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Effects of Nitrogen Rate and Plant Density on Agronomic Nitrogen Efficiency and Maize Yields Following Wheat and Faba Bean

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Abstract: Preceding crops (PC), nitrogen fertilizer (N) and plant density (PD) are management methods that can increase agronomic nitrogen efficiency (ANE) and grain yield of maize. This study was conducted at the farm of the Experimental Research Center, of the Faculty of Agriculture Benha Univ., during 2006 and 2007 seasons. The aim of this investigation was to study the influence of four N rates (0, 40, 80 and 120 kg N/fed[1]) and three plant densities (18000, 24000 and 30000 plants/fed) on ANE and maize yields following wheat and Faba bean. Results indicated that there were significant effects for winter preceding crops on plant height, chlorophyll content (SPAD-units), ear weight, grain yield/fed, grain protein content (GPC) and grain N uptake. Sowing maize after faba bean gave high grain yield and its components. Growth, yield of maize and yield components significantly increased with increasing the rate of N fertilizer up to 120 kg N/fed. Applying N at 40, 80 and 120 kg/fed resulted in ANE of 10.32, 10.49 and 9.92 kg grains/kg N applied in 2006, being 10.2, 8.82 and 7.78 kg grains/kg N in 2007, respectively. Increasing PD from 18000 to 30000 plants/fed delayed tasseling and silking date, but increased plant and ear heights and ANE. On the other hand, increasing planting density significantly decreased ear leaf area and most of yield components. However, increasing PD did not significantly affect grain yield in the 2nd season and ANE in the 1st season. The three main factors i.e. preceding winter crops, N rates and planting density positively interacted.

Key words: Maize, Preceding crops, Plant density, N rates, Yield and ANE

INTRODUCTION

Maize *(Zea mays L.)* is one of the most important cereal crop grown principally during the summer season in Egypt. It ranks the third position among cereal crops after wheat and rice, which ranked as first and the second, respectively. Maize agronomists continually search for methods that help them to increase grain yield and net return of the crop. Many factors affect grain yield of maize and ANE such as preceding crops, fertilization and plant population density.

Many investigators studied the effect of preceding crops on the growth and grain yield of maize [1-5]. Results of their experiments indicate clearly that winter legumes are the ideal preceding crops for maize. Varvel and Peterson [6] concluded that crop rotation reduced inorganic nitrogen fertilizer needs and at the same time reduced the amount of nitrogen available for leaching, both of which were important for increasing crop yields. Cereal yield superiority after legume crops have been attributed to less N-uptake by the legume and increasing residual organic matter [7]. Shams [2] demonstrated that wheat as preceding crop stimulated maize to be more responsive to utilize N applied as compared to legume as preceding crops.

Egyptian soils are known to be poor in available nitrogen due to their low content of organic matter and the small amounts of organic manures added annually. Excessive N fertilization may results in low nitrogen use efficiency (NUE) and potentially exerts more pressure on the environment. Therefore, applying the optimum N level and suitable N carrier are most important means for raising the yield of maize and improving plant efficiency in using nitrogen. The positive effects of N application on growth and yield of maize were demonstrated by several investigators [8-11]. Increasing grain protein content (GPC) and grain N uptake by applying higher fertilizer N rates is relatively inefficient (NUE decrease with increasing N levels), especially under dry soil conditions[12]. Sowers, *et al.* [13] found that the

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[1]fed.=4200 m^2

application of high N rates may result in poor N uptake and low NUE due to excessive N losses. Ma *et al.* [14] using 100 and 200 kg N /ha and indicated that increasing N fertilizer rates caused to increased the grain yield (by an average of 20 %) and NUE (by an average 17.5 %). The same trend was also reported by El-Gizawy [15] and Barbieri, *et al.* [16].

Maize grain yield is a result of grain yield per plant and number of plant per unit area. Therefore, studying the effect of plant density on grain yield is necessary for a wide range of conditions. Unfortunately, there is no single recommendation for all conditions, because the optimum plant density varies depending on environmental factors such as soil fertility, moisture supply, genotype, planting date, planting pattern and harvest time. Many studies have been conducted with the aim of determining the optimum plant density for maize. Bedeer *et al.* [17] reported that planting maize at density of 24000 plants/fed produced the maximum grain yield/fed, however, increasing plant density from 24 to 30 thousand plants/fed significantly decreased grain yield/plant. Zeidan *et al.* [18] reported that grain yield and many plant characteristics were affected by plant density.

This research was carried out to study the effect of N rates and plant density on ANE and maize yields following wheat and faba bean.

MATERIALS AND METHODS

Experimental Site and Soil Characteristics: Two field experiments were carried out in the Agricultural Research and Experimental Center, Faculty of Agriculture at Moshtohor, Kalubia Governorate, Benha University, during 2006 and 2007 seasons. The aim was to assess the effect of N rates and PD on maize yield following wheat and faba bean. The soil was clay textured with 1.85% organic matter. Results of soil analysis samples were taken from the surface 20 cm are reported in Table 1.

Treatments and Experimental Design: Each experiment included 24 treatments which were the combination of two previous crops (wheat and faba bean), four N rates (0, 40, 80 and 120 kg N/fed) and three plant population densities {18000 (33.3 x 70 cm), 24000 (25.0 x 70 cm) and 30000 (20 x 70 cm^2) plants/fed}.

To initiate the previous crop treatments, wheat and faba bean were planted in a randomized complete block design in the winter of 2005/06 and 2006/07. Recommended cultural practices for these crops were followed, but yields were not recorded. A split- split plot arrangement of a randomized complete block design with four replications was used with previous crops as main plots, nitrogen rates as subplots and plant population densities as sub-subplots. Plot size was 10.5 m^2 (3 x 3.5) having 5 ridges of 3 m in length and 0.7 m in width.

Crop Management Practices: Maize cv. TWC 351 (developed by the Maize Research Section of the Agricultural Research Center, Giza, Egypt) was planted on 12^{th} and 5^{th} June in 2006 and 2007 growing seasons, respectively. Two kernels were hand planted in each hill. Phosphorus fertilizer was applied before planting at the rate of 150 kg Calcium super phosphate (15.5 % P_2O_5)/fed. Plots were hand-thinned at the V_3-V_4 leaf stage (before the 1^{st} irrigation) to one plant per hill and the appropriate PD. The plots were hand hoed twice for controlling weeds before the first and second irrigations. Recommended pest control was applied when necessary. Ammonium nitrate (NH_4 NO_3-33.5 N %) was used as the nitrogen source in both seasons, which was applied in two equal doses, at the V_3-V_4 and at V_5-V_6 leaf stage (before the 1^{st} and 2^{nd} irrigations).

Data Collected: Time of tasseling and silking were determined as number of days from sowing to 50 % tasseling and silking on the whole plot basis. Plant and ear heights and area of the top most ear leaf were measured after 75 days from planting as the average of 10 plants. At growth stage R_1 (silking) average of thirty chlorophyll meter readings of the ear leaf were taken in each plot using a portable chlorophyll meter (SPAD-502, Minolta, Tokyo, Japan) and was expressed in arbitrary absorbance (or SPAD) values [20]. At harvest time the following data were recorded on 10 plants random samples: number of ears/plant, No. of grains/ear, 100-grain weight, ear weight, grains weight/ear. Grain yield ardab/fed (ardab=140 kg) was recorded on whole plot basis adjusted to 15.5 % moisture content. Grain protein content (GPC %) was estimated as N% X 6.25 on dry weight basis (N % in grain was determined by the

Table 1: Soil chemical analysis of the experimental site in 2006 and 2007 seasons

	2006				2007			
Preceding crop	pH	N %	P%	K%	pH	N %	P%	K%
Wheat (Sakha 93)	7.8	0.13	0.14	0.45	7.4	0.11	0.12	0.52
Faba bean (Giza 843)	8.0	0.23	0.16	0.48	7.8	0.28	0.21	0.50

* Available N, P and K were determined according to Black [19]

microkjeldahl method according to A.O.A.C. [21]. Grain nitrogen uptake per unit area was obtained as a product of grain N content and grain yield per unit area (kg /fed), Agronomic nitrogen efficiency (ANE; kg grains increase/kg N applied) as the ration of (Grain yield F – Grain yield C) to N applied. Apparent N recovery in grains (ANR; grain N uptake per unit of N supply) as the ratio of (N uptake F – N uptake C) to N applied. Where F = Fertilized plots and C = non-fertilized plots (control). These characters were calculated according to Craswall and Godwin [22].

Statistical Analysis: Data were statistically analyzed according to Gomez and Gomez [23] using the MSTAT-C Statistical Software Package [24]. Where the F- test showed significant differences among means, Least Significant Differences (LSD) test was performed at the 0.05 level of probability to separate means.

RESULTS AND DISCUSSION

The Effect of the Preceding Crops: Data in Table 2 indicate that the preceding winter crops had insignificant effect on the average number of days to 50 % tasseling and silking. The data revealed that time to anthesis and days to silking of maize preceded by faba bean was shorter as compared with maize preceded by wheat. Moreover, differences were not great enough to reach the 5 % level of significance. Data presented in the same Table show clearly that plant height of maize and chlorophyll concentration (SPAD-units) preceded by faba bean were higher than when maize plants were preceded by wheat. However, the analysis of variance revealed insignificant differences among faba bean and wheat on ear height and ear leaf area. There are significant effects ($P<0.05$) for faba bean on ear weight; grain weight/ear and grain yield/fed (Table 3). Whereas, 100-grain weight

Table 2: Effect of preceding crops, N rate and plant density on flowering date, plant and ear height, ear leaf area and chlorophyll content of maize in 2006 and 2007 seasons

	50 % Tassling		50 % Silking		Plant height(cm)		Ear height (cm)		Ear leaf area (cm^2)		Chlorophyll SPAD-units	
Treatments	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Preceding crops												
Wheat	60.8	61.5	63.2	64.1	235.9	233.4	113.1	112.3	576.8	567.7	38.8	40.0
Faba bean	60.7	61.1	63.0	63.8	244.2	243.8	112.5	114.6	584.8	573.0	44.4	45.7
F test	n.s	n.s	n.s	n.s	*	*	n.s	n.s	n.s	n.s	**	**
N rates kg/fed												
0	61.8	62.3	63.7	64.7	226.2	219.1	99.7	95.8	498.3	495.4	33.8	33.7
40	61.0	61.5	63.5	64.2	233.5	236.3	113.1	113.3	556.4	536.0	39.7	39.8
80	60.5	61.2	63.0	63.7	248.6	242.0	117.5	117.5	629.5	612.2	43.0	45.9
120	59.8	60.3	62.5	63.0	251.8	256.8	120.9	127.4	639.1	637.7	49.9	52.0
LSD 5%	0.4	0.5	0.5	0.3	4.9	5.6	2.9	4.1	9.5	19.3	1.3	2.2
PD 1000/fed												
18	59.8	60.1	62.4	62.9	227.2	225.3	105.7	106.4	604.5	583.9	44.0	45.9
24	60.9	61.5	63.1	64.1	240.9	238.6	112.1	113.5	582.1	576.7	41.0	42.6
30	61.7	62.4	63.9	64.8	252.0	251.8	120.5	120.5	555.9	550.4	39.8	40.0
LSD 5%	0.3	0.4	0.3	0.2	2.5	3.1	2.8	2.0	4.2	16.9	0.9	1.0
F test Prob.						*P>F*						
PC	n.s	n.s	n.s	n.s	*	*	n.s	n.s	n.s	n.s	**	**
N	**	**	**	**	**	**	**	**	**	**	**	**
PD	**	**	**	**	**	**	**	**	**	**	**	**
PC * N	n.s	*	n.s	*	n.s	*	**	n.s	n.s	n.s	n.s	n.s
PC * PD	*	n.s	*	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
N * PD	n.s	n.s	n.s	*	*	n.s	n.s	n.s	n.s	n.s	n.s	n.s
PC * N * PD	n.s	n.s	*	*	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
CV, %	1.10	0.99	1.11	0.91	2.15	2.61	4.98	3.57	1.45	5.90	4.59	4.58

*, ** significantly different at 0.05 and 0.01 probability levels, respectively n.s: not significant

Table 3: Effect of preceding crops, N rate and plant density on number of ears/plant, number of grains/ear, 100-grain weight, ear weight, grain weight/ear and grain yield/fed of maize in 2006 and 2007 seasons

	No. ears/plant		No. grains/ear		100-grain wt. (g)		Ear wt. (g)		Grain wt./ear (g)		Grain yield ardab/fed	
Treatments	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Preceding crops												
Wheat	0.97	0.99	541.9	562.9	33.2	31.7	227.8	232.1	196.0	198.6	21.4	21.3
Faba bean	1.05	1.04	546.0	568.0	34.0	33.7	240.8	242.7	206.4	208.4	22.7	22.5
F test	*	n.s	n.s	n.s	n.s	*	**	*	**	*	**	*
N rates kg/fed												
0	0.78	0.80	375.4	405.2	30.9	29.3	207.5	201.0	171.8	166.4	17.6	18.2
40	1.06	1.06	556.4	577.8	33.2	32.2	228.4	233.0	197.2	197.2	20.6	21.1
80	1.09	1.06	596.4	626.2	34.0	32.8	234.1	242.0	200.6	209.5	23.9	23.3
120	1.12	1.14	647.7	652.6	36.2	36.3	267.5	273.7	235.1	240.8	26.1	24.9
LSD 5%	0.03	0.06	10.5	16.1	0.7	0.9	5.8	5.8	6.6	5.4	0.6	0.9
PD 1000/fed												
18	1.08	1.09	564.0	589.1	34.7	34.1	244.1	250.1	209.9	215.3	22.2	21.9
24	1.01	1.02	540.1	562.4	33.5	32.5	233.4	236.4	201.5	203.9	22.6	22.1
30	0.94	0.93	527.8	544.8	32.5	31.4	225.5	225.8	192.1	191.4	21.3	21.6
LSD 5%	0.03	0.03	5.4	15.5	0.4	0.4	2.0	3.0	2.5	3.3	0.3	n.s
F test Prob.						*P>F*						
PC	*	n.s	n.s	n.s	n.s	*	**	*	**	*	**	*
N	**	**	**	**	**	**	**	**	**	**	**	**
PD	**	**	**	**	**	**	**	**	**	**	**	n.s
PC * N	**	n.s	**	n.s	n.s	n.s	**	n.s	**	*	*	n.s
PC * PD	n.s	n.s	n.s	n.s	n.s	n.s	**	n.s	n.s	n.s	n.s	n.s
N * PD	n.s	n.s	*	*	n.s	*	n.s	*	n.s	n.s	n.s	*
PC * N * PD	n.s	n.s	n.s	n.s	n.s	n.s	*	*	*	*	n.s	n.s
CV, %	5.95	6.44	1.99	5.48	2.87	2.72	1.74	2.53	2.51	3.23	3.41	5.08

*, ** significantly different at 0.05 and 0.01 probability levels, respectively n.s: not significant

in the 1st season, number of ears/plant in the 2nd season and number of grains/ear in both seasons were not affected. The highest values were observed from maize grown after faba bean and the lowest values were observed for maize grown after wheat in both seasons. Grain yield of maize grown after faba bean was higher than after wheat by 1.3 and 1.2 ardab/fed in the 1st and 2nd seasons, respectively. These increases correspond to 6.07 % in the 1st season and 5.63 %in the2nd seasons. These results could be attributed to the effect of faba bean as a legume crop in enriching the soil with N and organic matter and the effect of its residues in improving the physical, chemical and biological characters of the soil. These induced better growth of the following maize. These results are in agreement with those obtained by Badr [1] Shams [2] and Abd El-All [25] who found that maize grown after legume crops gave higher yield than after cereal crops.

Results of analysis revealed that the highest GPC% and grain N uptake were obtained after faba bean while the lowest means were noticed after wheat (Table 4). These results showed that legume residues had higher nitrogen content than non-legume crops [26].

Data in Table 4 indicate that agronomic nitrogen efficiency (ANE) of maize preceded by wheat insignificantly increased as compared with maize preceded by faba bean. It is evident from the same Table that the differences between the average values of preceding crops on apparent nitrogen recovery (ANR) were not significant in both growing seasons. Similar results were also reported by Shams [2].

The Effect of N Fertilizer Rates: Nitrogen fertilizer caused a significant decrease ($P<0.05$) in the time to 50 % tasseling and silking in both seasons. A higher N rate (120 kg N/fed) significantly decreased tassilling and silking date (Table 2). These results might be due to the positive effect of N on tassling and silking due to its role on C/N ration in maize plants. Increasing N rates significantly increased growth characters, i.e. plant and ear height, ear leaf area and chlorophyll SPAD-units at

Table 4: Effect of preceding crops, N rate and plant density on grain protein content (GPC), grain N uptake, agronomic N efficiency and apparent N recovery in 2006 and 2007 seasons

	GPC %		Grain N uptake kg/fed		ANE kg/kg		ANR kg/kg	
Treatments	2006	2007	2006	2007	2006	2007	2006	2007
Preceding crops								
Wheat	6.82	6.86	33.5	33.5	12.21	9.58	0.23	0.28
Faba bean	7.51	8.24	39.1	42.1	8.58	8.29	0.25	0.22
F test	**	**	**	**	n.s	n.s	n.s	n.s
N rates kg/fed								
0	5.46	5.70	21.6	23.5	--	--	--	--
40	6.74	7.60	31.1	36.1	10.32	10.20	0.24	0.31
80	7.83	8.28	42.0	43.2	10.94	8.82	0.25	0.24
120	8.62	8.62	50.6	48.4	9.92	7.78	0.24	0.20
LSD 5%	0.37	0.51	1.7	3.3	n.s	1.59	n.s	0.04
PD 1000/fed								
18	7.65	8.16	39.1	40.9	10.90	7.33	0.28	0.27
24	6.97	7.42	36.2	37.6	9.99	9.53	0.23	0.26
30	6.87	7.07	33.7	34.9	10.29	9.94	0.22	0.23
LSD 5%	0.24	0.26	1.4	1.5	n.s	1.74	0.03	n.s
F test Prob.				*P>F*				
PC	**	**	**	**	n.s	n.s	n.s	n.s
N	**	**	**	**	n.s	*	n.s	*
PD	**	**	**	**	n.s	*	*	n.s
PC * N	*	*	*	n.s	*	n.s	n.s	n.s
PC * PD	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
N * PD	*	n.s	*	n.s	n.s	n.s	n.s	n.s
PC * N * PD	n.s	n.s	n.s	*	n.s	n.s	n.s	n.s
CV, %	6.89	6.83	7.85	7.89	25.8	23.3	20.8	25.1

*, ** significantly different at 0.05 and 0.01 probability levels, respectively n.s: not significant

Table 5: Effect of the interaction between preceding crops and nitrogen rates

N rates	Tassling date	Silking date	Plant height(cm)	Ear height(cm)	Ears/ plant	Grains/ ear	Ear wt.(g)	Grain wt. /ear(g)		Yield ardab/fed	ANE Kg/kg
kg/fed	2007	2007	2007	2006	2006	2006	2006	2006	2007	2006	2006
Wheat											
0	62.5	65.0	220.4	98.3	0.70	379.1	201.6	167.9	163.3	16.5	--
40	60.4	63.2	226.6	116.2	1.02	542.0	226.0	194.8	198.3	20.6	14.2
80	62.3	64.5	235.0	115.0	1.07	604.5	220.8	187.9	197.5	23.4	12.1
120	61.0	63.5	251.6	122.9	1.10	642.0	262.9	233.3	235.5	25.3	10.2
Faba bean											
0	62.0	64.5	217.9	101.2	0.85	371.6	213.3	175.8	169.5	18.8	--
40	62.5	65.3	246.0	110.0	1.10	570.8	230.7	199.5	196.2	20.6	6.3
80	60.1	62.9	249.1	120.0	1.10	588.3	247.4	213.3	221.6	24.4	9.8
120	59.6	62.5	262.0	119.0	1.13	653.3	272.0	237.0	246.2	27.0	9.5
LSD 5%	0.6	0.5	6.9	4.2	0.54	14.8	8.2	9.3	7.6	0.9	3.4

75 days from planting (Table 2). Loecke *et al.* [27] found that chlorophyll meter reading of corn ear leaves at growth stage R_1 responded positively to urea application rates. The results in Table (3) showed that N application results in increasing significantly (*P<0.05*) No. of ears/plant, No. of grains/ear, ear weight, grain weight/ear, 100-grain weight and grain yield/fed. The higher N rate (120 kg N/fed) was more effective in increasing grain yield. This might be due to the well utilization of N fertilizer in metabolism and meristimic activity which improved growth characters and yield components. The application of 40, 80 and 120 kg N/fed increased the grain yield over the control treatment by 3.0, 6.3, 8.5 ardab in the 1st season and by 2.9, 5.1, 6.7 ardab in the 2nd season, respectively.

These increases correspond to 17.04, 35.79 and 48.29% in the first season and 15.93, 28.02 and 36.81%in the second season. These results indicate that the experimental soil was deficient with regard to available N (Table 1). The marked increase in growth characters and yield components contributed for the significant increase in maize grain yield.

The present results indicated clearly the vital role of N in plant life and its contribution in increasing the grain yield. Such results clarified that N is essential for cell division and elongation as well as the root growth and dry matter content of maize plants [26]. Gungula ***et al.*** [9] reported that the highest grain yield was recorded at 120 kg N/ha.

Results in Table 4 indicated clearly that GPC% and grain N uptake markedly increased with the increase in N rates in both seasons. In 2006, applying N at 40, 80 and 120 kg/fed increased N uptake in grain by 43.9, 94.4 and 134.2 % compared with the check treatment, respectively. In 2007, the same N rates increased N uptake by 53.6, 83.8 and 105.9 %, respectively. It is evident that the highest N rates i.e. 120 kg/fed caused a marked increase in N uptake compared with the lower rates.

Agronomic N efficiency decreased due to the increase in N rates in the second season only. In 2007 season applying N at 40, 80 and 120 kg/fed produced ANE of 10.20, 8.82 and 7.78 (kg grains/kg N applied). Moreover, further investigations are needed to study the efficient use of the higher N rates than had been used in the present work.

In 2006 season, N recovery was estimated as 0.24, 0.25 and 0.24 kg/kg for N rates of 40, 80 and 120 kg/fed, respectively. In 2007 season a gradual decreased was observed with the increase in N rates and the same rates of N produced N recovery of 0.31, 0.24 and 0.20 kg/kg, respectively. Similar results were also reported by El-Gizawy [15] who found that ANE, ANR decreased and N uptake increased as N rate increased up to 150 kg/fed. Similar values of ANE and ANR were obtained by Berenguer *et al.* [11].

The Effect of Plant Densities: Increasing planting density significantly delayed ($P<0.05$) tassling and silking date, but increased plant and ear height in both seasons. However, ear leaf area and chlorophyll concentration were significantly decreased with increasing plant density (Table 2). This may be due to increasing the competition between plants for the seraphic and climatic environmental resources. Similar trend was obtained by several investigators among them are El-Sheikh [28] and Baributsa *et al.* [29].

Number of ears/plant, number of grains/ear, ear weight, grains weight/ear and 100-grain weight significantly decreased for each increment increase in plant density in both seasons (Table 3). On the other hand, plant density of 24000 plants/fed was produced the highest grain yield in 2006 season only. Our findings are in good agreement with those obtained of Bedeer *et al.* [17] who reported that planting maize at density of 24000 plants/fed produced the maximum grain yield/fed, however, increasing plant density from 24 to 30 thousand plants/fed significantly decreased grain yield/plant. Bavec and Bavec [30] found that grain yield of maize increases when plant population (PP) was increased from 7 to13 plants/m^2. Monneveux *et al.* [31] showed that the SPAD values were lower under high plant population.

Plant density showed a significant effect ($P<0.05$) on the average ANE in the 2nd season. It is clear from Table 4 that the highest ANE was produced by using 24000 plants/fed. Apparent N recovery (ANR) was significantly increased by increasing plant density up to 24000 plants/fed in the 1st season. Similar results were also found by El-Sheikh [28].

The Effect of Interactions: Table 5 show significant interaction effects between preceding crops and N fertilizer on plant and ear heights, number of ears/plant, number of grains/ear, ear weight, grain yield/fed and ANE in the 1st season, tassling and silking dates in the 2nd season and grain weight/ear in both seasons. Results also indicated that maize grown after faba bean and receiving 120 kg N/fed recorded maximum plant and ear heights, number of ears/plant, number of grains/ear, ear weight and grain yield/fed, while the lowest values of this treats were obtained when maize was sown after wheat under zero control. Maize plants fertilized with 120kg N/fed following faba bean reached flowering time earlier, while those unfertilized with N following wheat were the latest in this respect. Sowing maize after wheat and receiving 40 kg N/fed gave high ANE. Goodroad and Jellum [32] found

Table 6: Effect of the interaction between preceding crops and plant densities

Treatments	Tassling date	Silking date	Ear wt. (g)
PD 1000/fed	2006	2006	2006
Wheat			
18	60.1	62.7	238.6
24	60.9	63.2	227.8
30	61.6	63.8	217.1
Faba bean			
18	59.5	62.0	249.6
24	60.8	63.1	239.0
30	61.8	64.0	234.0
LSD 5%	0.47	0.49	2.9

Table 7: Effect of the interaction between nitrogen rates and plant densities

N rates kg/fed	PD 1000/fed	Silking date 2007	Plant height (cm) 2006	Grains/ ear 2006	Grains/ ear 2007	100- grain wt. (g) 2007	Ear wt. (g) 2007	Yield ardab/fed 2007
0	18	63.1	211.2	395.0	458.7	29.6	219.3	18.7
	24	65.2	227.5	376.2	387.5	29.5	197.5	18.3
	30	66.5	240.0	355.0	369.3	28.8	186.2	17.6
40	18	63.5	218.7	572.5	593.1	33.5	243.7	20.7
	24	64.2	231.8	550.0	577.8	32.5	233.7	21.8
	30	65.1	250.0	546.8	562.5	30.8	221.6	21.0
80	18	62.6	239.1	627.5	641.2	34.6	253.7	23.0
	24	64.2	250.6	588.7	631.7	32.5	241.2	23.0
	30	64.5	256.2	573.1	605.6	31.5	231.2	23.8
120	18	62.3	240.0	661.2	663.5	38.7	283.7	25.4
	24	62.8	253.7	645.6	652.5	35.7	273.1	25.4
	30	63.8	261.7	636.2	641.8	34.5	264.3	24.0
LSD 5%		0.6	5.1	10.8	31.1	0.8	6.0	1.1

Table 8: Effect of the interaction between preceding crops, nitrogen rates and plant densities

N rates kg/fed	PD 1000/fed	Silking date (day) 2006	Silking date (day) 2007	Ear weight (g) 2006	Ear weight (g) 2007	Grain weight/ear (g) 2006	Grain weight/ear (g) 2007	Grain N uptake kg/fed 2007
Wheat								
0	18	63.5	63.7	213.7	212.5	175.0	173.7	19.8
	24	64.4	65.2	200.0	195.0	167.5	165.0	18.9
	30	65.0	66.0	191.2	186.2	161.2	151.2	15.3
40	18	63.7	62.5	235.7	243.7	203.2	210.0	34.6
	24	63.5	63.0	228.7	238.7	200.0	203.7	35.4
	30	63.7	64.2	213.7	217.5	181.2	181.2	28.6
80	18	62.5	63.0	233.7	245.0	201.2	211.2	42.2
	24	63.0	65.5	217.5	230.0	185.0	197.5	38.8
	30	63.5	65.5	211.2	216.2	177.5	183.7	39.8
120	18	61.2	62.7	271.2	278.7	240.0	242.5	49.0
	24	62.5	63.2	265.0	265.0	236.2	234.0	40.3
	30	63.2	64.5	252.5	257.5	223.7	230.0	39.2
Faba bean								
0	18	62.0	62.5	218.7	226.2	187.5	190.0	31.0
	24	63.0	65.2	211.2	200.0	175.0	165.0	27.5
	30	64.7	66.0	210.0	186.2	165.0	153.7	28.5
40	18	61.2	64.5	237.5	243.7	206.2	208.7	43.1
	24	64.0	65.5	230.0	228.7	197.5	196.2	38.6
	30	64.7	66.0	224.7	225.7	195.0	183.7	35.9
80	18	62.7	62.2	257.2	262.5	221.2	231.2	49.9
	24	63.0	63.0	246.2	252.5	213.7	221.2	42.8
	30	63.5	63.5	238.7	246.2	205.0	212.5	46.1
120	18	62.2	62.0	285.0	288.7	244.7	255.0	57.8
	24	62.5	62.5	268.7	281.2	237.5	248.7	58.3
	30	63.2	63.2	262.5	271.2	228.7	235.0	45.9
LSD 5%		1.1	0.8	5.8	8.5	7.2	9.3	4.2

that maximum nitrogen use efficiency was obtained when the nutrient concentration was near the critical level and was bounded with the lowest rate of nitrogen applied to maize plants. Similar results were also found by Shams [2].

Table 6 revealed that the interaction between preceding crops and plant density had significant effect ($P<0.05$) on tassling and silking dates and ear weight in the 1st season only. Planting maize after faba bean and using 18000 plants/fed induced early flowering and recorded the highest values of ear weight.

Nitrogen fertilizer rates and plant density interaction (Table7)was significant for plant height in the 1st season, silking date, 100-grain weight, ear weight and grain yield /fed in the 2nd season and number of grains/ear in both seasons. Plant density of 18000 plants/fed with 120 kg/fed gave the highest grains/ear, 100-grain weight, ear weight and grain yield/fed. Similar results were also reported by El-Sheikh [28].

There was also a second order interaction which involved the three factors of this study (Table 8). Sowing maize following faba bean and/or wheat and receiving 120 kg N/fed with 18000 or 24000 plants/fed reached silking time earlier. Maize plants grown after faba bean and receiving 120 kg N/fed with the lowest density (18000 plants/fed) gave the highest ear weight and grain weight/ear in both seasons. The lowest values of these traits were shown when maize was grown after wheat and receiving no N fertilizer with the highest PD (30000 plants/fed). Maize after faba bean and receiving 120 kg N/fed with 18000 and/or 24000 plants/fed gave the highest grain N uptake in 2006. The lowest values of these traits were shown by maize grown after wheat receiving no N fertilizer with 30000 plants/fed.

CONCLUSION

It could be concluded that under the conditions of the current experiment, maize grown after faba bean and receiving 120 kg N/fed at plant density of 18000 plants/fed is recommended for maize production. On the other side, agronomic nitrogen efficiency (ANE) of maize preceded by wheat insignificantly increased as compared with maize preceded by faba bean.

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REFERENCES

1. Badr, S.K.A., 1999. Effect of some preceding winter crops and application time of micro-nutrients on growth, yield and yield components of yellow maize in sandy soil. Minufiya J. Agric. Res., 24(3): 895-909.
2. Shams, S.A.A., 2000. Effect of some preceding winter crops, nitrogen levels and zinc foliar application on grain yield of maize (*Zea mays*, L). Annals of Agric. Sci., Moshtohor, 38(1): 47-63.
3. Khalil, H., S.Sh. El-Tabbakh, M.M. El-Ganbeehy and S.E. Toaima, 2001. Maize response to preceding winter crops and phosphorus levels. J.Agric., Sci., Mansoura Univ., 26(1): 105-115.
4. El-Douby, K.A., 2002. Effect of preceding crops and bio-mineral fertilizer on growth and yield of maize. Annals of Agric. Sci., Moshtohor, 40(1): 27-37.
5. Toaima, S.E.A. and S.A. Saleh, 2003. Yield and yield components of maize and sunflower as affected by preceding crops and N-fertilizer level. J. Agric. Sci. Mansoura Univ., 28(4): 2467-2476.
6. Varvel, G.E. and T.A. Peterson, 1990. Residual soil nitrogen as affected by continuous two-year and four-year crop rotation systems. Agron. J., 82: 958-962.
7. MacCall, D., 1991. Studies on maize (*Zea mays*,L) at Bunda, Malwi, II: Yield in short rotation with legume. Exp. Agric., 25: 367-374.
8. Al-Kaisi, M. and X. Yin, 2003. Effects of nitrogen rate, irrigation rate and plant population on corn yield and water use efficiency. Agron. J., 95: 1475-1482.
9. Gungula, D.T., A.O. Togun and J.G. Kling, 2005. The influence of N rates on maize leaf number and senescence in Nigeria. World J. Agric.,Sci., 1(1): 1-5.
10. Al-Kaisi, M. and D. Kwaw-Mensah, 2007. Effect of tillage and nitrogen rate on corn yield and nitrogen and phosphorus uptake in a corn-soybean rotation. Agron. J., 99: 1548-1558.
11. Berenguer, P., F. Santiveri, J. Boixadera and J. Lloveras, 2009. Nitrogen fertilization of irrigated maize under meditrranean conditions. Europ. J. Agron., 30: 163-171.
12. Gauer, L.E., C.A. Grant, D.T. Gehl and L.D. Bailey, 1992. Effects of nitrogen fertilization on grain protein content, nitrogen uptake and nitrogen use efficiency of six spring wheat (*Triticum aestivum* L.) cultivars in relation to estimated moisture supply. Can.J.Plant Sci., 72: 235-241.

13. Sowers, K.E., W.L. Pan, B.C. Miller and J.L. Smith, 1994. Nitrogen use efficiency of split nitrogen application in soft white winter wheat. Agron. J., 86: 942-948.
14. Ma, B.L., L.M. Dwyer and E.G. Gregorich, 1999. Soil nitrogen amendment effect on nitrogen uptake and grain yield of maize. Agron. J., 91: 650-656.
15. EL-Gizawy, N.Kh.B., 2005. Effect of irrigation intervals, nitrogen rates and spraying with zinc on yield, uptake and agronomic efficiency of nitrogen in maize. Annals of Agric. Sci., Moshtohor, 43(3): 1007-1020.
16. Barbieri, P.A., H.E. Echeverría, H.R. Saínz Rozas and F.H. Andrade, 2008. Nitrogen use efficiency in maize as affected by nitrogen availability and row spacing. Agron. J., 100: 1094-1100.
17. Bedeer, A.A., Sh. A. Gouda and M.M. Ragheb, 1992. Response of different maize varieties to plant population density and nitrogen fertilization under farmer's condition. Egypt. J. Appl.Sci., 7(7): 1-14.
18. Zeidan, M.S., A. Amany and M.F. El-Kramany, 2006 Effect of N-fertilizer and plant density on yield and quality of maize in sandy soil. Res. J. of Agric. and Biol. Sci., 2(4): 156-161.
19. Black, C.A., 1965. Methods of Soil Analysis. Am. Soc. Agron. Madison, Wisc. USA
20. Dwyer, L.M., M. Tollenaar and L. Houwing, 1991. A non-destructive method to monitor leaf greenness in corn. Can. J. Plant Sci., 71: 505-509.
21. A.O.A.C. 1990. Official tentative methods of Analysis of Association of Official Analytical Chemists. Washington.D.C., 15th Ed.
22. Craswell, E.T. and D.C. Godwin, 1984. The efficiency of nitrogen fertilizers applied to cereals in different climates In Tinker, P.B. and A. Luchli (ed).Advances in Plant Nutrition, Vol.1.Praeger.
23. Gomez, A.K. and A.A. Gomez, 1983. Statistical Procedures for Agricultural Research. 2nd ed. John Wiley and Sons, New York.
24. Michigan State University, 1983. MSTAT-C: Micro-computer Statistical Program, Version 2. Michigan State University, East Lansing.
25. Abd El-All, A.M., 2002. Effect of preceding crops, organic and mineral nitrogen and plant density on productivity of maize plant. J. Agric.Sci., Mansora Univ., 27(12): 8093-8105.
26. Marschner, H., 1995. Mineral Nutrition of Higher Plants. Academic Press Inc.London LTD.
27. Loecke, T.D., M. Liebman, C.A. Cambardella and T.L. Richard, 2004. Corn response to composting and time of application of solid swine manure. Agron. J., 96: 214-223.
28. El-Sheikh, F.T., 1998. Effect of plant population density on nitrogen use efficiency of some maize varieties. Annals of Agric. Sci., Moshtohor, 36(1): 143-162.
29. Baributsa, D.N., E.F. Foster, K.D. Thelen, A.N. Kravchenko, D.R. Mutch and M. Ngouajio, 2008. Corn and cover crop response to corn density in an interseeding System. Agron. J., 100: 981-987.
30. Bavec, F. and M. Bavec, 2002. Effect of plant population on leaf area index, cob characteristics and grain yield of early maturing maize cultivars (FAO 100-400). Europ. J. Agron., 16: 151-159.
31. Monneveux, P., P.H. Zaidi and C. Sanchez, 2005. Population density and low nitrogen affects yield-associated traits in tropical maize. Crop Sci., 45: 535-545.
32. Goodroad, L.L. and D. Jellum, 1988. Effect of N fertilizer rate and soil pH on N efficiency in corn. Plant Soil, 106: 85-89.