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THE EFFECT OF NITROGEN SOURCE AND POPULATION DENSITY ON CORN PRODUCTION
A- GROWTH ANALYSIS AND PARAMETERS

BY

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ABSTRACT

This investigation was carried out during 1999 and 2000 seasons, at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University at Giza, Egypt to study, the effect of N fertilization treatments (mineral as urea (46.5% N) with farmyard manure (FYM) as cattle manure) and plant population density (20000, 25000 and 30000 plant/fed.) on growth analysis and parameters of maize Single cross 10.

The results showed that, in general, the most studied growth characters increased by raising the quantity of N from urea. However, the differences between 120 kg N/fed. as urea alone and 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure were insignificant in most characters. Also, increasing plant population density from 20000 to 30000 plant/fed. significantly increased plant height, time of 50% tasseling and silking, LAI, CGR, and RGR. However, dry weight and leaf area per plant deacreased The interaction between N combinations and plant population density had a significant effect on all studied characters.

INTRODUCTION

Maize (*Zea mays* L.) is a major cereal crop in Egypt and all over the world. Factors that determine maize production are numerous, among which nitrogen fertilization and plant population density are of great importance. The optimum plant population plays a great role in increasing maize productivity. Several forms of mineral fertilizers as well as organic nitrogen manure, especially farmyard manure (FYM) and chicken manure are commonly used in Egypt.

Increasing plant population density from 16000 to 30000 plant/fed. significantly increased number of days from planting date to 50% tasseling and silking (Al-Shebani, 1998 and Said and Gabr, 1999). On the contrary, Abdel-Aal *et al.* (1997) found that number of days from sowing date to 50% tasseling and silking was decreased by decreasing plant population density from 30000 to 17000 plant/fed. While, Khalil *et al.* (1999) found that decreasing plant population density from 30000 to 17500 plant/fed. significantly increased the number of days to 50% silking.

Several workers found that maize plant height was significantly increased with application of either 10 m^3 FYM/fed. (Khalil, 1992) or up to 40 m^3 FYM/fed. (Faisal and Shalaby, 1998 and Fatma Nofal 1999). Plant height was significantly highest for application of 120 kg N + 60 kg P_2O_5 + 60 kg K/ha. with 4.5 tons/ha. poultry manure (Madhavi *et al.*, 1995) or with 16.82 tons/ha. fresh chicken manure (Tuivavalagi and Silva 1996).

In respect to stem diameter, Khalil (1992) reported that such character was not significant affected by application of 10 to 20 m^3 FYM/fed.

Some investigators found that dry matter was significantly increased with application of 60 kg N as urea with 30 tons organic matter/fed. (Sakr *et al.*, 1992) or with using 120 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha. with

4.5 tons FYM/ha. (Madhavi *et al.*, 1995). However, Ren-Shih Chung *et al.* (2000) showed that compost with an adequate amount of chemical N fertilizer could reach a high dry matter yield and N accumulation even than the conventional chemical N fertilizer treatment. However, Khalil (1992) reported that number of green leaves per plant was not significantly affected by FYM application, but Faisal and Shalaby (1998) found that increasing organic manure rates from 0 to 40 m^3/fed significantly increased number of green leaves/plant.

Leaf area per plant (LA), significantly increased with addition of 16.82 tons/ha. fresh chicken manure (Tuivavalagi and Silva, 1996), also, by application 40 m^3 FYM/fed. as mentioned by (Faisal and Shalaby, 1998 and Fatma, Nofal 1999).

Some workers have emphasized the importance of organic manure for improving soil fertility. Accordingly, it was very important to evaluate the two main kinds of nitrogen fertilizer upon corn plant growth i.e. parameters and analysis.

Consequently, the present investigation aimed to study the effect of organic and mineral fertilization on growth anlysis and parameters.

MATERIALS AND METHODS

The experiments were carried out during 1999 and 2000 seasons at Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, at Giza, Egypt to study the effect of N treatments including specific combination of both mineral sources (urea 46.5% N) and cattle manure ratios, plant population densities and their interaction on growth, grain yield and its components of maize (*Zea mays* L.) Single cross 10. The chemical analysis of soil in 1999 and 2000 seasons are presented in Table 1.

Table (1): Chemical analysis of upper 50 cm of soil in 1999 and 2000 seasons.

Nutrient	The chemical analysis of soil	
	1999 season	2000 season
N (ppm)	40.0	37.0
P (ppm)	18.0	17.0
K (ppm)	373.0	330.0
Fe (ppm)	1.09	1.16
Mn (ppm)	0.99	0.56
Zn (ppm)	0.66	0.38
Cu (ppm)	0.18	0.44
pH	7.6	7.9
EC (mm/cm)	0.45	0.31
$CaCO_3$ (%)	3.51	2.95
Ca (mg/L)	0.80	0.60

Experimental treatments:

The experiment included 18 treatments which were the combination of 6 treatments for N fertilization combinations (urea 46.5% with cattle manure) and three plant population densities.

A. Treatments for N fertilization combinations:

1. (N_1), Zero kg N/fed. as urea plus zero kg N/fed. As cattle manure (unfertilized control).
2. (N_2), Zero kg N/fed. as urea plus 120 kg N/fed. as cattle manure.
3. (N_3), 30 kg N/fed. as urea plus 90 kg N/fed. as cattle manure.
4. (N_4), 60 kg N/fed. as urea plus 60 kg N/fed. as cattle manure.
5. (N_5), 90 kg N/fed. as urea plus 30 kg N/fed. as cattle manure.
6. (N_6), 120 kg N/fed. as urea plus zero kg N/fed. as cattle manure.

B. Plant population density:

1. 20000 plant/fed. (30cm between plants).
2. 25000 plant/fed. (24cm between plants).
3. 30000 plant/fed. (20cm between plants).

The physical and chemical analysis of the cattle manure are presented in Table 2.

Table (2): Chemical analysis of the cattle manure applied in 1999 and 2000 seasons.

Fertilizer characteristics	Cattle manure analysis	
	1999 season	2000 season
Organic matter %	70.30	67.70
Total N (%)	0.89	1.01
Total P (%)	0.55	0.81
Total K (%)	1.19	1.54
NO_3-N (ppm)	185.10	182.0
Fe (ppm)	1810.0	1807.2
Mn (ppm)	205.0	415.0
Zn (ppm)	75.0	100.0
Cu (ppm)	140.0	161.0

Grains of maize (Single cross 10) were hand planted on 13 and 8 June in the first and second season, respectively. Thinning to one plant/hill was practiced 21 days from planting. Cattle manure was applied to each sub-plot before planting (The required of cattle manure were calculated according to total N content in cattle manure (Table 2.) and the chemical nitrogen fertilization as urea (46.5% N) was applied in two equal doses, i.e. before the first and second irrigation.

Both organic and chemical N sources were specified to secure a constant 120 kg nitrogen per feddan in both seasons.

Experimental design:

The experimental design was a split-plot with four replications. The main plots were devoted for treatments of N fertilization combinations and the sub-plots were assigned to plant densities.

The plots size of each sub-plot was 16.8 m^2 (4.2 × 4 m), containing 6 rows (4m long and 70 cm apart).

The outer row of each sub-plot was left for vegetative sampling (growth conesquent measurements). Then the next three rows were taken for yield and its components determination and the remaining two rows were also left for vegetative sampling. The samples were randomly taken after 45, 60 and 75 days from planting (DAS).

Growth analysis was determined on five plants basis randomly taken from each sub-plot. Moreover, plant height and green leaves per plant were determined. Samples were carried out to the laboratory and were separated into leaves, stem and ears. Plant materials were dried in a ventilated oven to the constant weight for 48 hours at 70 centigrade to determine the dry matter.

Studied characters:

1. Growth characters

1.1. Plant height. (cm) at harvest.
1.2. Stem diameter (mm) at harvest on the ear node level.
1.3. Plant dry weight (g).
1.4. Number of green leaves/plant.
1.5. Time to 50% tasseling.
1.6. Time to 50% silking.
1.7. Ear position {(ear hight /plant hight)X100}.
1.8. Leaf area per plant (dm^2): determined using the method described by Pearce *et al.* (1975) measerment of ear leaf length X width X0.75 Xthe number of green leaves/plant.

2. Growth analysis

2.1. Leaf area index (LAI): calculated as total area per plant divided by unit ground area.
2.2. Crop growth rate (CGR): determined as follows:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \chi\ 1/G_A \ \text{gm/m}^2\text{/day}$$

2.3. Relative growth rate (RGR): determined as follows:

$$RGR = \frac{L_nW_2 - L_nW_1}{T_2 - T_1} \ \text{mg/gm/day}$$

2.4. Net assimilation rate (NAR): determined as follows:

$$NAR = \frac{(W_2 - W_1)(L_nLA_2 - L_nLA_1)}{(T_2 - T_1)(LA_2 - LA_1)} \ \text{mg/dm}^2\text{/day}$$

where : W_1, LA_1 and W_2, LA_2 refer to plant dry weight and leaf area per plant at T_1 and T_2

time of sampling, respectively. Whereas G_A=ground area and L_n (x)= 2.303 X Log (x). RGR, CGR, NAR were calculated using Watson's formula (Radford, 1967).

All data were subjected to the statistical analysis according to Steel and Torrie (1980), using the MSTAT-C Program. Test for homogeneity of variance was used to compare between variances over two seasons before deciding the validity of combined analysis.

RESULTS AND DISCUSSION

1. Growth characters:

1.1. Plant height:

The effects of N fertilization combination treatments, plant population density and their interaction on plant height (cm) are presented in Table 3.

1.1.1. Effect of N treatments:

Results in Table 3 clearly indicated that plant height was significantly affected by N fertilization combination treatments. In general, plant height was increased with raising the quantity of N as urea in the fertilization combination. Tallest plants were obtained with using 120 Kg N/fed. as urea + zero N/fed. as cattle manure (N_6 treatment), followed by 90 Kg N/fed. as urea + 30 Kg N/fed. as cattle manure (N_5 treatment) and 60 kg N/fed. as urea + 60 kg N/fed. as cattle manure (N_4 treatment). However, differences between the above three treatments were insignificant. The present results are in general agreement with those reported by Madhavi *et al.* (1995) and Tuivavalagi and Silva (1996).

1.1.2. Effect of plant population density:

Plant height was significantly increased with increasing plant population density from 20000 to 30000 plant/fed. The tallest plants were obtained at 30000 plant/fed., Such results may be due to the fact that increasing plant density reduces light penetration between plants. As a result of intensive plant competition for light, each individual plants tries to reach the proper light intensity by increasing its height. These results are in agreement with those obtained by Matta *et al.* (1990), Abdul-Galil *et al.* (1990), Al-Shebani (1998) and Khalil *et al.* (1999). They agreed that plant height was significantly increased with increasing plant population density from 15000 to 30000 plant/fed.

Table (3): Means of plant height and stem diameter at harvest in cm as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization)	Plant height				Stem diameter			
(Urea + cattle manure)	Plant densities / fed.			Means	Plant densities / fed.			Means
Kg N/ fed.	20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	208.1	215	227.1	216.7	1.83	1.75	1.76	1.78
Zero + 120 (N_2)	249.4	266.2	282.3	265.9	2.04	2.08	2.00	2.04
30 + 90 (N_3)	249.4	267.8	268.7	262.0	2.25	2.11	2.07	2.14
60 + 60 (N_4)	265.3	267	272.5	268.2	2.23	2.24	2.12	2.19
90 + 30 (N_5)	266.6	270.2	272.3	269.7	2.35	2.27	2.19	2.27
120 + Zero (N_6)	267.1	272.8	288.1	276.0	2.40	2.37	2.29	2.35
Means of plant densities	251	259.8	268.5		2.18	2.14	2.07	

L.S.D. at 5% level for :

	Plant height	Stem diameter
(N)	**11.7**	**0.08**
(P)	**4.8**	**N.S**
(N×P)	**11.9**	**0.46**

However Abdel-Raouf (1973) showed that plant height was not significantly affected by increasing plant population density from 16000 to 32000 per fed.

1.1.3. Effect of interaction:

Results indicated that plant height was significantly affected by the interaction between N treatments and plant densities. The tallest plants were obtained by planting 30000 plant/fed. with 120 Kg N/fed. as urea + Zero N/fed. as cattle manure (N_6 treatment).

1.2. Stem diameter (cm):

Results in Table 3 showed the effect of N treatments, plant population density and their interaction on stem diameter (cm).

1.2.1. Effect of N treatments:

Results indicated that N fertilization combination treatments had a significant effect on stem diameter. The highest stem diameter was obtained from N_6 treatment (120 Kg N/fed. as urea + Zero N/fed. as cattle manure), followed by N_5 treatment (90 Kg N/fed. as urea + 30 Kg N/fed. as cattle manure).

1.2.2. Effect of plant population density:

Plant population density had no significant effect on stem diameter which tended to decrease with increasing plant densities. These results are in concordance with the findings of Al-sheb› ‹ (1998) and Said and Gabr (1999).

1.2.3. Effect of interaction:

Results showed that the interaction between N treatments and plant population density had a significant effect on stem diameter being highest for 20000 plant/fed. with 120 kg N/fed. as urea + zero N/fed. as cattle manure (N_6 treatment). While, the lowest value was obtained by planting 25000 plant/fed. under zero nitrogen.

1.3. Plant dry weight (g):

The effect of N fertilization treatments, plant population density and their interaction on plant dry weight (g) are presented in Table 4.

1.3.1. Effect of N treatments:

The results indicated that plant dry weight was significantly affected by N combination treatments at all growth stages. In general, plant dry weight was increased with raising the quantity of N as urea in the combinations. Application of 120 kg N/fed. as urea + zero kg N/fed. as cattle manure (N_6 treatment), gave highest plant dry weight, followed by applying 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment). These results were in harmony with those obtained by Baser *et al.* (1986), Sakr *et al.* (1992), Madhavi *et al.* (1995), Khalil *et al.* (2000) and Ren-Shih Chung *et al.* (2000) who reported that addition of different organic manures with mineral fertilization significantly increased dry matter per plant.

1.3.2. Effect of plant population density:

Plant dry weight was significantly decreased with increasing plant population density from 20000 to 25000 and 30000 plant/fed. at all growth stages. This could be explained on the bases of the reduction of plant competition, more interception of light energy per plant, higher light energy conversion of light energy to chemical energy with the balanced carbohydrate distribution in different plant parts. These results are in agreement with those obtained by Matta (1981), Attia (1988), Bangarwa *et al.* (1989), Ogunlela *et al.* (1989), Abdul-Galil *et al.* (1990), and Al-Shebani (1998) who found that plant dry weight was significantly decreased with increasing plant population density per unit area.

1.3.3. Effect of interaction:

Results indicated that the interaction between N fertilization treatments and plant population density significantly affected plant dry weight at all growth stages. The highest dry weight was obtained by planting 20000 plant/fed. and fertilized with 120 kg N/fed. as urea + zero kg N/fed. as cattle manure (N_6 treatment), followed by planting 20000 plant/fed. with applying 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment), among which differences were not significant at the two first growth stages.

1.4. Number of green leaves per plant:

The effects of N treatments, plant population density and their interaction on number of green leaves per plant are presented in Table 5.

1.4.1. Effect of N treatments:

The effect of N fertilization combination treatments on number of green leaves per plant was significant at all growth stages. However, results indicated that the differences between N_2, N_3, N_4, N_5 and N_6 treatments did not reach the level of significance in most cases.

1.4.2. Effect of plant population density:

In general, the highest number of green leaves per plant was obtained with planting 30000 plant/fed. These results are not agreement with those obtained by Abdel-Raouf (1973), Shaheen (1985), Matta *et al.* (1990), and Al-Shebani (1998) showed that number of green leaves/plant was significantly increased with decreasing plant population density from 31000 to 15000 plant/fed.

1.4.3. Effect of interaction:

It is quite clear from these results that the interaction between N fertilization treatments and plant population density had a significant effect on number of green leaves per plant at all growth stages.

1.5. Time of 50% tasseling:

The effects of N fertilization treatments, plant population density and their interaction on time of 50% tasseling are presented in Table 6.

1.5.1. Effect of N treatments:

Results indicated that number of days from planting to 50% tasseling was significantly affected by this factor. The differences between the fertilized treatment were not significant, while it were significant between the N1 treatment (control) and any of the remainder treatments. Results claimed that N induced earlier tasseling in maize plants. The results indicated the role of N in the formation of sexual organs and in enhancing an early flowering through an increase in the meristematic activity in plants. In this connecting Ponsica *et al.* (1983) and Tuivavalagi and Silva (1996) reported that application of animal manure or poultry manure combined with mineral fertilizers decreased number of days from planting to 50% tasseling.

1.5.2. Effect of plant population density:

The results in Table 6 showed that number of days from planting to 50% tasseling was significantly increased with increasing plant population density from 20000 to 30000 plant/fed. This increment may be attributed to the competition between plants for light within the dense plant population. Also, high plant density might have reduce light intensity within plants canopy and encourage IAA synthesis. These results are in harmony with those reported by Galal and El-Zeir (1990), Ali *et al.* (1994), Abdel- Maksoud (1995), Abdel-Aal *et al.* (1997), Al-Shebani (1998), and Said and Gabr (1999) who found that number of days from sowing date to 50% tasseling was significantly increased by increasing plant population density up to 30000 plant/fed.

1.5.3. Effect of interaction:

Interaction between N treatments and plant population density had a significant effect on time of 50% tasseling.

1.6. Time of 50% silking:

The effects of N combination treatments, plant population density and their interaction on time of 50% silking are presented in Table 6.

1.6.1. Effect of N treatments:

The results showed that N fertilization treatments significantly affected number of days from planting to 50% silking. However the differences among the five N fertilized treatments failed to be significant.

The results also showed a significant delay in time of silking with N abscence as in (the check treatment). The effect of N treatments on time of 50% silking was about similar to that on time of 50% tasseling. Ponsica *et al.* (1983) and Tuivavalagi and Silva (1996) mentioned that application of animal manure or poultry manure combined with mineral fertilizers decreased number of days from planting to 50% silking.

Table (4): Means of plant dry weight in gm as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization)	45 days after planting				60 days after planting				75 days after planting			
(Urea + cattle manure)	Plant densities/fed.				Plant densities/fed.				Plant densities/fed.			
Kg N/ fed.	20000	25000	30000	Mean	20000	25000	30000	Mean	20000	25000	30000	Mean
Zero + Zero (N_1)	93.3	91.1	78.8	89.1	140.9	135.8	120.1	132.3	219.2	215.6	190.2	208.3
Zero + 120 (N_2)	113.1	93.6	79.8	95.5	177.5	154.6	132.1	154.7	305.3	281.6	243.2	276.7
30 + 90 (N_3)	110.4	99. 7	90.1	100.1	181.0	166.0	147.9	165.0	330.4	301.5	267.2	299.7
60 + 60 (N_4)	115.2	103.0	86.0	101.4	188.2	173.8	150.0	170.6	347.6	319.4	273.8	313.6
90 + 30 (N_5)	123.2	111.4	93.6	109.4	199.7	183.6	161.2	181.5	348.5	323.7	291.0	321.1
120 + Zero (N_6)	125.1	113.9	97.5	112.2	209.4	189.1	167.4	188.6	378.9	339.2	301.5	339.9
Means of plant densities	114.1	102.1	87.6		182.8	167.1	146.5		321.7	296.8	261.2	

L.S.D. at 5% level for :		45 days	60 days	75 days
	(N)	6.52	9.52	15.81
	(P)	2.88	4.5	6.04
	(N×P)	7.06	11.03	14.79

Table (5): Means of number of green leaves per plant as affected by N-fertilization and plant densities (combined over 1999 and 2000 Seasons).

N fertilization)	45 days after planting				60 days after planting				75 days after planting			
(Urea + cattle manure)	Plant densities/fed.				Plant densities/fed.				Plant densities/fed.			
Kg N/ fed.	20000	25000	30000	Mean	20000	25000	30000	Mean	20000	25000	30000	Mean
Zero + Zero (N_1)	9.4	9.5	9.2	9.4	12.4	12.9	12.9	12.7	14.1	14.3	14.4	14.3
Zero + 120 (N_2)	10.8	10.9	10.7	10.8	14.6	14.8	14.4	14.6	15.7	16.3	15.9	16.0
30 + 90 (N_3)	10.5	10.6	11.5	10.9	14.1	14.4	15.5	14.7	15.9	15.9	16.2	16.0
60 + 60 (N_4)	10.9	11.2	11.3	11.1	14.6	15.3	15.0	15.0	16.2	16.3	16.2	16.2
90 + 30 (N_5)	11.2	11.1	11.0	11.1	15.0	14.9	14.6	14.8	16.1	16.2	16.5	16.3
120 + Zero (N_6)	11.0	11.7	11.7	11.4	14.6	15.8	15.4	15.3	16.3	16.5	17.0	16.6
Means of plant densities	10.6	10.8	10.9		14.2	14.7	14.6		15.7	15.9	16.0	

L.S.D. at 5% level for :		45 days	60 days	75 days
	(N)	0.42	0.63	0.51
	(P)	0.22	0.35	N.S
	(N×P)	0.55	0.87	0..84

1.6.2. Effect of plant population density:

Number of days from planting to 50% silking was significantly increased with increasing plant population density from 20000 to 30000 plant/fed. This was true in both seasons (Table 8 in App.). The effect of plant densities on time of 50% silking is similar to its effect on time of 50% tasseling. Similar results were obtained by Galal and El-Zeir (1990), Ali *et al.* (1994), Abdel-Maksoud (1995), Abdel–Aal *et al.* (1997), and Khalil *et al.* (1999) who found that number of days from planting to 50% silking was significantly increased with increasing plant population density from 16000 to 30000 plant/fed.

1.6.3. Effect of interaction:

Results indicated that the interaction between the two factors under study had a significant effect on time of 50% silking (Table 6).

1.7. Ear position (%):

The effects of N combinations treatments, plant population density and their interaction on ear position (%) are presented in (Table 6).

1.7.1. Effect of N treatments:

Nitrogen combinations showed a significant effect on ear position. However, the differences within all the N combinations (from N_2 to N_6) did not reach the level of significance. Results also showed that the unfertilized check gave significantly lower ears on the plant than the fertilized treatments.

1.7.2. Effect of plant population density:

The results in Table 6showed that ear position was not significantly affected by increasing plant population density from 20000 to 30000 plant/fed.

Similar results were obtained by Abdel-Raouf (1973), Kamel *et al.* (1983), Soliman *et al.* (1995) and El-Agamy *et al.* (1999).

1.7.3. Effect of interaction:

The interaction between the N treatments and plant population density had a significant effect on this trait. The highest value of ear position (50.3%) was obtained with 30000 plant density and 90 Kg N/fed. as urea + 30 N/fed. as cattle manure (N_5 treatment) followed by application of 60Kg N/fed. as urea + 60 N/fed. as cattle manure (N_4 treatment).

1.8. Leaf area per plant (dm^2):

The effects of N fertilization treatments, plant population density and their interaction on leaf area per plant are presented in Table (7).

1.8.1. Effect of N treatments:

Results indicated that N fertilization treatments had a significant effect on leaf area per plant at all growth stages. Leaf area/plant slightly increased with raising the quantity of N as urea within the combinations. The highest leaf area per plant was obtained with application of 120 kg N/fed. as urea + zero kg N/fed. as cattle manure (N_6 treatment), followed by applying 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment) without significant differences between them in two out of three samples.

1.8.2. Effect of plant population density:

Results showed that leaf area per plant significantly decreased with increasing plant population density from 20000 to 30000 plant/fed. This is true at all growth stages. In general, the highest leaf area per plant was obtained from the lowest density (20000 plant/fed.), while the lowest one was produced from the highest density (30000 plant/fed.) while, 25000 plant density came in between. The tendency of leaf area decrement at high plant densities may be due to maximization of mutual shading between plants. Results mean that decreasing plant density per unit area caused an increase in leaf extension and total leaves area. These results are in harmony with those obtained by Bedeer (1984), Mourad *et al.* (1986), Abdul-Galil *et al.* (1990), Al-Shebani (1998) Said and Gabr (1999) and Hassan (2000).

1.8.3. Effect of interaction:

The interaction between N fertilization treatments and plant population density had a significant effect on leaf area per plant at all growth stages. The highest leaf area per plant was obtained with planting 20000 plant/fed. which fertilized with 120 kg N/fed.

as urea + zero kg N/fed. as cattle manure (N_6 treatment), followed by planting 20000 plant/fed. with 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment) at the first stage and by planting 20000 plant/fed. which fertilized with 60 kg N/fed. as urea + 60 kg N/fed as cattle manure (N_4 treatment) during the second and third stages.

2. Growth analysis

2.1. Leaf area index (LAI):

The effects of N treatments, plant population density and their interaction on leaf area index (LAI) are presented in Table 8

2.1.1. Effect of N treatments:

Results indicated that N treatments had a significant effect on LAI at all growth stages. LAI increased when the quantity of N as urea raised in the nitrogen combinations at all growth stages. In general, the highest LAI was obtained by using 120 kg N/fed. as urea + zero kg N/fed. as cattle manure (N_6 treatment), followed by 90 kg N/fed as urea + 30 kg N/fed as cattle manure (N_5 treatment). The differences between N_5 and N_6 treatments were insignificant in two out of three samples.

2.1.2. Effect of plant population density:

Results clearly indicated that plant population density had a significant effect on Leaf area index (LAI) at all growth stages. Mean values of leaf area index (LAI) significantly increased with increasing plant population density from 20000 to 30000 plant/fed. at all growth stages. It could be concluded that increasing plant density from 20000 to 30000 plant/fed. caused an increase in the total leaf area of the unit area. Similar results were reported by Bangarwa *et al.* (1989), Al-Shebani (1998) and Khalil *et al.* (1999) who agreed that leaf area index (LAI) increased with increasing number of plant per unit area.

2.1.3. Effect of interaction:

Results indicated that the interaction between N fertilization and plant population density had a significant effect on leaf area index (LAI). The highest LAI was obtained by planting 30000 plant/fed. which fertilized with 120 kg N/fed. as urea + zero N/fed. as cattle manure (N_6 treatment) during the first and second growth stages, and by planting 30000 plant/fed. with using 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment) at the third growth stage.

2.2. Crop growth rate (CGR):

The effects of N fertilization treatments, plant population density and their interaction on crop growth rate (CGR) are presented in Table 9

2.2.1. Effect of N treatments:

Results indicated that N fertilization treatments had a significant effect on crop growth rate (CGR) at all growth stages. Generally, there was a slightly increase in CGR with raising the quantity of N from urea in the fertilization combination treatments. The highest CGR was obtained by application 120 kg N/fed. as urea + zero kg N/fed as cattle manure (N_6 treatment), followed by using 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment). No significant differences between these treatments was detected at the 1st period (45-60 days after planting).

2. 2.2. Effect of plant population density:

Crop growth rate was significantly increased with increasing plant population density from 20000 to 30000 plant/fed. at two growth periods. The highest CGR was obtained by planting 30000 plant/fed. during two growing periods, while the lowest one was noticed with planting 20000 plant/fed. Similar results were obtained by Al-shebani (1998). On the contrary, Mohamed (1990) and Abdul-Galil *et al.* (1990), found that CGR decreased with increasing plant density. However, Anber (1979) reported that plant density per unit area did not significantly affect CGR.

2.2.3. Effect of interaction:

The interaction between N treatments and plant population density had a significant effect on CGR during the two growth periods (45-60 and 60-75 days after planting) and being highest for 30000 plant density with 120 kg N/fed. as urea + zero kg N/fed as cattle manure (N_6 treatment).

2.3. Relative growth rate (RGR):

The effects of N combination treatments, plant population density and their interaction on relative growth rate (RGR) are presented in Table 10

Table (6): Means of time of 50% tasseling, time of 50% silking and ear position % as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization)	Time of 50% tasseling; days after planting				Time of 50% silking; days after planting				Ear position %			
(Urea + cattle manure)	Plant densities / fed.			Means	Plant densities / fed.			Means	Plant densities / fed.			Means
Kg N/ fed.	20000	25000	30000		20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	60.7	59.5	60.2	60.1	65.17	65	65.8	65.3	42.5	45.6	44.6	44.2
Zero + 120 (N_2)	56.0	57.0	57.5	56.8	61.8	63	64	62.9	46.9	45.4	47.7	46.7
30 + 90 (N_3)	56.2	56.5	57.5	56.7	63.2	62.8	64.2	4.63	47.6	44.4	46.9	46.3
60 + 60 (N_4)	55.7	57.7	58.3	57.2	62.2	63.5	64.5	63.4	46.5	47.9	49.5	48.0
90 + 30 (N_5)	55.7	57.8	58.2	57.2	62.4	63.9	64.9	63.7	46.3	46.7	50.3	47.9
120 + Zero (N_6)	55.8	57.2	58.8	57.3	62.5	63.4	65.5	63.8	45.5	47.7	48.2	47.1
Means of plant densities	56.7	57.1	58.4		62.9	63.6	64.8	65.3	45.9	46.3	47.9	

L.S.D. at 5% level for:	Tasseling	Silking	Ear position
(N)	0.8	0.96	1.4
(P)	0.43	0.55	N.S
(N×P)	1.06	1.36	2.8

Table (7): Means of leaf area per plant in dm2 as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization)	45 days after planting				60 days after planting				75 days after planting			
(Urea + cattle manure)	Plant densities / fed.			Means	Plant densities / fed.			Means	Plant densities / fed.			Means
Kg N/ fed.	20000	25000	30000		20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	37.69	35.23	31.09	34.67	55.03	56.21	51.1	54.11	72.49	69.59	62.59	68.22
Zero + 120 (N_2)	44.13	40.17	30.02	38.1	85.66	77.15	59.23	74.01	96.99	88.73	78.52	88.08
30 + 90 (N_3)	46.34	39.46	35.82	40.54	78.41	71.65	63.5	71.19	101.96	92.52	83.48	92.65
60 + 60 (N_4)	44.69	38.01	37.47	40.06	84.75	75.12	61.62	73.83	105.28	93.72	83.99	94.33
90 + 30 (N_5)	46.1	40.91	37.21	41.4	83.6	76.65	66.79	75.68	101.97	96.53	91.8	96.77
120 + Zero (N_6)	53.62	43.26	39.41	45.43	92.92	77.54	65.07	78.51	107.55	101.21	91.09	99.95
Means of plant densities	45.43	39.5	35.17		80.06	72.39	61.22		97.71	90.38	81.91	

L.S.D. at 5% level for:	45 days	60 days	75 days
(N)	3.3	4.7	6.9
(P)	2.1	2.7	3.1
(N×P)	5.3	6.7	7.6

Table (8): Means of leaf area index as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization)	45 days after planting				45 days after planting				45 days after planting			
(Urea + cattle manure)	Plant densities / fed.			Means	Plant densities / fed.			Means	Plant densities / fed.			Means
Kg N/ fed.	20000	25000	30000		20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	1.8	2.01	2.23	2.01	2.62	3.26	3.41	3.1	3.37	3.82	4.47	3.89
Zero + 120 (N_2)	2.1	2.3	2.15	2.18	4.08	4.41	4.4	4.3	4.62	5.07	5.61	5.1
30 + 90 (N_3)	2.21	2.26	2.42	2.29	3.73	4.09	4.66	4.16	4.86	5.29	5.96	5.37
60 + 60 (N_4)	2.18	2.26	2.5	2.31	4.04	4.29	4.45	4.26	5.01	5.36	5.99	5.46
90 + 30 (N_5)	2.2	2.34	2.63	2.39	3.98	4.38	4.77	4.38	4.86	5.52	6.56	5.64
120 + Zero (N_6)	2.55	2.47	2.82	2.61	4.42	4.43	4.83	4.56	5.12	5.77	6.51	5.8
Means of plant densities	2.17	2.27	2.46		3.81	4.14	4.42		4.64	5.14	5.85	

L.S.D. at 5% level for :				
	(N)	0.19	0.25	0.4
	(P)	0.11	0.15	0.18
	(N×P)	0.29	0.38	0.46

Table (9): Means of crop growth rate (CGR) gm/m2/day as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization) (Urea + cattle manure)	1st Growth period 45-60 days after planting				2nd Growth period 60-75 days after planting			
Kg N/ fed.	Plant densities / fed.			Mean	Plant densities / fed			Mean
	20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	13.52	16.99	19.79	16.75	24.84	30.39	33.36	29.53
Zero + 120 (N_2)	20.42	22.97	24.9	22.76	40.59	48.66	52.92	47.39
30 + 90 (N_3)	22.43	25.28	27.64	25.12	47.4	51.6	56.79	51.93
60 + 60 (N_4)	23.16	27.78	30.46	27.13	50.61	55.47	58.94	55.01
90 + 30 (N_5)	24.29	28.31	32.2	28.27	47.25	53.38	61	54.14
120 + Zero (N_6)	26.77	29.07	32.67	29.5	53.85	58.22	63.85	58.64
Means of plant densities	21.77	25.06	27.94		44.09	49.62	54.61	

L.S.D. at 5% level for:			
	(N)	1.78	4.24
	(P)	0.88	1.46
	(N×P)	2.16	3.58

2.3.1. Effect of N treatments:

Results showed that N treatments had a significant effect on relative growth rate (RGR) during the two growth periods. The difference among the N_3, N_4, N_5 and N_6 treatments was insignificant in the first and second periods. However, raising quantity of N as urea in the fertilization combination treatments caused a slight increase in RGR at two growing periods.

2.3.2. Effect of plant population density:

The effect of plant population density on relative growth rate (RGR) was significant during both growing periods. It is quite clear from these results that RGR increased with increasing plant population density from 20000 to 30000 plant/fed. The highest RGR was obtained by planting 30000 plant/fed., while the lowest one was noticed with planting 20000 plant/fed. such results were in agreement with those reported by Eraky *et al.* (1982), Mohamed (1990) and Al-shebani (1998). On the contrary, and Abdul-Galil *et al.* (1990) found that RGR decreased by increasing plant density. On the other hand, Anber (1979) found that plant density had no significant effect on RGR.

2.3.3. Effect of interaction:

Interaction between N treatments and plant population density had a significant effect on RGR in both growing periods, being highest with 30000 plant density with 90 kg N/fed. as urea + 30 kg N/fed, as cattle manure (N_5 treatment) at the first period, or with 60 kg N/fed. as urea + 60 kg N/fed. as cattle manure (N_4 treatment) during the second period.

2.4. Net assimilation rate (NAR):

The effects of N fertilization treatments, plant population density and their interaction on net assimilation rate (NAR) are presented in Table 11.

2.4.1. Effect of N treatments:

The effect of N combination treatments on net assimilation rate (NAR) was significant in both growth periods. The differences within N_3, N_4, N_5 and N_6 treatments were insignificant, but it was significant between any of them and the control treatment or N_2 treatment.

Table (10): Means of relative growth rate (RGR) mg/gm/day as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization) (Urea + cattle manure)	1st Growth period 45-60 days after planting				2nd Growth period 60-75 days after planting			
Kg N/ fed.	Plant densities / fed.			Mean	Plant densities / fed			Mean
	20000	25000	30000			20000	25000	30000
Zero + Zero (N_1)	23.48	26.63	28.24	26.11	28.89	28.89	30.5	29.33
Zero + 120 (N_2)	29.97	33.14	34.18	32.43	36.27	38.65	39.14	38.02
30 + 90 (N_3)	32.36	34.6	35.43	34.13	38.45	39.2	39.69	39.11
60 + 60 (N_4)	32.73	35.04	36.37	34.71	37.55	40.7	42.66	40.3
90 + 30 (N_5)	32.37	34.63	38.63	35.21	37.84	39.37	41.79	39.67
120 + Zero (N_6)	33.92	35.09	37.68	35.56	39.76	40.77	40.76	40.43
Means of plant densities	30.8	33.19	35.09		36.41	37.93	39.09	

L.S.D. at 5% level for :

	1st period	2nd period
(N)	1.94	2.11
(P)	1.08	1.39
(N×P)	2.66	3.42

Table (11): Means of net assimilation rate (NAR) mg/dm2/day as affected by N-fertilization and plant densities (combined over 1999 and 2000 seasons).

N fertilization) (Urea + cattle manure) Kg N/ fed.	1st Growth period 45-60 days after planting				2nd Growth period 60-75 days after planting			
	Plant densities / fed			Mean	Plant densities / fed			Mean
	20000	25000	30000		20000	25000	30000	
Zero + Zero (N_1)	68.52	64.75	59.63	64.3	79.48	75.49	71.3	75.43
Zero + 120 (N_2)	82.38	71.37	69.81	74.52	109.2	103.06	93.7	101.99
30 + 90 (N_3)	85.16	82.75	78.47	82.13	113.5	111.01	110.34	111.61
60 + 60 (N_4)	90.54	85.2	77.31	84.35	119.3	115.8	112.79	115.95
90 + 30 (N_5)	90.04	84.91	81.53	85.49	120.6	117.14	109.68	115.79
120 + Zero (N_6)	93.88	86.14	79.07	86.36	119.5	116.65	116.53	117.56
Means of plant densities	85.09	79.18	74.3		110.3	106.52	102.39	

L.S.D. at 5% level for:		
(N)	5.62	9.01
(P)	2.26	3.72
(N×P)	5.54	9.11

2.4.2. Effect of plant population density:

Results clearly indicated that plant population density had a significant effect on this trait at both growth periods. Net assimilation rate (NAR) was decreased with increasing plant population density from 20000 to 30000 plant/fed. during the two growing periods. Such effect may be due to decrease in photosynthesis rate as a result of more competition between plants at the dense planting. These results agreed with those obtained by Mohamed (1990), Abdul-Galil *et al.* (1990), and Al-shebani (1998) who reported that NAR decreased with increasing plant density before and after flowering periods.

2.4.3. Effect of interaction:

The effect of interaction between N treatments and plant population density on net assimilation rate (NAR) was significant at both growing periods. The highest values of NAR were obtained by planting 20000 plant/fed. with 120 kg N/fed. as urea + zero N/fed. as cattle manure (N_6 treatment) in the first period, or with 90 kg N/fed. as urea + 30 kg N/fed. as cattle manure (N_5 treatment) in the second period.

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تاثير مصدر النتروجين والكثافة النباتية على الذرة الشامية
١. قياسات وتحليل النمو

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أجريت هذه الدراسة فى موسمى ١٩٩٩ و٢٠٠٠ فى محطة البحوث والتجارب الزراعية – كلية الزراعة – جامعة القاهرة لدراسة تأثير التسميد النتروجينى المعدنى (يوريا ٤٦,٥%) والعضوى (سماد الماشية) عند استخدامها فى توافيق خاصة بنسب مختلفة من كل منهما وكذلك ثلاثة كثافات نباتية (٢٠ و٢٥و٣٠) الف نبات / فدان على قياسات وتحليل النموفى الذرة الشامية (هجين فردى ١٠) واتضح من النتائج بصفة عامة ان صفات النموقد زادت بزيادة كمية النتروجين فى الصورة المعدنية الا ان معدل ١٢٠ كجم نتروجين فى صورة يوريا لم يختلف معنويا عن المعاملة التى تم فيها استبدال ربع كمية النتروجين (٣٠٠ كجم N) بصورة عضوية (سماد الماشية)وذلك بالنظر لمعظم قياسات النمو.

أدت زيادة كثافة النباتات من ٢٠ الى ٣٠ الف نبات / فدان الى زيادة معنوبة فى كل من طول النبات، ميعاد التزهير المذكر والمؤنث ، دليل مساحة الاوراق، معدل نموالمحصول، المعدل النسبى للمحصول. بينما انخفضت كل من الوزن الجاف ومساحة الاوراق / نبات بزيادة الكثافة كما كان تأثير التفاعل بيت المعاملات النتروجينية وكثافة النباتات معنويا عبى معظم قياسات وتحليلات النمو.