in soil increased growth and a companing higher absorption (Gutiev and Khavkin, 1989) who reported that increasing N&P substantially increased utilization and the productivity per unit N absorbed. Furthermore in the same table the application at 200 kg N/fed significantly increased N, P and K uptake by maize plants than 100 kg N/fed fertilizer. These results may be due to the variation of nitrogen rate which it reflect that a higher absorption of nitrogen by maize plant from soil.

Generally, the highest value when applying 200 kg N/fed fertilizer, vs the lowest value at 100 kg N/fed. Generally, it was observed that in Table (3), a positive effect was recorded at 200 kg N/fed, which gave the highest mean values of N, P and K uptake by maize plants, i.e., 3.37, 0.62 and 2.40 g/plant, while addition of 100kg N/fed gave the lowest mean values of 2.93, 0.52 and 2.38 g/plant. The average increase significantly were 24.6, 8.4 and 9.3% for uptake as compared with the addition of different sources at 100 kg N/fed.

c- Effect of the interaction between nitrogen sources and rates:

Data presented in Table (3) show that the interaction between application of nitrogen sources and rates significantly affected N, P and K uptake by maize plant. The addition of calcium nitrate at 200 kg N/fed followed by ammonium sulphate increased N, P and K uptake than the addition of urea at 100 kg/fed. it could to be that the result emphasized the superiority of calcium nitrate fertilizer than other treatments. Furthermore, N plays a vital role in nutrition and physiological status on plants.

3- Effect of different nitrogen sources, rates and their interaction on micronutrients (Fe, Zn and Mn) after 60 days of sowing:

a- Effect nitrogen sources :

The application of different sources and rates of nitrogen on the uptake of Fe, Zn and Mn in ear leaf were higher than the control. Data also show that use of calcium nitrate followed by ammonium sulphate fertilizer gave the highest uptake of Fe, Zn and Mn in maize plant according to the report by Cook (1984), the use of ammonium sulphate fertilizer treatments tented to make the soil acidic, so the obtained results may be due to the fact that lower pH values induced by ammonium sulphate evidently is responsible for higher levels of Fe, Zn and Mn in leaf tissue (Gupta *et al*., 1991). The addition of urea indicated the lowest effect on Fe, Zn and Mn uptake by maize plants. On the other hand, Sarhan *et al.* ((2004) stated that the application of all nitrogen forms caused an increase in Zn concentrations in leaf tissues but this increase was not significant with zinc in both seasons. This may attributed to the dilution effect which decreases Zn concentration in the leaf . In the same table, plants received calcium nitrate or ammonium sulphate showed significantly higher values of Fe, Zn and Mn than those received urea fertilizer this may be due to the increase in utilization coefficient of calcium nitrate or ammonium sulphate as a source of nitrogen form. Generally, data show that the highest values of Fe, Zn and Mn uptake by maize plants were obtained by using calcium nitrate followed by ammonium sulphate and urea in decreasing order.

b- Effect of nitrogen rates:

Concerning the applied N rates, the uptake of Fe, Zn and Mn increased with increasing N rates up to 200 kg/fed at both seasons of maize plant as shown in Table (4).

c- Effect of interaction between nitrogen sources and rates:

Data presented in Table (4) show that the interaction between the applied nitrogen sources and rates (N-Sources X N-rates) significantly affected Fe, Zn and Mn uptake by maize plants in both seasons. The addition of calcium nitrate at the rate of 200 kg N/fed increased Fe, Zn and Mn uptake than the addition of urea at same rate. The highest values of micronutrient were obtained by ammonium sulphate at the rate of 200 kg N/fed. While, the lowest value of micronutrients were obtained by using urea fertilizer at rate 100 kg N/fed. Thus, the result emphasized the superiority of calcium nitrate followed by ammonium sulphate fertilizer than urea treatment, furthermore, N plays a vital role in nutrition and physiological status on plants.

TABL4 4

4- Effect of different nitrogen sources, rates and their interaction on grain yield at harvesting during summer seasons 2007 and 2008:

a- Effect nitrogen sources :

The application of different sources of nitrogen on dry weight of maize plants are presented in Table (5). It was observed that the addition of nitrogen significantly increased grain yields (ton/fed) of maize plants as compared with the control treatment. Results also reveal that the application of calcium nitrate and ammonium sulphate significantly increased the grain yields of maize plants as compared with (urea fertilizer treatment) in both two seasons. These results are in agreement with those obtained by Norman *et al*. (1987) and Clay *et al*. (1990). In this concern. Also, Murihead *et al.* (1985), Baldwiny (1986) and Sutton *et al*. (1986) found that the yield of maize increased with nitrogen application. In the same table data show that applying ammonium sulphate increased significantly grain yields of maize plants than urea fertilizer. The high efficiency of ammonium sulphate as compared to urea, could be partly attributed to more volatilization of urea fertilizer which results in a higher losses of N under alkaline soil conditions as reported by Hassan and Gaballah (2000) and Singh *et al.*(1990). Generally, the application of calcium nitrate fertilizer gave the highest grain yields by about 6.06, 5.78 and 5.32 ton/fed (for first season), while by about 6.08, 5.75 and 5.40 ton/fed (for second season) for calcium nitrate, ammonium sulphate and urea treatments, respectively.

Table (5): Effect of nitrogen sources and rates on grain yield (ton/fed) of maize plant at harvesting during summer seasons 2006 and 2007.

N Source (A)	rate (kg N/fed) (B)			
	0	100	200	Mean
	First season (Summer season 2007)			
Calcium N.	3.28	7.18	7.72	6.06a
Urea	3.28	5.94	6.75	5.32b
Am. Sulphate	3.28	6.86	7.19	5.78a
Mean	3.28c	6.66b	7.22a	
L.S.D (0.05)	A=0.30	B=0.21	AxB=0.21	
	Second season (Summer season 2008)			
Calcium N.	3.31	7.33	7.60	6.08a
Urea	3.31	6.56	6.31	5.40c
Am. Sulphate	3.31	7.03	6.90	5.75b
Mean	3.31b	6.97a	6.94a	
L.S.D (0.05)	A=0.31	B=0.18	AxB=0.18	

*** Means with same letters are not significantly different.**

NS = Not significant.

b- Effect of nitrogen rates :

The obtained data in Table (5) show that increasing nitrogen rates led to a significant increase in maize grain yield as compared with the control treatment. El-Douby *et al* (2001), El-Naggar and Amer (1999) found that maize grain yield was significantly increased N rate increases and maximum figure was obtained due to addition of 200 kg N/fed. Moreover, it is clear from Table (5) that increasing nitrogen rates from 100 to 200 kg N/fed significantly increased grain yields of maize plant compared with other N-levels in two growing seasons. Generally, data also show that the highest values of grain yields of maize plants were obtained by using 200 kg N/fed reached about 7.72, 7.19 and 6.75 ton/fed (1st season), and about 7.60, 6.90 and 6.31 ton/fed (2nd season) for calcium nitrate, ammonium sulphate and urea treatments, respectively.

c- Effect of interaction between nitrogen sources and rates:

All interactions data in Table (5) for grain yields of maize plants are significantly increased, except rate 0 kg N/fed for the nitrogen sources. The addition of calcium nitrate or ammonium sulphate fertilizer at 200 kg N/fed increased significantly grain yield as compared with urea fertilizer at 200 kg N/fed (Table 5). It important to mention that the highest grain yields values were obtained through the interaction between calcium nitrate treatment at rate 200 kg N/fed followed by ammonium sulphate at the same rate.

5- Effect of different nitrogen sources and rates and their interaction on macronutrients (N, P and K) at harvesting:

a- Effect nitrogen sources :

Data in Table (6) show that the mean values generally significantly increased N, P and K uptake by grains by N sources and rates. The higher values of N, P and K uptake by grains were found when applying calcium nitrate followed by ammonium sulphate than the urea fertilizer. So, it could be mentioned here that using of calcium nitrate and ammonium sulphate as nitrogen form increased the nutrition value of maize grain comparing to the urea form. Also, these results attributed to increase utilization coefficient of calcium nitrate or ammonium sulphate as a source of N fertilizer resulted from reduction of soil pH increased nutrients availability and improved efficiency of macronutrients uptake. These results are in agreement with those obtained by Abd-El-Kader (2007) and Norman *et al*. (1987). It was found that application of calcium nitrate at 200 kg N/fed followed by ammonium sulphate at the same rate gave higher values than urea treatment in decreasing order. In this concern Fayiad (1989) reported that increasing N rates caused an increase in P uptake by wheat plants. The results are in harmony with those obtained by Omar *et al*. (1979) and Kumar *et al*. (1986). Furthermore, it may be interested to observe that the highest P content and

Table 6

uptake at all stage growth of maize ear leaf or straw and grain yield was obtained as result of significant of N x P x K interaction i.e., highest rate of both N and source of N with recommended doses of P and K, the best value of the grain yields of maize plant which recorded the maximum value when plants received calcium nitrate at arte of 200 kg N/fed, while the minimum value recorded when applying urea fertilizer at 100 kg N/fed.

Generally, data presented in Table (6) show that the highest value of N, P and K uptake by grains of maize plants were obtained when applying of calcium nitrate followed by ammonium sulphate fertilizer. The mean values of N-uptake by grain yields are 103.95, 99.27 and 89.99 kg N/fed (1st season), 109.70, 101.67 and 95.02 kg N/fed (2nd season) for calcium nitrate, ammonium sulphate and urea, respectively. While, the mean values of P-uptake by grain yields were 19.89, 18.19 and 15.13 kg P/fed (1st season) vs 20.0, 17.30 and 15.55 kg P/fed (2nd season) for calcium nitrate, ammonium sulphate and urea, respectively . In case of K-uptake by maize grains, the mean values of K-uptake by grain were 33.20, 31.59 and 28.64 kg K/fed (1st season) vs 34.39, 33.70 and 31.70 kg K/fed (2nd season) for calcium nitrate, ammonium sulphate and urea, respectively.

b- Effect of N rates:

The obtained data in Table (6) show that increasing nitrogen rates led to a significantly increase in N, P and K concentrations and uptake by maize plants as compared with the control. When the application at 200 kg N/fed gave the highest values in all N, P and K uptake by maize grains in both seasons. Furthermore in the same table the application at 200 kg N/fed significantly increased N, P and K uptake by maize grains than 100 kg N/fed fertilizer.

Generally, it was observed that in Table (6), a positive effect was recorded concerning application of 200 kg N/fed which gave the highest mean values of N, P and K uptake by maize grains vs the lowest ones at 100 kg N/fed.

c- Effect of interaction between nitrogen sources and rates:

Data presented in Table (6) show that the interaction between application of nitrogen sources and rates significantly affected N, P and K uptake by maize plant. The addition of calcium nitrate at 200 kg N/fed followed by ammonium sulphate increased N, P and K uptake by grains than the addition of urea at 100 kg/fed, it could be emphasized the superiority of calcium nitrate fertilizer than other treatments, further more N plays a vital role in nutrition and physiological status on plants. The highest mean values of N, P and K uptake by maize grains were 141.22, 27.78 and 44.76 kg/fed (1st season), 149.64, 27.34 and 46.33 kg/fed (2nd season) for calcium nitrate at rate of 200 kg N/fed.

6- Effect of different nitrogen sources and rates and their interaction on micronutrients (Fe, Zn and Mn) at harvesting:

a- Effect of nitrogen sources :

The application of different N-sources and rates on the uptake of Fe, Zn and Mn in ear leaf are presented in Table (7). Data also show that use of calcium nitrate followed by ammonium sulphate fertilizer gave the highest uptake of Fe, Zn and Mn in maize plants. Cook (1984) reported that the use of ammonium sulphate fertilizer treatments tented to make the soil acidic, so the obtained results may be due to the fact that lower pH values induced by ammonium sulphate evidently is responsible for higher levels of Fe, Zn and Mn in leaf tissue. The addition of urea gave the lowest Fe, Zn and Mn uptake in maize plants. In this respect, Sarhan *et al.* (2004) stated that the application of all nitrogen forms caused an increase of Zn concentration in leaf tissues but this increase was not significant with zinc in both seasons. This may attributed to the dilution effect which decreases Zn concentration in the leaf. In the same table, plants received calcium nitrate or ammonium sulphate showed significantly higher level of Fe, Zn and Mn than those received urea fertilizer this may be due to increase in utilization coefficient of calcium nitrate or ammonium sulphate as a source of nitrogen form. Generally, data show that the highest values of Fe, Zn and Mn uptake by maize plant were obtained by using calcium nitrate followed by ammonium sulphate and urea in decreasing order. The application of calcium nitrate fertilizers was the most effective nitrogen form in increasing Fe, Zn and Mn concentration in maize grain more than the other nitrogen forms. This may be due to the superiority of ammonium sulphate nitrogen form in grain yield might be ascribed to increase in the studied components of grain yield, moreover, applying urea gave the lowest values. Moreover, these results are in agreement with those obtained by Darwish (1998) and Gupta and Polalia (1991) stated that ammonium sulphate fertilizer was more effective than urea in increasing the *Zea mays* yield, Fe and Mn contents and its uptake by plants. Where as ammonia gas showed significantly difference compared with urea. These results attributed to be explained by the interaction of nitrogen with iron through changes in pH, plants release protons causing the growth media to be more acidic and iron availability media increased (Marchenerc and Ossenberg-Neuhous, 1982). Generally, it was observed that the addition of calcium nitrate followed by ammonium sulphate gave the highest uptake of Fe, Zn and Mn by maize grains amounted by 0.63, 0.30 and 0.22 kg/fed, respectively while the lowest values were recorded when applying urea fertilizer and amounted 0.52, 0.25 and 0.19 kg/fed respectively.

Table 7

b- Effect of nitrogen rates:

Concerning N-rates, it was noticed that Fe, Zn and Mn concentrations increased with increasing N-rates in maize plants at harvesting in both seasons (Table 7). Generally, the concentrations of micronutrients increased with increasing N-rates up to 200 kg N/fed which led to increase the grain yields.

c- Effect of interaction between nitrogen sources and rates:

Data presented in Table (7) showed that the interaction between applied nitrogen sources and rates (N-Sources X N-rates) significantly affected Fe, Zn and Mn uptake by maize plant in both seasons. The addition of calcium nitrate at 200 kg N/fed increased Fe, Zn and Mn uptake than the addition of urea at 200 kg/fed. The highest values of micronutrient were obtained by using calcium nitrate followed by ammonium sulphate at the rate of 200 kg N/fed. While, the lowest values of micronutrients were obtained by using urea fertilizer at the rate of 100 kg N/fed. it could to that the result emphasized the superiority of calcium nitrate followed by ammonium sulphate fertilizer than other treatments, further more N plays a vital role in nutrition and physiological status on plants.

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تأثر محصول الحبوب وامتصاص المغذيات لنبات الذرة باختلاف مصادر ومعدلات النيتروجين

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الملخص العربي

اقيمت تجربة حقلية خلال موسمى ٢٠٠٧/٢٠٠٨ فى منطقة البدرشين التابعة لمحافظة ٦ اكتوبر منطقة مصر الوسطى لدراسة تأثير صور مختلفة من التسميد النيتروجينى (يوريا – كبريتات امونيوم – نترات كالسيوم) ومعدلات صفر، ١٠٠، ٢٠٠ كجم /ف على النمو والمحتوى من المغذيات وكذلك المحصول لنبات الذرة هجين فردى ١٠.

وقد أظهرت النتائج المتحصل عليها علاقة معنوية عالية باستخدام نترات الكالسيوم يليها كبريتات الأمونيوم فيما كان أدناها عند استخدام اليوريا على الوزن الجاف لحبوب الذرة الشامية وكذلك الأمتصاص من مغذيات N, P, K, Zn, Fe and Mn بعد ٦٠ يوم من الزراعة.

كما أوضحت النتائج ايضا أن زيادة معدل النتروجين إلى ٢٠٠كجم /فدان أدى إلى زيادة معنوية فى الوزن الجاف ومحصول الحبوب وكذلك امتصاص النبات لعناصر N, P, K, Fe, Zn, Mn خاصة عند استخدام نترات الكالسيوم سواء عند ٦٠ يوم أو عند الحصاد خلال موسمى الزراعة ٢٠٠٧ ، ٢٠٠٨ يليها استخدام سلفات الأمونيوم واليوريا، وقد تلاحظ أن زيادة جرعة التسميد النتروجينى قد أدى إلى انخفاض تركيز عناصرMn, Zn, Fe وعليه فان مصدر النيتروجين له دور هام ومؤثر تأثيرا معنويا في زيادة المادة الجافة والحبوب لمحصول الذرة.

وعموما فان أعلى نمو خضري وأعلى محصول من الحبوب تم الحصول عليه باستخدام نترات الكالسيوم يليه سلفات الأمونيوم تحت معدل ٢٠٠كجم/ف بينما أقل القيم عند استخدام معاملة اليوريا بمعدل ١٠٠كجم/فدان .س

Table (3): Effect of nitrogen sources and rates on macronutrients (N, P and K) uptake by maize plant after 60 days from sowing during summer seasons 2007 and 2008.

N Source (A)	N uptake (g/plant)				P uptake (g/plant)				K uptake (g/plant)			
	Rate (kg N/fed) (B)				Rate (kg N/fed) (B)				Rate (kg N/fed) (B)			
	0	100	200	Mean	0	100	200	Mean	0	100	200	Mean
	First season (Summer season 2007)											
Calcium N.	0.79	3.21	3.53	2.51a	0.187	0.560	0.657	0.468a	1.013	2.547	3.070	2.21a
Urea	0.79	2.56	2.44	1.93c	0.187	0.457	0.443	0.362c	1.013	2.040	2.017	1.69c
Am. Sulphate	0.79	3.01	3.17	2.33b	0.187	0.550	0.597	0.444b	1.013	2.547	2.100	2.097b
Mean	0.79	2.93	3.05		0.187c	0.522b	0.566a		1.013c	2.378b	2.596a	
L.S.D $_{(0.05)}$	A=0.09	B=0.09	AxB=0.09		A=0.020	B=0.017	AxB=0.17		A=0.081	B=0.086	AxB=0.9	
	Second season (Summer season 2008)											
Calcium N.	0.84	3.66	3.89	2.80a	0.207	0.597	0.767	0.523a	0.73	2.67	2.20	1.87
Urea	0.84	3.89	2.53	2.42b	0.207	0.487	0.470	0.388c	0.73	2.14	2.13	1.67
Am. Sulphate	0.84	2.53	2.53	1.97c	0.207	0.610	0.637	0.484b	0.73	2.64	2.84	2.07
Mean	0.84c	2.986	3.369a		0.207	0.564	0.624		0.73b	2.48a	2.39a	
L.S.D $_{(0.05)}$	A=0.028	B=0.057	AxB=0.57		A=0.003	B=0.014	AxB=0.14		A=ns	B=0.690	AxB=ns	

* NS = Not significant.

Table (4): Effect of nitrogen sources and rates on micronutrients (Fe, Zn and Mn) uptake by maize plant after 60 days from sowing during summer seasons 2007 and 2008.

N Source (A)	Fe uptake (mg/plant)				Zn uptake (mg/plant)				Mn uptake (mg/plant)			
	Rate (kg N/fed) (B)				Rate (kg N/fed) (B)				Rate (kg N/fed) (B)			
	0	100	200	Mean	0	100	200	Mean	0	100	200	Mean
	First season (Summer season 2007)											
Calcium N.	12.00	34.74	37.71	28.15a	3.77	14.17	19.05	12.33a	10.28	14.71	17.33	14.11a
Urea	12.00	26.68	25.98	21.56c	3.77	10.18	11.08	8.43b	10.28	11.54	11.41	11.08c
Am. Sulphate	12.00	31.39	33.46	25.62b	3.77	15.58	17.27	12.21a	10.28	14.38	15.07	13.25b
Mean	12.00c	30.94b	32.39a		3.77c	13.31b	15.80a		10.28c	13.55b	14.60a	
L.S.D (0.05)	A=1.04	B=1.03	AxB=1.0		A=0.506	B=0.404	AxB=0.40		A=0.46	B=0.38	AxB=0.4	
	Second season (Summer season 2008)											
Calcium N.	11.71	36.95	39.01	29.22a	3.94	14.86	19.98	12.92a	10.14	15.57	17.92	14.54a
Urea	11.71	11.71	27.31	22.49c	3.94	10.48	11.70	8.71b	10.14	11.91	12.05	11.37c
Am. Sulphate	11.71	32.18	35.58	26.49b	3.94	17.13	17.95	13.00a	10.14	15.52	16.24	13.97b
Mean	11.71c	32.15b	34.34a		3.94c	14.16b	16.54a		10.14c	14.34b	15.40a	
L.S.D (0.05)	A=0.28	B=0.48	AxB=0.5		A=0.20	B=0.27	AxB=0.3		A=0.20	B=0.21	AxB=0.2	

* NS = Not significant.

Table (6): Effect of nitrogen sources and rates on macronutrients (N, P and K) uptake (kg/fed) by maize plant at harvesting during summer seasons 2007 and 2008.

N Source (A)	N uptake (kg/fed)				P uptake (kg/fed)				K uptake (kg/fed)			
	Rate (kg N/fed) (B)				Rate (kg N/fed) (B)				Rate (kg N/fed) (B)			
	0	100	200	Mean	0	100	200	Mean	0	100	200	Mean
	First season (Summer season 2007)											
Calcium N.	43.65	126.99	141.22	103.95a	8.20	23.67	27.78	19.89a	16.11	38.74	44.76	33.20a
Urea	43.65	102.75	123.58	89.99b	8.20	16.93	20.25	15.13c	16.11	37.14	37.14	28.64b
Am. Sulphate	43.65	126.12	128.03	99.27a	8.20	21.94	24.45	18.19b	16.11	40.28	40.28	31.59a
Mean	43.65 c	118.26b	130.42a		8.20c	20.85b	24.16a		16.11c	36.60b	40.72a	
L.S.D $_{(0.05)}$	A=5.48	B=3.78	AxB=3.8		A=0.97	B=0.74	AxB=0.7		A=0.82	B=1.2	AxB=1.3	
	Second season (Summer season 2008)											
Calcium N.	44.41	134.95	149.64	109.7a	8.74	24.19	27.34	20.09a	17.23	39.60	46.33	34.39a
Urea	44.41	121.88	118.68	95.02c	8.74	18.36	19.57	15.55c	17.23	40.00	37.88	31.70b
Am. Sulphate	44.41	134.26	126.34	101.67b	8.74	21.03	22.09	17.30b	17.23	41.12	42.80	33.72a
Mean	44.41b	130.40a	131.55a		8.74c	21.21b	22.99a		17.23c	40.24b	42.34a	
L.S.D $_{(0.05)}$	A=5.72	B=3.46	AxB=3.5		A=0.93	B=0.53	AxB=0.5		A=1.53	B=1.04	AxB=1.0	

* NS = Not significant.

Table (7): Effect of nitrogen sources and rates on micronutrients (Fe, Zn and Mn) uptake by maize at harvesting during summer seasons 2006 and 2007.

N Source (A)	Fe uptake (mg/fed)				Zn uptake (mg/fed)				Mn uptake (mg/fed)			
	Rate (kg N/fed) (B)				Rate (kg N/fed) (B)				Rate (kg N/fed) (B)			
	0	100	200	Mean	0	100	200	Mean	0	100	200	Mean
	First season (Summer season 2007)											
Calcium N.	0.483	0.667	0.694	0.615a	0.205	0.287	0.339	0.277a	0.142	0.236	0.261	0.213a
Urea	0.483	0.510	0.585	0.526c	0.205	0.261	0.273	0.246b	0.142	0.201	0.233	0.192b
Am. Sulphate	0.483	0.595	0.639	0.573b	0.205	0.277	0.323	0.269b	0.142	0.237	0.239	0.206ab
Mean	0.483c	0.591b	0.640a		0.205c	0.275b	0.312a		0.142c	0.225b	0.244a	
L.S.D $_{(0.05)}$	A=0.026	B=0.023	AxB=0.02		A=0.023	B=0.020	AxB=0.02		A=0.014	B=0.010	AxB=0.01	
	Second season (Summer season 2008)											
Calcium N.	0.46	0.70	0.73	0.63a	0.20	0.35	0.35	0.30a	0.132	0.266	0.132	0.22a
Urea	0.46	0.61	0.56	0.55b	0.20	0.27	0.29	0.25c	0.132	0.216	0.220	0.189c
Am. Sulphate	0.46	0.64	0.62	0.57b	0.20	0.31	0.30	0.27b	0.132	0.132	0.239	0.20b
Mean	0.46c	0.64a	0.65a		0.20b	0.31a	0.31a		0.132c	0.23b	0.24a	
L.S.D $_{(0.05)}$	A=0.028	B=0.038	AxB=0.04		A=0.014	B=0.01	AxB=0.01		A=0.012	B=0.007	AxB=0.01	

* NS = Not significant.