Annals of Agric. Sc. Moshtohor.
Vol. 33(2) 483-494. 1995

GROWTH AND YIELD OF MAIZE (*Zea mays* L.) AS AFFECTED BY NITROGEN SOURCE AND TIME OF APPLICATION

BY

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ABSTRACT

Two field experiments were conducted during 1991 and 1992 seasons. at the Agricultural Research and Experiment Center. Faculty of Agriculture. Moshtohor. Zagazig University to study the effect of nitrogen source and time of application on growth. yield and yield components of maize. Giza 2 variety.

N addition as ammonium nitrate or urea showed a favourable effect in improving growth, yield and yield components of maize as compared with the addition of calcium nitrate. The highest values of maize growth and yield characters were recorded with the addition of ammonium nitrate and the lowest values were associated with calcium nitrate.

Split application of N fertilizer as: T_2. 1/3 N at planting + 2/3 N before the 1st irrigation. followed by T_4: 2/3 N before the 1st irrigation + 1/3 N before the 2nd irrigation or T_1: 1/3 N at planting + 1/3 N before the 1st irrigation + 1/3 N before the 2nd irrigation were superior to applying all amount of N before the 1st irrigation (T_3) on the growth, yield and yield components. Interaction effects between N source and time of application on growth, yield and yield components were not significant in the two seasons. except on shelling percentage in the first season. and ear diameter in the second one.

Under the conditions of the study. it can be concluded that supplying plants with N fertilizer as ammonium nitrate in split doses. during the first 6 weeks from planting. can be recommended.

INTRODUCTION

N fertilizer is an essential nutrient for maize production. Management system must be developed that result in most efficient N utilization for maximizing maize production. Source and time of N application are important management tools in this respect because maximum N efficiency is obtained when N is applied in the form and time which are available for uptake by plant as needed (Jokela and Randall. 1989). N can be utilized by maize plant as NH_4 or NO_3. NH_4 is converted to NO_3. Thus. the principal form of N available to maize plant throughout the majority of the growing season is considered to be NO_3. It is well known that the negative nitrate ions (NO_3) are not adsorbed by soil colloids. so it leach down the plant root zone and losse by leaching. while ammonium cation (NH_4) is adsorbed by soil colloids. thus it does not leach out of soil. Du Plessis and Kroontje (1966) reported that NH_3 losses would be considerably less from compounds such as NH_4NO_3. Bandel *et al.* (1980) and Touchton and Hagrove (1982) concluded that corn grain yields with ammonium nitrate were higher than yields with urea. Also. Fox *et al.* (1986) found that ammonium nitrate was superior to urea for grain yield and total N uptake because more losses of N as NH_3 from urea by volatilization. Effective diffusion coefficient for NO_3 in soil is more than 20 times that of NH_4 (Barber. 1984). Olson *et al.* (1986) explained that the superiority of ammonium nitrate over calcium nitrate and urea may be in the enhanced N utilization efficiency from the extended NH_4 nutrition, while calcium nitrate with its component of NO_3 only is highly soluble and highly losses by leaching and urea may allow both leaching loss and NH_3 volatilization. Also, Raun *et al.* (1989) reported the rapid hydrolysis of urea to ammonium carbonate and the subsequent potential for ammonia volatilization.

Maize productivity is improved when plants are supplied with a mixture of NO_3 and NH_4 compared with NO_3 as the sole N source (Schrader *et al.*, 1972; Alexander *et al.*, 1991 and Below and Gentry, 1992). Also, Smiciklas and Below (1992) concluded that mixed N nutrition (NO_3 + NH_4) increased grain yield and productivity of maize by increasing dry matter production and accumulation and partitioning to the grain, enhanced formation and development of reproductive tissues and N accumulation. Similar results were indicated by Gentry and Below (1993). All the previous studies indicated that supplying plant with both form of N (NO_3 + NH_4) can optimize maize growth and yield.

Maize grain yield was improved when N was applied half at planting and half at the 8th leaf stage (after about 35 days from planting). compared to full N application at planting (Hussein *et al.*, 1978 and Balko and Russel. 1980). Bishr *et al.* (1977) noted that grain yields tended to increase when N was split as compared to the whole amount applied at planting time or before the first irrigation. Sharma (1980) found that application of N splits at planting, knee-height stage and tasseling stage of corn growth resulted in production of significantly higher yields than full dose application at the time of planting. Faisal (1983) and Abou Mady (1985) found that maize grain yield was significantly affected by time of N application. Fox *et al.* (1986) reported that side dress application of N (26 to 31 days after plant emergence) resulted in more efficient N fertilizer utilization (yield and N uptake per unit of N applied)

The objectives of this experiment is to investigate the effect of source and time of N application on the growth. yield and yield components of maize

MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural Research and Experiment Center. Faculty of Agriculture at Moshtohor for two growing seasons. where the planting dates were 20th and 26th June in 1991 and 1992 seasons. respectively. to determine the effect of N source and time of application on maize yield. The preceding crop was wheat in the two seasons. The composite maize variety Giza 2 was used in this study. Normal cultural practices were applied properly.

Soil was clay textured with pH value of 7.9. 2.55% (organic matter) and 3.65% $CaCO_3$ contents.

Each experiment included 15 treatments which were the combination of three N sources: Calcium nitrate. $Ca(NO_3)_2$ $2H_2O$, 15.5% N; Ammonium nitrate, NH_4NO_3, 33.5% N and Urea, $CO(NH_2)_2$, 46% N and five times of N application: T_1=1/3 at planting + 1/3 before 1st irrigation + 1/3 before 2nd irrigation; T_2=1/3 at planting + 2/3 before 1st irrigation; T_3= all N before 1st irrigation; T_4= 2/3 before 1st irrigation + 1/3 before 2nd irrigation; and T_5= 1/2 before 1st irrigation + 1/2 before 2nd irrigation, as indicated in Table (1).

Table (1): Time of N application treatments.

Time of N application	At planting	Before 1st irrigation (3 weeks from planting)	Before 2nd irrigation (5 weeks from planting)
T_1	1/3	1/3	1/3
T_2	1/3	2/3	-
T_3		All N	-
T_4	-	2/3	1/3
T_5	-	1/2	1/2

Hill placement of 105 kg N/fed was added according to the assigned previous treatment times. The treatments were laid out in a randomized complete block design with four replications The size of each plot was 10.5 m^2 (3 x 3.5 m) or 1/400 fed. and contained 5 ridges.

At harvest. 10 plants and 10 ears were taken randomly from each plot to determine plant height (cm). ear height (cm). stem diameter (mm) of the internode below the ear number of rows/ear. number of kernels/row ear weight (gm). 100-kernel weight (gm) and shelling percentage Grain yield (kg/fed) adjusted to 15.5% moisture content. was estimated from the middle 3 rows of each plot

Statistical analysis for the studied characters were conducted according to Steel and Torrie (1981).

RESULTS AND DISCUSSION

1- Growth studies:

Data in Tables (2 and 3) showed that plant height, ear height and stem diameter were significantly affected by different sources and times of N application in the two seasons. The tallest plants were recorded with the addition of N as ammonium nitrate, whereas, the shortest plants were produced with calcium nitrate. The same trend was observed with ear height. Also, application of ammonium nitrate produced the greater stem diameter as compared to urea or calcium nitrate. According to Barber (1984), loss of N as NO_3 from calcium nitrate by leaching was most rapid than from ammonium nitrate or urea. The superiority of ammonium nitrate and urea on the vegetative growth also, may be due to continuous and slow release of N to maize plants as a result of transforming of NH_4 to NO_3 form, and this means, extended NH_4 nutrition (Olson *et al.*, 1986). These findings are supported with those results obtained by Schrader *et al.* (1972) and Below and Gentry (1987) who indicated that corn vegetative growth was enhanced more by a combination of NH_4 and NO_3 forms than by either form alone. Also, the superiority of ammonium nitrate (NH_4NO_3) which is considered as a mixed N nutrition can arise from other physiological strategies such as: increased dry matter production and accumulation and altering the partitioning of the dry matter between root and shoot of maize plants (Gentry *et al.*, 1989 and Smiciklas and Below, 1992); NH_4 in mixed N nutrition stimulated corn root growth (Anghinoni and Barber, 1988) and enhanced lateral root branching (Wang and Below, 1992) and consequently increased plant weight (Below and Gentry, 1987).

Time of N application significantly affected plant height, ear height and stem diameter in both seasons. Addition of N in two doses: 1/3 at planting + 2/3 before the 1st irrigation or 2/3 before the 1st irrigation + 1/3 before the 2nd irrigation, produced the tallest maize plants as well as ear height in the first and second seasons, respectively. While, the shortest plant was recorded with the addition of all amount of N before the 1st irrigation. The greatest stem diameter was produced with the addition of N as 1/3 at planting and 2/3 before the 1st irrigation. Increases in growth characters with early addition of N may be due to the stimulation effect of N on cell elongation as well as cell diameter, which consequently increase internode length and diameter. These results are in harmony with those obtained by Hussein *et al.* (1978), Khalil (1978) and Abou-Mady (1985). The negative effect of T_3 (all N rate was added before the 1st irrigation) on the growth characters may be due to that applying all N rate in one dose means that N supply is greater than what is needed for optimum plant uptake and can cause movement of N beyond the root zone of plants and losses by leaching (Jokela and Randall, 1989).

Table (2): Effect of N source on the growth, yield and yield components of maize in 1991 and 1992 seasons.

N source	Plant height "cm"	Ear height "cm"	Stem diameter "mm"	Ear length "cm"	Ear diameter "mm"	Number of rows/ear	Number of kernels/ row	Ear weight "gm"	100- kernel weight "gm"	Shelling %	Grain yield kg/fed.
1991 season											
Calcium nitrate	194.5	105.3	18.8	17.2	46.1	12.2	35.3	197.1	33.2	78.4	2324
Ammonium nitrate	218.6	121.0	20.1	18.0	48.1	12.2	36.0	201.3	33.7	79.0	2664
Urea	211.3	120.3	19.5	17.7	46.4	12.2	36.0	205.5	33.8	78.8	2444
L.S.D. 5%	6.0	3.9	0.6	N.S.	1.0	N.S.	N.S.	N.S.	0.4	0.2	120
1992 season											
Calcium nitrate	226.0	116.4	16.8	17.1	45.4	13.1	34.6	196.3	35.2	81.5	2758
Ammonium nitrate	235.0	128.6	18.4	18.1	48.2	13.2	37.8	235.5	35.8	81.8	3312
Urea	240.0	132.5	17.4	17.4	46.3	12.8	37.5	210.1	35.1	81.5	3090
L.S.D. 5%	12.6	4.3	0.9	0.7	0.9	N.S.	1.9	25.8	0.5	0.14	158

Table (3): Effect of N application time on the growth, yield and yield components of maize in 1991/1992 seasons.

N source	Plant height "cm"	Ear height "cm"	Stem diameter "mm"	Ear length "cm"	Ear diameter "mm"	Number of rows/ear	Number of kernels/ row	Ear weight "gm"	100-kernel weight "gm"	Shelling %	Grain yield kg/fed.
						1991 season					
T1	206.6	113.3	18.8	17.5	46.3	12.2	35.4	197.5	32.8	78.4	2534
T2	220.1	121.7	21.2	19.3	49.3	12.2	40.1	209.8	35.4	79.8	2712
T3	194.2	108.6	17.7	15.6	44.7	12.2	28.8	198.7	30.9	77.7	2324
T4	214.3	118.6	20.4	17.9	47.4	12.2	37.3	192.3	34.4	78.8	2414
T5	205.4	115.3	19.1	17.8	46.6	12.3	37.2	208.2	34.2	78.9	2402
L.S.D. 5%	7.7	5.0	0.8	0.9	1.3	N.S.	2.1	N.S.	0.5	0.27	157
						1992 season					
T1	235.2	124.9	18.0	17.5	46.1	13.0	32.9	214.3	34.0	81.4	3257
T2	243.3	128.0	18.5	18.3	49.7	13.0	43.4	238.5	37.8	82.7	3380
T3	212.2	116.8	15.8	16.5	43.5	13.1	31.8	203.3	32.1	80.1	2382
T4	245.1	132.3	18.0	17.8	47.7	13.1	38.8	207.3	36.6	82.0	3118
T5	232.0	127.0	17.2	17.3	46.2	12.8	36.1	206.3	36.2	81.7	3130
L.S.D. 5%	16.3	5.5	1.1	0.9	1.2	N.S.	2.6	33.3	0.7	0.2	233

The interaction between N source and time of application had no significant effect on growth characters

2- Yield and yield components:

Data in Table (2) indicated that N source significantly affected ear diameter. 100-kernel weight. shelling percentage and grain yield/fed in the first season. and ear length. ear diameter. number of kernels/row. ear weight. 100-kernel weight. shelling percentage and grain yield/fed in the second season. while other parameters did not show any significant response. N addition as ammonium nitrate or urea showed a favourable effect in improving yield components of maize as compared with the addition of calcium nitrate. These results indicated that the highest values of the yield components were recorded with the addition of ammonium nitrate, whereas, addition of calcium nitrate was associated with the lowest values of these parameters. Similar results were reported by Smiciklas and Below (1992) who indicated that maize plants grown with mixed N nutrition (NO_3 + NH_4) as ammonium nitrate (NH_4NO_3) significantly increased kernels number and weight and enhanced ear shoot and ovule development. Also similar conclusions were reported by Gentry and Below (1993).

Grain yield/fed was significantly influenced by different N sources in the two seasons. The highest grain yield was produced with the addition of N fertilizer as ammonium nitrate. while the addition of N as calcium nitrate recorded the lowest grain yield/fed. Lower response of maize to calcium nitrate as compared to ammonium nitrate under the experiment conditions of higher pH. CaCO3 and available irrigation may be due to more N losses from calcium nitrate form by leaching. however. ammonium nitrate enhanced N utilization efficiency from the extended NH_4 nutrition (Fenn and Kissely. 1973 and Olson *et al.*, 1986). A further physiological explanation for the superiority of ammonium nitrate as mixed nutrition (NH_4NO_3) is due to less energy required for assimilation of NH_4 as compared to NO_3 (Salsac *et al.* 1987), increased P uptake (Below and Gentry, 1987), enhanced lateral root branching (Wang and Below, 1992) and increased the supply of endogenous cytokinin (Smiciklas and Below, 1992). Also, Smiciklas and Below (1992) and Gentry and Below (1993) concluded that mixed N nutrition (NH_4NO_3) increased grain yield and productivity of maize by increasing and altering the dry matter production and accumulation and partitioning to the grain. and increasing N accumulation. All the previous studies indicated that supplying plants with both forms of N (NH_4NO_3). as ammonium nitrate. can optimize maize growth and yield

Data in Table (3) showed that grain yield and its components with few exception were significantly affected by time of N application in the two seasons. The highest values of yield and its components were recorded when N was added in split doses with T_2: 1/3 at planting + 2/3 before the first irrigation. followed by T_4: 2/3 N before 1st irrigation and 1/3 before 2nd irrigation. Whereas. the lowest values of yield and its components were observed when N was applied in one dose before the 1st irrigation (T_3). These results may be attributed to the effect of early N application in increasing the vegetative growth, photosynthetic accumulation and net assimilation rate. Similar results were reported by Bisher *et al.* (1977) Hussein *et al.* (1978) and Abou Mady (1985).

Under the conditions of this study, it can be concluded that split application of N fertilizer as: (T_2) at planting and at 1st irrigation or (T_4) at 1st irrigation + 2nd irrigation was superior to applied all amount of N before the 1st irrigation could be recommended. Similar results were reported by Jung *et al.* (1972) and Fox *et al.* (1986) who indicated that side dress application of N (26 to 31 days after emergence) resulted in more efficient N fertilization (yield and N uptake per unit of N applied). Also, Russelle *et al.* (1983) showed that earlier applications of N (at planting or 4-leaf stage) resulted in greater FN (fertilizer-derived N) accumulation and N recovery rates, during vegetative growth, than later application (8-leaf stage or 16-leaf stage). FN accumulation and N recovery have been closely related to grain yield and vegetative growth. While, Howard and Tyler (1989) observed improved grain yield of corn when half of N was applied at planting and half at the eight leaf stage compared to all N applied at planting. However, Bishr *et al.* (1977) noted that grain yields tended to increase when N was split as compared to whole amount applied at planting time or before the first irrigation.

Results showed that the interaction effects between N-source and time of application on growth, yield and yield components were not significant in the two seasons, except shelling percentage in the first season, and ear diameter, 100-kernel weight and shelling percentage in the second one which were significantly influenced by this interaction (Tables, 4 and 5). whereas, the highest values of shelling percentage were produced by using ammonium nitrate at T_2 application time (1/3 N at planting + 2/3 N before the 1st irrigation) in the two seasons. Also, the greatest ear diameter and 100-kernel weight were produced with the same treatment.

Table (4) Shelling percentage as affected by the interaction between N sources and times of application in 1991 and 1992 seasons.

N source	Time of N application in 1991 season					Time of N application in 1992 season				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
Calcium nitrate	78.00	79.65	77.30	78.30	78.50	81.20	82.75	80.00	81.85	81.60
Ammonium nitrate	78.70	80.20	78.00	79.20	78.80	81.70	82.85	80.05	82.35	82.05
Urea	78.50	79.60	77.75	79.00	79.35	81.40	82.50	80.20	81 90	81 40
L.S.D. 5%			0.47					0.30		

Table (5) Ear diamter and 100-kernel weight as affected by the interaction between N sources and times of application in 1992 season

N source	Time of N application in 1992 season					Time of N application in 1992 season				
	T_1	T_2	T_3	T_4	T_5	T_1	T_2	T_3	T_4	T_5
	Ear diameter (mm)					100-kernel weight (gm)				
Calcium nitrate	45.25	48.00	40.75	47.00	46.00	35.75	37.35	31.20	36.15	35.55
Ammonium nitrate	47.25	52.00	44.50	49.50	47.75	32.45	38.45	33.95	37.00	36.95
Urea	45.75	49.00	45.25	46.50	44.75	33.80	37.70	31.15	36.65	36.10
L.S.D. 5%			2.12					1.20		

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تأثير مصادر ومواعيد إضافة السماد الأزوتى على نمو ومحصول الذرة الشامية

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أقيمت تجربتان حقليتان خلال موسمى ١٩٩١، ١٩٩٢م بمركز البحوث والتجارب الزراعية بكلية الزراعة بمشتهر، وذلك لدراسة تأثير مصدر وميعاد إضافة السماد الأزوتى على نمو ومحصول الذرة الشامية (صنف جيزة ٢). واستخدم تصميم القطاعات الكاملة العشوائية فى أربع مكررات.

وتشير النتائج إلى:

- أدى استخدام السماد الأزوتى فى صورة نترات الأمونيوم (٣٣,٥٪ ن) إلى زيادة ملحوظة فى صفات النمو ومكونات المحصول ومحصول الحبوب للفدان وذلك مقارنة بسماد نترات الكالسيوم (١٥,٥٪ آزوت). وجاء استخدام سماد اليوريا (٤٦٪ ن) بعد نترات الأمونيوم من حيث التأثير المفيد على الصفات المدروسة.
- أدت إضافة السماد الأزوتى على دفعتين (٣/١ الكمية عند الزراعة + ٣/٢ قبل الرية الأولى أو ٣/٢ الكمية قبل الرية الأولى + ٣/١ قبل الرية الثانية) إلى الحصول على أعلى قيم فى صفات النمو والمحصول ومكوناته مقارنة باضافته دفعة واحدة قبل الرية الأولى.
- لم يكن للتفاعل بين مصادر و مواعيد اضافة السماد الأزوتى تأثير معنويا على الصفات المدروسة عدا النسبة المئوية للتفريط فى الموسم الأول وقطر الكوز ووزن مائة حبة وكذلك النسبة المئوية للتفريط فى الموسم الثانى.
- تحت ظروف هذه الدراسة يمكن الحصول على أحسن نمو وأعلى محصول للذرة الشامية باستخدام سماد نترات الأمونيوم واضافته على دفعتين (٣/١ قبل الزراعة و ٣/٢ قبل الرية الأولى).