USE EFFICIENCY OF MINERAL AND ORGANIC NITROGEN IN SIX MAIZE GENOTYPES

By

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ABSTRACT

Field experiments were carried out at the Agric. Res. and Experim. Cent., Fac. Agric., Moshtohor, Banha Univ. in 2005 and 2006 seasons to study the performance of 6 maize cultivars: S.C. 3084 (yellow kernels), S.C. 30K8, T.W.C. 323, D.C. Dahab (yellow kernels), Giza 2 (synthetic) and Nab El-Gamel (open pollinated) as local cv. in Moshtohor under 7 N rates, concerning their grain yield potentiality, N uptake, NUE and N recovery %. Comparison of mineral N versus mineral + Organic N was considered.

Fertilizer rates were: control, 60 kg N fed^{-1}, 90 kg N fed^{-1}, 120 kg N fed^{-1}, 40 kg N + 20 t FYM fed^{-1}, 60 kg N + 30 t FYM fed^{-1} and 80 kg N + 40 t FYM fed^{-1}.

Results showed that the 2 single crosses were superior in grain yield followed by D.C. Dahab then T.W.C. 323 and the composite varity followed by Nab El-Gamel. Nab El-Gamel and D.C. Dahab contained greater N% in grain. The single crosses as well as D.C. Dahab recorded higher N uptake, NUE and NR % and Giza2 and Nab El-Gamel recorded the lowest values.

The increase in N rates significantly increased grain yield fed^{-1}, total N% in grain, NUE and N recovery %. The greatest values of these traits were produced from applying 80 kg N+40t FYM fed^{-1}. The results showed that combining mineral and organic N should bring great advantages and will reduce soil and plant pollution. Also single maize crosses should cover maize area.

INTRODUCTION

Maize *(Zea mays L.)* is one of the most important cereal crops in Egypt. Maize grain is used for human consumption, animal and poultry feeding and industrial purposes.

Nitrogen fertilization is an important factor in maximizing maize yield. Increasing the cost of N fertilizer and concern over N pollution in the environment have increased the interest in improving plant efficiency in using N. The plant ability to absorb, partition and remobilize N affects efficiency of N fertilizer use.

Some investigators reported that efficiency of N use decreased as N rates were increased **(Anderson *et al.*, 1984; Mahgoub, 1987; Sisson *et al.*, 1991 and Campbell *et al.*, 1993).** On the other hand, some researchers reported that N recovery was negatively correlated with available N and there were differences between genotypes in this respect **(Gasser and Kalembasa, 1976; Mohgoub, 1987 and Reeves *et al.*, 1993). Shafshak *et al.* (1994)** found that N uptake in maize grain increased due to the increase in N level and S.C.10 was superior in N uptake than T.W.C. 310, D.C. 215 and Giza 2. They also found that NUE increased with increasing N level and the single cross 10 was superior compared with the other varieties, N recovery % increased with increasing N level. **Fatma Nofal (1999)** found that N uptake increased but NUE as well as N recovery % were slightly reduced with the increase in N level from zero to 35, 90 and 135 kg N/fed. **El-Gezawy (2005)** reported that raising N level from zero to 150 kg/fed increased grain N uptake but reduced agronomic NE and apparent N recovery.

Several investigators reported the superiority of maize grain yield of hybrid maize varieties, particularly, single crosses over the open-pollinated varieties **(Shafshak *et al.*, 1994; El-Hariri *et al.*, 1996; Abu-Grab *et al.*, 1997; El-Sheikh, 1999; Fatma Nofal, 1999; and El-Wakil, 2002).**

The use of FYM for maize will certainly reduce a considerable part of mineral fertilizers which in turn will reduce the hazards of soil pollution from an intensive use of mineral fertilizers. **Awad–Allah and Nabila Bassiony (1993)** reported that, in general, FYM contains 8% organic matter, 0.3% N, 0.4%

P_2O_5 and 1.2% K_2O. One cubic meter of FYM contains about 64, 2.4, 3.2 and 9.6 kg O.M., N, P_2O_5 and K_2O respectively. **Ali (1995)** stated that about 30% of the total NPK contents in FYM can be in available from for the growing crops during the first year after application, and about 25% would be utilized in the second year and the rest (45%) is utilized in the third year. He added that the application of $20m^3$ of FYM/fed (16 tons) will supply the soil with 14.4, 19.2 and 57.6 kg N, P_2O_5 and K_2O respectively during the first year after application. **Fatma Nofal (1999)** reported that one kg of mineral N was equal in its effect on grain of maize one ton of FYM. She found that NUE of mineral N was 20.7 kg grain as against 20.8 kg produced by one ton FYM on the average of 1995 and 1996 season.

Hamissa *et al.* (1979) stated that the highest yield of maize was obtained when treated with organic manure. compared with inorganic N. The results reported by **Sabry (1990), Mohamed and El-Aref (1999)** and **Fatma Nofal (1999)** indicated that FYM application was greatly effective in increasing maize grain yield. **Farghly *et al.* (2001),** applying 120 kg N/fed; and **Soliman *et al.* (2001),** applying 150 kg N/fed, reported significant effect of grain yield increase in maize. **Abd El-All (2002)** found that the highest maize grain yield was produced by applying 30 kg organic N+90 kg mineral N per fed.

The present investigation was carried out to study the performance of 4 hybrids and 2 open-pollinated maize varieties under 7 rates of mineral and organic N and to find out their yield potentiality, N uptake, NUE and N recovery%.

MATERIAL AND METHODS

Two field experiments were carried out at the Agriculture Research and Experimental Center of the Faculty of Agriculture, Moshtohor, Kalubia Governorate, Benha University, Egypt, in the two successive seasons 2005 and 2006 to study the performance of four hybrids and two open-pollinated varieties under seven nitrogen fertilizer rates applied as mineral or mineral mixed with farmyard manure (FYM).

Factors under study were as follows:

Six maize varieties, i.e.

1- Single Cross 3084 **(S.C. 3084).**
2- Single Cross 30K8 **(S.C. 30K8).**
3- Double Cross Dahab **(D.C. Dahab).**
4- Three way Cross 323 **(T.W.C. 323).**
5- Synthetic variety Giza 2 **(Giza 2).**
6- Open pollinated variety **(Nab El-Gamal)** as the local variety grown in Moshtohor village.

Nitrogen fertilizer rates, i.e.

Seven N fertilizer rates were used in this study.

1- Control (Zero)
2- 60 kg N fed^{-1}.
3- 90 kg N fed^{-1}.
4- 120 kg N fed^{-1}.
5- 40 kg N + 20 ton FYM fed^{-1}.
6- 60 kg N + 30 ton FYM fed^{-1}.
7- 80 kg N + 40 ton FYM fed^{-1}.

FYM used in the present study was obtained from Research and Experimental Center, traditionally produced by the cattle. According to previous research work concerning the evaluation of FYM as a source of N for maize, it was found that one ton of Egyptian FYM is equivalent in its effect to one kg of mineral N **(Fatma Nofal, 1999).** This evaluation is supported by the conclusion of **Awad-Allah and Nabila Bassiouny, (1993) and Ali (1995).**

Consequently, the rates of FYM applied in the treatments based on this estimation.

But it is worth mentioning here that FYM contains different nutrients in addition to N and improves soil physical and biological conditions and its beneficial effects will last for some years.

The manure was applied during soil preparation before sowing. While, N fertilizer rates in the form of urea (46% N) were added at two equal doses, the first dose after thinning and before the first irrigation and the second dose before the second irrigation in both seasons. The preceding winter crop was wheat.

Soil samples from the experimental site were collected from Zero to 30 cm depth and composite samples were done. The soil samples were air dried, ground and sieved through a 2 mm mesh sieve then subjected to mechanical and chemical analyses whose results are presented in **Table (1)**. Organic fertilizer was in the form of farm yard manure (FYM) whose chemical composition is presented in **Table (2).**

Maize genotypes namely T.W.C. 323 and Giza 2 were developed by Maize Research Section, Field Crops Research Institute, ARC, Giza, Egypt. Maize genotypes namely S.C.3084, S.C. 30K8 and D.C. Dahab were developed by Pioneer Company. Nab El-Gamal cultivar was produced by farmers in the region as the popular native open pollinated variety and usually termed as "Baladi".

Table (1): Mechanical and some chemical properties of the investigated soil sample

Soil characteristics	**2005 season**	**2006 season**
Mechanical analysis:		
Coarse sand %	5.10	5.21
Fine sand %	24.20	24.46
Silt %	20.01	20.12
Clay %	50.69	50.21
Textural class	Clay	Clay
Chemical analysis:		
pH (1: 2.5)	8.06	8.02
Organic matter %	1.91	1.98
EC (dSm^{-1})*	1.85	1.95
Total N%	0.14	0.12
Total P%	1.32	1.41
Total K%	0.51	0.49
Soluble cations and anions (m mol_c 1^{-1})*		
Na^+	9.15	9.50
K^+	0.65	0.60
Ca^{+2}	5.20	5.35
Mg^{+2}	3.50	3.05
Cl^-	7.80	8.10
CO_3^{-2}	0.00	0.00
HCO_3^-	4.50	4.70
SO_4^{-2}	6.20	6.70

* Soil paste extract

Experimental design

A split plot design with four replications was used in each trial. The six maize genotypes were allocated in main plots and the seven treatments of nitrogen fertilizer rates were randomly distributed in the sub plots. The area of sub-plot was 3.5m X 3m = 10.5 m^2 (1/400 fed).

Table (2): Some characteristics of the farm yard manure used in the study

Characteristics	2005 season	2006 season
Moisture %	34.50	35.40
Total C%	16.0	16.4
Total N%	0.98	0.94
Total P%	0.42	0.38
Total K%	0.92	0.96
C/N ratio	16: 1	17: 1
Organic matter %	27.60	27.28
pH (1: 5)	7.91	7.98
EC (1: 5) dSm^{-1}	3.8	3.4

Cultural practices

Before sowing of maize hybrids soil samples were taken from plots for soil analysis. At planting, super phosphate (15.5%), at a rate of 30 kg P_2O_5/fed was applied. Maize grains were planted on 9th and 6th June in the first and second season, respectively. Maize genotypes were planted on ridges, 25 cm between hills and thinning was done after 21 days from planting to one plant per hill. The width of ridge 70 cm, the number of ridge was five, the length of ridge was 3m. Other agricultural practices were done as recommended in region.

Chemical analyses

1- Soil analyses.

-Particle size distribution was conducted according to the international pipette method described by **Page *et al.* (1982).**

-Soil pH and soil content of calcium carbonate, electrical conductivity, the total soluble ions and total N,P,K were determined using the standard methods outlined by **Jackson (1973).**

-Soil organic matter was determined according **to Walkley and Black (1934).**

2- Organic manure analyses.

-EC, pH and organic matter were determined using the standard methods as mentioned before. Total N, P and K were determined according to the methods described by **Jackson (1973).**

3- Grain analyses.

-Grain were oven dried at 60 – 70ºC for 48 hours ground to pass through 0.5 mm sieve and sub samples of 0.2g portions were wet digested using a mixture of sulphuric (H_2SO_4) and perchloric ($HClO_4$) acids according to **Jackson (1973).** The digested solution was analyzed for total nitrogen percentage in grains according to the modified micro Kjeldahl method **(A. O. A. C., 1990).**

Data Recorded:

1- Grain yield (kg fed^{-1}) was recorded from whole plot in each treatment from four replications and adjusted to 15.5% moisture content.

Grain yield = Ears yield in kg fed^{-1} X shelling percentage.

2- Total N% in grain.

3- Nitrogen uptake (NUP) in grains kg fed^{-1} = Grain yield kg fed^{-1} X total N% in grain.

4- Nitrogen use efficiency (NUE) (kg grain kg^{-1} N applied) was calculated according to **Craswell and Godwin (1984)** as follows:

$$\text{NUE} = \frac{\text{Grains yield/fed fertilized plot - grains yield/fed control}}{\text{nitrogen applied}}$$

5- Apparent nitrogen recovery (NRC) (g N in grain kg^{-1} N applied) was calculated according to **Craswell and Godwin (1984)** as follows:

$$NRC = \frac{\text{NUP in grain fertilized plot} - \text{NUP in grain control}}{\text{nitrogen applied}}$$

Statistical analysis

The collected data were statistically analyzed according to the method described by **Gomez and Gomez (1984),** the means and interaction compared according to the least significant difference (L.S.D.) at 5%.

RESULTS AND DISCUSSION

1- Grain Yield in kg feddan^{-1} :

Results for the effect of maize genotypes, N fertilizer rates (mineral & organic) and their interactions in 2005 and 2006 seasons on grain yield feddan^{-1} of maize are presented in **Table (3).**

1.1. Effect of genotypes.

The results in **Table (3)** showed that the 6 evaluated genotypes significantly varied in their yield performance in both seasons. It was evident that the general trend of the results indicated that the 2 single crosses were superior in grain yield and ranked the first and second positions without significant difference between then in both seasons. D.C. Dahab ranked the third position and was significantly superior compared with T.W.C. 232 in both seasons. The composite variety Giza 2 followed the 4 hybrids ranking the fifth position in both seasons and outyielded significantly the open – pollinated (local) variety Nab El-Gamal which was the last variety and significantly inferior compared with the 5 other genotypes.

It could be concluded that single crosses were superior in grain productivity, followed by double and three way crosses, then the composite variety Giza 2, and then Nab El-Gamal. The results were nearly identical in both seasons, and S.C. 3084 out yielded S.C. 30k8, D.C. Dahab, T.W.C.323, Giza 2 and Nab El-Gamal by 0.32, 4.03, 21.16, 47.11 and 80.74% respectively, in the first season.

In the second season, S.C. 30k8 outyielded S.C. 3084, D.C. Dahab, T.W.C.323, Giza 2 and Nab El-Gamal by 1.61, 3.86, 15.96, 39.92 and 64.59%, respectively.

The present results are a good and clear evidence for the superiority of single crosses and indicate the role of selecting the best maize varieties in increasing grain production of maize.

The superiority of growing hybrid maize varieties was also indicated by several investigators **(Shafshak; *et al.*, 1994; Mabrouk and Aly, 1998; El-Bana, 2001; Oraby *et al.*, 2003; Ahmed and Mekki, 2005; Atta, 2007; Abd El-Maksoud and Sarhan, 2008 and Hassan *et al.*, 2008).**

1.2. Effect of N rates.

Grain yield feddan^{-1} of maize as affected by N rates is presented in **Table (3)**. Grain yield was significantly increased by increasing N rates up to 80 kg N+40 (t/FYM) fed^{-1} in 2005 and 2006 seasons. In the first season, the grain yield increased by 70.66, 138.99, 191.14, 73.25, 151.62 and 206.20% when maize plants received 60 kg N, 90 kg N, 120 kg N, 40 kg N+20 (t/FYM), 60 kg N+30 (t/FYM) and 80 kg N+40 (t/FYM) fed^{-1}, respectively over the control treatment. Similar results were noticed in the second season, and the application of the same N rate significantly increased grain yield by 61.27, 118.26, 169.31, 65.88, 130.16 and 177.56%, respectively. It is clear from **Table (3)** that the effect of N on grain yield feddan^{-1} was evident in both seasons. In the first and second seasons, all differences in grain yield among N levels were significant.

It could be concluded that N is an essential element needed for producing higher grain yield. N rats of 80 kg N+40 (t/FYM) fed^{-1} or 120 kg N/fed could be recommended for producing the best grain yield.

It is worthy to note that combining mineral and organic nitrogen by means of applying mineral fertilizer and FYM was more effective in increasing grain yield than single application of mineral fertilizer. The effect of FYM as a soil amendment as well as the inclusion of different macro and microelements in the manure contributed for the good performance of the manure.

Similar results were also obtained by **Mohamed and Al-Aref (1999); Allam *et al.* (2001); Suleiman (2004); Derby *et al.*, (2005); Bahr *et al.*, (2006); Ibrahim and Kandil (2007) and El-Mekser and Seiam (2008).**

1.3. Interaction effect.

Grain yield feddan^{-1} of maize was significantly affected by the interaction between genotypes and N rates (mineral & organic) in 2005 and 2006 seasons as shown in **Table (3).** The heaviest grain yield feddan^{-1} in the two seasons (4466.7 and 4191.5 kg) was obtained by S.C.30k8 when received 80 kg N+40 (t/FYM) fedd^{-1}. Whereas, the lowest values of grain yield feddan^{-1} (702.3 and 854.5 kg) were obtained by Nab El-Gamal cultivar under zero N in the two seasons. These results agree with those obtained by **Abu-Grab *et al* (1997); El-Sheikh (1998); El-Bana (2001); Oraby *et al* (2003); El-Aref *et al* (2004) and El-Mekser and Seiam (2008).**

Table (3): Grain yield (kg fed$_{-1}$) of maize as affected by genotypes, N fertilizer rates and their interactions in 2005 and 2006 seasons.

N Fertilizer rates	2005 season						
	Genotypes						
	S.C. 3084	S.C. 30K8	D.C. Dahab	T.W. C. 323	Giza 2	Nab El-Gamal	Means
Zero	1402.6	1268.1	1286.4	1240.6	1136.9	702.3	**1172.8**
60 kg N/fed	2289.7	2322.8	2208.6	2070.7	1756.3	1361.8	**2001.6**
90 kg N/fed	3679.4	3334.9	340.2	2545.6	1999.4	1857.9	**2802.9**
120 kg N/fed	4005.1	4224.2	3547.7	3484.8	2837.2	2388.3	**3414.5**
40 kg N/fed+20(t/FYM)	2227.9	2603.0	2222.4	2101.1	1787.9	1249.3	**2031.9**
60 kg N/fed+30(t/FYM)	3848.0	3389.4	3480.3	2837.9	2187.0	1963.9	**2951.1**
80 kg N/fed+40(t/FYM)	4226.0	4466.7	3738.7	3612.7	3031.7	2471.0	**3591.2**
Means	**3097.0**	**3087.0**	**2840.6**	**2556.2**	**2105.2**	**1713.5**	**2566.6**
N Fertilizer rates	**2006 season**						
	Genotypes						
	S.C. 3084	**S.C. 30K8**	**D.C. Dahab**	**T.W. C. 323**	**Giza 2**	**Nab El-Gamal**	**Means**
Zero	1559.2	1196.0	1554.8	1384.6	1073.1	854.5	**1270.4**
60 kg N/fed	2332.2	2399.5	2154.5	2153.6	1872.7	1380.6	**2048.9**
90 kg N/fed	3224.9	3243.0	3475.4	2655.4	2111.2	1927.4	**2772.9**
120 kg N/fed	3806.5	4159.9	3681.7	3448.5	2970.1	2462.1	**3421.4**
40 kg N/fed+20(t/FYM)	2439.5	2445.9	2194.3	2168.5	1913.2	1783.3	**2107.4**
60 kg N/fed+30(t/FYM)	3257.9	3478.7	3508.1	2833.6	2204.1	2261.9	**2924.0**
80 kg N/fed+40(t/FYM)	4159.9	4191.5	3761.1	3563.8	3022.6	2458.2	**3526.2**
Means	**2968.6**	**3016.3**	**2904.3**	**2601.1**	**2166.7**	**1832.6**	**2581.6**

First season (2005)	**Second season (2006)**
L.S.D. at 5% Genotypes = 73.2	L.S.D. at 5% Genotypes = 63.9
L.S.D. at 5% Fertilizer = 60.9	L.S.D. at 5% Fertilizer = 50.1
L.S.D. at 5% G.XF. = 149.1	L.S.D. at 5% G.XF. = 122.8

2- Nitrogen content in grain:

Results for the effect of maize genotypes, N fertilizer rates (mineral & organic) and their interactions in 2005 and 2006 seasons on N content in grain are presented in **Table (4).**

Table (4): Total nitrogen % in maize grain as affected by genotypes, N fertilizer rates and their interactions in 2005 and 2006 seasons.

N Fertilizer rates	2005 season						
	Genotypes						
	S.C. 3084	S.C. 30K8	D.C. Dahab	T.W. C. 323	Giza 2	Nab El-Gamal	Means
Zero	1.37	1.40	1.50	1.43	1.50	1.60	**1.46**
60 kg N/fed	1.46	1.44	1.60	1.50	1.57	1.71	**1.54**
90 kg N/fed	1.49	1.45	1.65	1.55	1.62	1.79	**1.59**
120 kg N/fed	1.81	1.50	1.82	1.65	1.71	1.91	**1.73**
40 kg N/fed+20(t/FYM)	1.73	1.46	1.61	1.55	1.63	1.63	**1.60**
60 kg N/fed+30(t/FYM)	1.77	1.50	1.60	1.60	1.65	1.65	**1.63**
80 kg N/fed+40(t/FYM)	1.82	1.64	1.74	1.64	1.78	1.90	**1.75**
Means	**1.63**	**1.48**	**1.64**	**1.56**	**1.64**	**1.74**	**1.62**
N Fertilizer rates	**2006 season**						
	Genotypes						
	S.C. 3084	**S.C. 30K8**	**D.C. Dahab**	**T.W. C. 323**	**Giza 2**	**Nab El-Gamal**	**Means**
Zero	1.52	1.53	1.67	1.62	1.62	1.55	**1.58**
60 kg N/fed	1.55	1.59	1.70	1.65	1.65	1.70	**1.64**
90 kg N/fed	1.58	1.61	1.72	1.68	1.71	1.72	**1.67**
120 kg N/fed	1.73	1.68	1.99	1.74	1.90	1.77	**1.80**
40 kg N/fed+20(t/FYM)	1.63	1.65	1.69	1.68	1.71	1.73	**1.68**
60 kg N/fed+30(t/FYM)	1.68	1.68	1.77	1.70	1.74	1.76	**1.72**
80 kg N/fed+40(t/FYM)	1.72	1.72	1.83	1.78	1.80	1.78	**1.77**
Means	**1.63**	**1.63**	**1.77**	**1.69**	**1.73**	**1.71**	**1.69**

First season (2005)	**Second season (2006)**
L.S.D. at 5% Genotypes = 0.10	L.S.D. at 5% Genotypes = 0.07
L.S.D. at 5% Fertilizer = 0.04	L.S.D. at 5% Fertilizer = 0.03
L.S.D. at 5% G.XF. = 0.10	L.S.D. at 5% G.XF. = 0.06

2.1. Effect of genotypes.

Results in Table (4) showed significant differences in total N% in grain among the 6 genotypes in both seasons.

In 2005 season, the local open-pollinated variety Nab El-Gamal contained significantly greater N% in grain than the other 5 genotypes, then 4 genotypes namely, Giza 2, D.C. Dahab, S.C. 3084 and T.W.C. 323 followed as one group and the lowest genotypes was S.C 30k8 with 1.48% N in grain.

In 2006 season, the highest N% in grain was 1.77% which was recorded by D.C. Dahab, and the lowest content was 1.63% recorded by the two single crosses and the rest 3 genotypes, namely, Giza 2, (1.73%), Nab El-Gamal (1.71%) and T.W.C. 323 (1.69%) were in – between as one group. It could be concluded that the 2 open-pollinated varieties as well as the yellow maize D.C. Dahab were superior in N% in grain. The differences in this trait are mainly due to the genetically differences among the genotypes. Similar results were obtained by **Shafshak *et al* (1994); Abu-Grab *et al* (1997) and Khalil (2001).**

2.2. Effect of N rates.

Results presented in Table (4) clearly show that the increase in N rates caused significant increase in N content in maize grains during 2005 and 2006 seasons. In the first season, applying N at 60 kg N, 90 kg N, 120 kg N, 40 kg N+20 (t/FYM). 60 kg N+40 (t/FYM), 80 kg N+40 (t/FYM) fed^{-1} caused significant increase in nitrogen content in maize grains over the control treatment by 0.08, 0.13, 0.27, 0.14, 0.17 and 0.29% respectively when compared with the control treatment. In the second season, the respective increases were 0.06, 0.09 0.22, 0.10, 0.14 and 0.19%. The differences in the N content in maize grain due to applying 120 kg N fed^{-1} and 80 kg N+40 (t/FYM) fed^{-1} as well as 90 kg N, 40 kg N+20 (t/FYM) and 60 kg N+30 (t/FYM) fed^{-1} were not significant in both seasons.

It could be concluded that the increase N supply improved the grain quality of the end product expressed as nitrogen content in maize grains. Theses results are in agreement with that obtained by **Shafshak *et al.* (1994);Abu-Grab *et al.* (1997); Mohamed and El-Aref (1999) and Suleiman (2004).**

2.3. Interaction effect.

N content in maize grains was significantly affected by the interaction between genotypes and N rates (mineral & organic) in both seasons **Table (4).**

The highest N content (1.91 and 1.99%) was obtained by Nab El-Gamal and D.C. Dahab when received 120 kg N fed^{-1} in the first and second seasons, respectively, whereas, the lowest values of N content (1.37 and 1.52%) were obtained from S.C.3084 under zero N in both seasons.

3- Nitrogen uptake (kg fed^{-1}) in maize grain:

Results for the effect of maize genotypes, N fertilizer rates (mineral & organic) and their interactions in 2005 and 2006 seasons on N uptake fed^{-1} in maize grain are presented in **Table (5).**

3.1. Effect of genotypes.

The results presented in Table (5) showed that the 6 genotypes were significantly different in N uptake in maize grain in both seasons.

In 2005 season, the genotypes could be arranged in regard to N uptake in grain in a descending order as follows: S.C.3084, D.C. Dahab, S.C.30k8, T.W.C.323, Giza 2 and Nab El-Gamal, all differences among these 6 genotypes were significant except that between S.C.30k8 and D.C. Dahab.

In 2006, slight differences were observed but the 2 single crosses as well as D.C. Dahab were superior than T.W.C.323 and the 2 open pollinated varieties. The arrangement of the 6 genotypes in the second season could be made as follows: D.C. Dahab, S.C.30k8, S.C.3084, T.W.C.323, Giza 2 and Nab El-Gamal, all differences in N uptake in grain were significant except that between D.C. Dahab and S.C.30k8 as shown in the first season also. It could be concluded that 3 genotypes (the 2 single crosses as well as D.C. Dahab) were superior in N uptake in grain in both seasons, one genotype (T.W.C.323) was in – between, and the 2 open-pollinated varieties were inferior in this trait.

The superiority of the single crosses as well as the D.C. Dahab is mainly due to higher response to N. The results here indicate a clear argument for the advantages of hybrid maize compared with the open pollinated variation. Similar results were obtained by **Abu-Grab *et al* (1997).**

3.2. Effect of N rates.

N uptake in maize grain as affected by N fertilizer rates is presented in Table (5). N uptake significantly increased by increasing N fertilizer rates up to 80 kg N+40 (t/FYM) fed^{-1} during 2005 and 2006 seasons. In the first season, the N uptake increased by 80.07, 158.67, 244.09, 90.12, 182.24 and 267.07% when maize plants received 60 kg N, 90 kg N, 120 kg N, 40 kg N+20 (t/FYM), 60 kg N+30 (t/FYM) and 80 kg N+40 (t/FYM) fed^{-1} respectively over the control. Similar results were noticed in the second season, and N uptake increased by 65.93, 128.74, 204.76, 75.17, 149.20 and 208.63% respectively.

It could be concluded that the nitrogen uptake of maize significantly increased with the increase in nitrogen level up to 80 kg N+ 40 (t/FYM) fed^{-1}. The increase in N uptake due to increasing N fertilizer rates is attributed to the increase in grain yield and N content in maize grain.

It is worthy to note that the application of mineral N in combination with organic N by means of FYM was more effective an increased N uptake considerably. For example applying 60 kg N/fed as mineral N increased N uptake by 30.82% in the first season and 33.60% over the control in the second one. When this N rate was applied as 40 kg N/fed as mineral 20 kg N as (FYM) the increase in grain yield were 32.51 and 35.40% in the first and second seasons, respectively. The increase in grain yield may be due to the inclusion of many macro and microelements in the manure.

Table(5): Nitrogen uptake (kg fed^{-1}) in maize grain as affected by genotypes, N fertilizer rates and their interactions in 2005 and 2006 seasons.

N Fertilizer rates	2005 season						
	Genotypes						
	S.C. 3084	S.C. 30K8	D.C. Dahab	T.W. C. 323	Giza 2	Nab El-Gamal	Means
Zero	19.22	17.07	19.19	17.73	17.00	11.20	**17.01**
60 kg N/fed	33.41	33.33	35.36	31.06	27.49	23.15	**30.63**
90 kg N/fed	54.83	48.21	56.11	39.32	32.40	33.12	**44.00**
120 kg N/fed	72.21	63.13	64.52	57.31	48.52	45.50	**58.53**
40 kg N/fed+20(t/FYM)	38.40	37.88	35.79	32.61	29.08	20.30	**32.43**
60 kg N/fed+30(t/FYM)	67.82	50.71	55.68	45.32	36.09	32.42	**48.01**
80 kg N/fed+40(t/FYM)	76.82	73.03	64.83	59.04	53.98	46.93	**62.44**
Means	**51.82**	**46.28**	**47.35**	**40.34**	**34.93**	**30.38**	**41.85**
N Fertilizer rates	**2006 season**						
	Genotypes						
	S.C. 3084	**S.C. 30K8**	**D.C. Dahab**	**T.W. C. 323**	**Giza 2**	**Nab El-Gamal**	**Means**
Zero	23.75	18.30	25.94	22.36	17.33	13.17	**20.14**
60 kg N/fed	35.98	38.18	36.61	35.53	30.80	23.40	**33.42**
90 kg N/fed	50.74	52.20	59.77	44.61	35.97	33.15	**46.07**
120 kg N/fed	65.84	69.69	73.06	60.00	56.35	43.46	**61.38**
40 kg N/fed+20(t/FYM)	39.66	40.24	37.07	36.32	32.71	25.66	**35.28**
60 kg N/fed+30(t/FYM)	54.74	58.23	62.07	48.16	38.22	39.71	**50.19**
80 kg N/fed+40(t/FYM)	71.32	71.90	68.62	63.24	54.27	43.63	**62.16**
Means	**48.86**	**49.82**	**51.88**	**44.32**	**37.94**	**31.74**	**44.09**

First season (2005)
L.S.D. at 5% Genotypes = 3.36
L.S.D. at 5% Fertilizer = 1.72
L.S.D. at 5% G.XF. = 4.21

Second season (2006)
L.S.D. at 5% Genotypes = 1.90
L.S.D. at 5% Fertilizer = 1.02
L.S.D. at 5% G.XF. = 2.49

Theses results are in agreement with those obtained by **Abdullah (1995); Abu-Grab *et al.* (1997); El-Sheikh (1999); Fatma Nofal (1999); Al-Kaisi and Yin (2003); Suleiman (2004); El-Gezawy (2005) and Bahr *et al.* (2006).**

3.3. Interaction effect.

Data for N uptake in maize grain in kg feddan^{-1} of maize in **Table (5)** indicate that the interaction between maize genotypes and N fertilizer rates was significant in the first and second seasons. The highest value of N uptake (76.82 and 73.06 kg) was produced from S.C. 3084 and D.C. Dahab under 80 kg N+40 (t/FYM) fed^{-1} and 120 kg N fed^{-1} in the first and second seasons, respectively, whereas, Nab El-Gamal cultivar under zero N fed^{-1} gave the lowest N uptake (11.20 and 13.17 kg) in the first and second seasons, respectively.

4- Nitrogen use efficiency (NUE):

Results in **Table (6)** present nitrogen use efficiency (NUE) as affected by maize genotypes, N fertilizer rates (mineral & organic) and their interactions in 2005 and 2006 seasons.

4.1. Effects of genotypes.

The six evaluated genotypes showed marked differences in their performance concerning NUE in both seasons as indicated in **Table (6).** The efficiency of the genotypes showed similar trend in both seasons. The 6 genotypes could be arranged in a descending order in regard to their NUE in the first season as follows: S.C.30k8 (22.49), S.C.3084 (21.04), D.C. Dahab (19.83 kg),T.W.C.323 (16.48 kg), Nab El-Gamal (12.63 kg) and Giza 2 (12.06 kg). All differences among the 6 genotypes were significant except that between the two open-pollinated varieties.

In the second season, about the same arrangement was observed, and the 6 genotypes could be arranged in a descending order as follows: S.C.30k8 (23.11 kg) S.C.3084 (17.56), D.C. Dahab (16.64 kg), T.W.C.323 (15.25 kg) Giza 2 (13.92 kg) and Nab El-Gamal (12.26 kg). All differences were significant in NUE except those between S.C.3084 and D.C. Dahab, D.C. Dahab and T.W.C.323, T.W.C.323 and Giza 2, as well as between Giza 2 and Nab El-Gamal. It could be concluded that the 2 single crosses were superior varieties in NUE, followed by D.C. Dahab, T.W.C.323 and the 2 open-pollinated varieties were inferior in this character.

It is clear that S.C.30k8 as the leading variety surpassed the local open-pollinated variety by 81.63 and 88.50% in the first and second season, respectively. These marked increases in NUE could be an argument for the advantages of growing single as well as three way and double crosses of maize.

Similar results were also reported by **Shafshak *et al* (1994).**

4.2. Effect of N rates.

Results in **Table (6)** showed that NUE was significantly affected by N application rate. In both seasons, the application of mineral + organic N recorded higher values of NUE compared with single application of mineral N. It was also observed that the increase in N level from 60 to 90 and 120 kg N/fed increased NUE but without significant differences between 90 and 120 kg N/fed levels.

It is worth mentioning here the use of FYM as a source of organic N significantly raised NUE in both season. For example the application of 80 kg mineral N+40 kg organic N/fed significantly increased NUE by 8.62 and 5.58% in the first and second seasons, respectively, compared with single application of 120 kg/fed mineral N. Also, applying 60kg mineral N+30 kg organic N/fed caused an increase NUE of 8.61 and 10.07% in the first and second seasons, respectively, compared with the single application of 90 kg mineral N/fed.

It could be concluded, that FYM as a source of organic N can play a good role in raising NUE. The manure contains many macro and micro elements in addition to organic matter, and improve physical and biological characters of the soil. Therefore, the increase in NUE of organic N is quite expected.

The present results recommend the use of the highest level of N in combination of 80kg mineral N and 40t FYM, according to the current prices for N and grain maize. One kg of grain maize = one E.L. and one kg of mineral N = 3.43 E.L. (according to the prices of the Agric. Credit and Dev. Bank)[*]

The FYM is commonly available in small as well as large size farms in Egypt and is usually used from several field crops, particularly maize. It is a common practice to use FYM of the farm and the costs are mainly those of transportation from the staple to the field. Also the residual effect of FYM will extend for at least 2 years.

According to the Annual Agriculture Statistical Year Book, Vol. 2, “Summer and Nile Crops 2005, one fed of summer maize needs on the average 100 E.L. for the costs FYM. Taking this value in

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(*) (Personal Communication).

consideration (one kg of organic N costs 2.5 E.L.) consequently, it is self-explanatory that the highest level of N (as 80 kg mineral N + 40 kg organic N) is the optimum N level under the conditions of the experiment. Similar results were obtained by **Shafshak *et al* (1994),** who reported that NUE markedly increased due the increase in N level.

The results reported by **Fatma Nofal (1999)** showed that NUE decreased with increasing N level from 45.90 and 135 kg N/fed.

4.3. Interaction effect.

NUE was significantly affected by the interaction between maize genotypes and N fertilizer rates in both seasons, as shown in **Table (6).** The highest values of NUE were 27.17 and 25.36 which were obtained by S.C. 3084 and S.C.30k8 under 60 kg N+30 (t/FYM) fed^{-1} in the first and second seasons, respectively. Whereas, Nab El-Gamal under zero N fed^{-1} gave the lowest value of NUE being 9.12 and 8.77 in the first and second seasons, respectively. Similar results were obtained by **El-Sheikh (1998) and El-Mekser and Seiam (2008).**

Table (6): Nitrogen use efficiency (kg grain kg^{-1} N) of maize as affected by genotypes, N fertilizer rates and their interactions in 2005 and 2006 seasons.

N Fertilizer rates	2005 season						
	Genotypes						
	S.C. 3084	S.C. 30K8	D.C. Dahab	T.W.C. 323	Giza 2	Nab El-Gamal	Means
Zero	---	---	---	---	---	---	---
60 kg N/fed	14.78	17.58	15.37	13.84	10.32	10.99	**13.81**
90 kg N/fed	25.30	22.96	23.49	14.50	9.58	12.84	**18.11**
120 kg N/fed	21.69	24.63	18.84	18.70	14.17	14.05	**18.68**
40 kg N/fed+20(t/FYM)	13.75	22.25	15.60	14.34	10.85	9.12	**14.32**
60 kg N/fed+30(t/FYM)	27.17	23.57	24.38	17.75	11.67	14.02	**19.76**
80 kg N/fed+40(t/FYM)	23.53	26.65	21.27	19.77	15.79	14.74	**20.29**
Means	**21.04**	**22.94**	**19.83**	**16.48**	**12.06**	**12.63**	**17.50**
N Fertilizer rates	**2006 season**						
	Genotypes						
	S.C. 3084	**S.C. 30K8**	**D.C. Dahab**	**T.W.C. 323**	**Giza 2**	**Nab El-Gamal**	**Means**
Zero	---	---	---	---	---	---	---
60 kg N/fed	12.88	20.06	10.00	12.82	13.33	8.77	**12.98**
90 kg N/fed	18.51	22.74	21.34	14.12	11.53	11.92	**16.69**
120 kg N/fed	18.73	24.70	17.72	17.20	15.81	13.40	**17.93**
40 kg N/fed+20(t/FYM)	14.67	20.83	10.66	13.07	14.00	10.48	**13.95**
60 kg N/fed+30(t/FYM)	18.87	25.36	21.70	16.10	12.57	15.64	**18.37**
80 kg N/fed+40(t/FYM)	21.67	24.96	18.39	18.16	16.25	13.36	**18.80**
Means	**17.56**	**23.11**	**16.64**	**15.25**	**13.92**	**12.26**	**16.46**

First season (2005)
L.S.D. at 5% Genotypes = 1.25
L.S.D. at 5% Fertilizer = 0.79
L.S.D. at 5% G.XF. = 1.94

Second season (2006)
L.S.D. at 5% Genotypes = 1.89
L.S.D. at 5% Fertilizer = 0.66
L.S.D. at 5% G.XF. = 1.61

5- Apparent nitrogen recovery%:

Results in Table (6) present means of apparent means of apparent nitrogen recovery % as affected by maize genotypes, N fertilizer rates (mineral & organic) and their interaction in 2005 and 2006 seasons.

5.1. Effects of genotypes.

The results in **Table (7)** showed great differences in N recovery % among the 6 maize genotypes. In 2005 seasons, S.C.3084 significantly surpassed the other 5 genotypes with a N recovery % of 40.23%. This leading S.C. was followed by S.C.30k8 (35.71%) and D.C. Dahal (35.33%), then T.W.C.323 was followed ranking the fourth position with N recovery % of 28.17%, the 2 open-pollinated varieties Nab El-Gamal (23.56%) and Giza 2 (22.17%) recorded the lowest values.

In 2006 season, some differences were observed in the performance of the genotypes, where S.C.30k8 recorded the highest N recovery % being 39.88% and significantly surpassed the other 5 genotypes, then D.C. Dahab (31.48%) and S.C.3084 (31.01%) were followed and were significantly superior to T.W.C.323 (27.34%) Giza 2 (25.87%) and Nab El-Gamal (23.36%).

The results showed clearly the superiority of the single crosses as well as the D.C. Dahab in N recovery % indicating greater response and better use of the applied N. Consequently, higher yield potentiality should be obtained by growing hybrid maize. Similar results were also reported by **Shafshak *et al.* (1994) and Fatma Nofal (1999).**

Table (7): Apparent nitrogen recovery % of maize as affected by genotypes, N fertilizer rates and their interactions in 2005 and 2006 seasons.

N Fertilizer rates	2005 season						
	Genotypes						
	S.C. 3084	S.C. 30K8	D.C. Dahab	T.W. C. 323	Giza 2	Nab El-Gamal	Means
Zero	---	---	---	---	---	---	---
60 kg N/fed	23.65	26.05	26.94	22.22	17.49	19.92	**22.71**
90 kg N/fed	39.57	33.90	41.02	23.99	17.11	24.35	**29.99**
120 kg N/fed	44.16	37.86	37.78	32.97	26.27	28.58	**34.60**
40 kg N/fed+20(t/FYM)	31.98	33.63	27.66	24.79	20.10	15.17	**25.55**
60 kg N/fed+30(t/FYM)	54.00	36.68	40.54	30.65	21.21	23.58	**34.44**
80 kg N/fed+40(t/FYM)	48.00	46.1	38.03	34.43	30.82	29.77	**37.86**
Means	**40.23**	**35.71**	**35.33**	**28.17**	**22.17**	**23.56**	**30.86**
N Fertilizer rates	**2006 season**						
	Genotypes						
	S.C. 3084	**S.C. 30K8**	**D.C. Dahab**	**T.W. C. 323**	**Giza 2**	**Nab El-Gamal**	**Means**
Zero	---	---	---	---	---	---	---
60 kg N/fed	20.40	33.14	17.79	21.95	22.45	17.05	**22.13**
90 kg N/fed	29.99	37.66	37.58	24.72	20.71	22.20	**28.81**
120 kg N/fed	35.08	42.83	39.27	31.37	32.43	25.24	**34.37**
40 kg N/fed+20(t/FYM)	26.25	36.58	18.55	23.27	25.64	20.81	**25.23**
60 kg N/fed+30(t/FYM)	34.43	44.41	40.14	28.66	23.21	29.49	**33.39**
80 kg N/fed+40(t/FYM)	39.65	44.67	35.57	34.07	30.78	25.39	**35.02**
Means	**31.01**	**39.88**	**31.48**	**27.34**	**25.87**	**23.36**	**29.82**

First season (2005)
L.S.D. at 5% Genotypes = 4.65

Second season (2006)
L.S.D. at 5% Genotypes = 2.70

L.S.D. at 5% Fertilizer = 1.80 L.S.D. at 5% Fertilizer = 1.92
L.S.D. at 5% G.XF. = 4.41 L.S.D. at 5% G.XF. = 3.17

5.2. Effect of rates.

Results in **Table (7)** show that N recovery % was markedly affected by N rates in the first and second seasons. The highest value of N recovery % was recorded with 80 kg N+40 (t/FYM) fed^{-1} being 37.86 and 35.02% in the first and second seasons, respectively, whereas, the lowest value of N recovery % was recorded from application 60 kg mineral N fed^{-1} being 22.71 and 22.13% in the first and second seasons, respectively. The differences between the 60 kg N/fed+30 (t/FYM) and 120 kg N fed^{-1} was not significant in the first season, also, the differences between the 120 kg N and 80 kg N+40 (t/FYM) fed^{-1} was not significant in the second season.

The results indicated clearly that combining mineral N with organic N raised significantly N recovery % in both seasons.

For example, applying 40 kg mineral N+20 kg organic N/fed, significantly increased N recovery % by 2.84 and 3.1% in the first and second seasons, respectively compared with the application of 60 kg mineral N/fed.

Also applying 60 kg mineral N+30 kg organic N/fed, resulted in an increase in N recovery % of 4.45 and 4.58% in the first and second seasons, respectively compared with the application of 90 kg mineral N/fed.

The increase of applying 80 kg mineral N+40 kg organic N/fed versus 120 kg mineral N/fed reached 3.26 and 0.65%, in the two successive seasons. It could be concluded that the application of a mixture of both mineral and organic N resulted in an increase in N recovery %. The role of FYM as a soil amendment is clearly demonstrated. The results reported by **Shafshak *et al.* (1994)** showed that N recovery % increased by increasing N level up to 130 kg N/fed. On the other hand, **Fatma Nofal (1999)** reported that raising N level from 45 to 135 kg N/fed reduced N recovery %.

5.3. Interaction effect.

N recovery % was significantly affected by the interaction between maize genotypes and N fertilizer rates in both seasons, as shown in **Table (7).** The highest value of N recovery % was 54.00% and 44.67% which was obtained by S.C.3084 and S.C.30k8 under 60 kg N+ 30 (t/FYM) fed^{-1} and 80 kg N+40 (t/FYM) fed^{-1} in the first and second seasons, respectively. Whereas, Nab El-Gamal under 40 kg N+20 (t/FYM) and 60 kg N fed^{-1} gave the lowest value of N recovery, being 15.17% and 17.05% in the first and second seasons, respectively.

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الملخص العربي

كفاءة استخدام النيتروجين المعدني والعضوي
في تسميد ستة تراكيب وراثية للذرة الشامية

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أجريت تجارب حقلية بمركز البحوث والتجارب الزراعية بكلية زراعة مشتهر بمحافظة القليوبية خلال عامي ٢٠٠٥، ٢٠٠٦ لدراسة كفاءة أربعة هجن من الذرة الشامية مقارنة بصنف تركيبي وآخر مفتوح التلقيح لاستخدام الأزوت المعدني والعضوي بمعدلات مختلفة. وكانت الأصناف المختبرة تشمل: هجين فردي (أصفر) ٣٠٨٤، هجين فردي ٣٠ك٨، والهجين الثلاثي جيزة ٣٢٣ والهجين الزوجي دهب (أصفر الحبوب) والصنف التركيبي جيزة ٢ والصنف البلدي ناب الجمل الذي يزرع كصنف محلي. وشملت مستويات التسميد: معاملة الكنترول (بدون تسميد)، ٦٠، ٩٠، ١٢٠كجم نيتروجين من السماد المعدني (يوريا) و٤٠كجم نيتروجين معدني+٢٠طن/فدان سماد بلدي، ٦٠كجم نيتروجين معدني+٣٠طن/فدان سماد بلدي، ٨٠كجم نيتروجين معدني+٤٠طن سماد بلدي/فدان.

وجمعت بيانات عن محصول الحبوب للفدان ومحتوى الحبوب من النيتروجين وكمية الأزوت الممتص بالحبوب بالفدان، وكفاءة استخدام النيتروجين والنسبة المئوية للأزوت المستفاد به.

وأوضحت النتائج تفوق الهجن الفردية في محصول الحبوب وفي كمية الأزوت المستفاد به في الحبوب وفي كفاءة استخدام الأزوت، وقد أظهر الهجين الزوجي دهب كفاءة عالية في الإنتاجية وفي كفاءة استخدام النيتروجين، وتلي هذه الأصناف الثلاثة الهجين الثلاثي ٢٣٢، بينما كان محصول الصنف التركيبي منخفضا وكان أقل الأصناف إنتاجية وكفاءة في استخدام النيتروجين الصنف البلدي ناب الجمل.

وقد استجاب محصول الحبوب لكل الأصناف للتسميد النيتروجيني المعدني والعضوي، وكانت أفضل المعاملات هي مستوى ٨٠ك نيتروجين معدني+٤٠كجم نيتروجين عضوي للفدان.

وحققت هذه المعاملة أعلى مستويات امتصاص النيتروجين وأعلى معدل كفاءة استخدام للنيتروجين.

ويمكن الاستنتاج بالأهمية القصوى لزراعة هجن الذرة الفردية والجمع بين التسميد العضوي والمعدني بالمعدل الأعلى المستخدم.