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Response of Maize (*Zea Mays* L.) to Plant Population Density and Nitrogen Fertilizer Levels

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ABSTRACT

An experiment was conducted at Agricultural Research Station, Faculty of Agriculture (Saba- Basha), Alexandria University, Egypt, during 2017 summer season to study response of single cross 10 (S.C. 10) to four plant population densities (19000, 23000, 27000 and 30000 plants/ fed) as main plot factor and four nitrogen fertilizer levels (100, 120, 140 and 160 kg/ fed) as sub-plot factor using split-plot design in three replications. The lowest plant density (19000 plants/ fed.) produced the shortest plants (216.38 cm), lowest ear height (139.42 cm), lowest leaf area index (4.36), earliest 50% silking (64.11 days), lowest barren stalks (2.17%) and lowest grain yield/ fed. (3.769 ton).Conversely, it produced the highest number of ears/ plant (1.22), tallest ears (26.62 cm), thickest ears (4.54 cm), highest number of kernels/ row (48.74), heaviest 100-kernel weight (43.29 g) and highest grain yield/ plant (200.09 g). However, the highest nitrogen fertilizer level (160 kg/ fed) produced the highest values for all the studied traits, except barren stalks percentage, where it reached the lowest level (4.04%). Sowing maize at 30000 plants/ fed under 140 or 160 kgN/ fed/., produced the highest leaf area index values (9.11 and 9.47), respectively, while 100 kgN/ fed., application gave the highest barren stalks (14.73%). The lowest plant density (19000 plants/ fed) treated with 160 kgN/ fed produced the highest number of ears/ plant, kernels/ row and grain yield/ plant (1.58, 56.92 and 225.19 g), respectively. The highest grain yield/ fed (4.673, 4.811 and 4.841 t/ fed) resulted from sowing 23000 plants/ fed fertilized with 140 or 160 kgN/ fed and 27000 plants/ fed under 160 kgN/ fed application, respectively.

Key words: ***Zea mays*, Plant density, Nitrogen fertilization levels, Plant growth and Grain yield.**

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop in the world and Egypt, where it occupied the third rank after wheat and rice. It is used as a staple food for farmers or mixed with wheat flour for bread making, feed crop for animals and poultry industry, besides it is used for starch, ethanol and vegetable oil industries.

The total cultivated area of this crop reached 2.1 million feddan, and produced about six million ton of grains **(FAOSTAT, 2015)**, but this quantity is inadequate for consumption in Egypt. To overcome this gap between maize production and consumption, there are continuous efforts for releasing the new high potential and more resistant maize hybrids to biotic and abiotic stresses and application of the proper agricultural management from seed to seed, especially plant population density and nitrogen fertilization levels.

Increasing plant population density increased plant to plant competition for light and consequently increased plant and ear height, leaf area index and number of days from sowing to 50% silking (Abo-Shetaia *et al*., 2000; Hassan, 2000; Sangoi *et al*., 2002; Soliman *et al*., 2005; Takatlisidis *et al*., 2005; Saber, 2007 , Asif *et al*., 2010 and Hassan *et al.,2016*). Although, increasing plant density decreased ear number and traits and 100-kernel weight, it led to increase the grain yield/ ha (Abo-Shetaia *et al.*, 2000; Bruns and Abbas, 2005; Soliman *et al*., 2005; Sharifi *et al*., 2009; Dahmardeh, 2011 and Van Roekel and Coulter, 2011).

Nitrogen fertilizer is one of the most important factor for maize growth and grain yield, where it plays an essential role on yield and yield components, plant growth, chlorophyll and many enzymes (Singh and Totawat, 2002; Singh *et al*., 2003; Rasheed *et al*., 2004; Patel *et al*., 2006; Bharathi *et al*., 2010; Zhang *et al*., 2014; Iqbal *et al*., 2015; Mosaad 2016; Mehasen *et al*., 2015 and Ali and Anjum, 2017).

The main objective of this study was to investigate the effect of different plant population densities, nitrogen fertilization levels and their interaction on growth, grain yield and yield attributes of maize.

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MATERIALS AND METHODS

A field experiment was carried out at Agricultural Research Station, Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt, during 2017 summer season to study the effect of plant population density and nitrogen fertilizer levels, besides their interactions, on growth and productivity of maize single cross 10. The experiment was conducted in a split plot design in three replicates, where the four plant population densities (19000, 23000, 27000 and 30000 plants/ fed.) were randomly assigned to the main plots, while four nitrogen fertilizer levels (100, 120, 140 and 160 kg/ fed.) were arranged in sub-plots. Each sub-plot consisted of 6 ridges, 3.50 m length and 70 cm in width. Sowing date was mid May after wheat as a preceding crop and all agronomic practices were uniformly applied to each plot. Soil was clay in texture with pH 8.1 and contained organic matter of about 1.42%, $CaCO_3$ 6.7%, available nitrogen, phosphorus and potassium 0.9, 3.7 and 5.2 (mg/ kg), respectively. The recorded characters included plant and ear height, leaf area index, days to 50% silking, barren stalks %, number of ears/ plant, ear length and diameter, number of kernels/ row, 100-kernel weight, grain yield per plant per and feddan.

Data were statistically analyzed according to Gomez and Gomez (1984). Means were compared using least significant differences (L.S.D.) at 0.05 level of probability.

RESULTS AND DISCUSSION

Growth characters:

Results presented in Table (1) showed that the studied growth traits, i.e., plant and ear height, leaf area index, days to 50% silking and barren stalks percentage of maize single cross 10 were significantly affected by plant population density and nitrogen fertilization levels. Also, leaf area index and barren stalk percent were significantly affected by the interaction between the two factors under study.

Concerning plant and ear height, increasing plant population density of S.C. 10 from 19000 to 30000 plants/ fed. gradually increased both traits by 23.92% and 23.45% for plant and ear height, respectively, at 30000 plants/ fed compared with 19000 plants/ fed. That might be due to increase in the competition level for light between maize plants with increasing plant density. These results were in agreement with those reported by Abo-Shetaia *et al*. (2000), Hassan (2000), Sangoi e*t al.* (2002) and Takatlisidis *et al.* (2005) for both traits.

On the other side, increasing nitrogen fertilization levels significantly increased the two aforementioned characters, where the tallest plants (258.02 cm) and highest ear (172.98 cm) resulted from 160 kgN/ fed application. That could be due to nitrogen effect for increasing plant growth. Similar trend of results was reported by Patel *et al.* (2006), Iqbal *et al.* (2015), Mehasen *et al.* (2015) and Ali and Anjum (2017) for both traits, besides Shivay *et al.* (2002) and Suryavanshi *et al.* (2008) for plant height.

Regarding leaf area index, data presented in Table (1) indicated that increasing plant population density of maize up to 30000 plants/ fed produced the highest value of that trait (8.24), while the lowest plant population (19000 plants/ fed) gave the lowest leaf area index (4.36). That might be due to increasing number of maize plants in unit area. Bruns and Abbas (2005), Saber (2007), Dehdashi and Riahinia (2008) and Asif *et al.* (2010) reported similar results.

Results presented in Table (1), also showed that increasing nitrogen fertilization levels from 100 to 160 kg/ fed significantly increased leaf area index from 4.52 to 7.27. Similar results were reported by Patel *et al.* (2006), Suryavanshi *et al.* (2008), Iqbal *et al.* (2015), Mehasen *et al.* (2015) and Ali and Anjum (2017).

With respect to plant populations × nitrogen fertilization levels interaction effect on leaf area index, results in Table (3) showed that the highest leaf area index values (9.11 and 9.47) resulted from the highest plant density (30000 plants/ fed) fertilized with higher nitrogen levels (140 and 160 kg/ fed), respectively. On the contrary, the lowest values of that trait (3.35, 4.14 and 4.14) resulted from 100 and 120 kgN/ fed application to 19000 plants/ fed, in addition to 23000 plants/ fed with 100 kgN/ fed, respectively. Similar findings were reported by Shrestha (2013) and Zakir *et al*. (2017).

With respect to days to 50% silking, results presented in Table (1) revealed that increasing both studied factors led to significant delay in silking in maize plants, where the latest silking (72.36 and 73.21 days) and (72.93 and 73.11 days) resulted from sowing 27000 and 30000 plants/ fed., and application of 140 and 160 kgN/ fed, respectively. In contrast, the lowest plant density (19000 plants/ fed) and nitrogen fertilizer level of 100 kg/ fed produced the earliest silking (64.11 and 65.34 days), respectively. Mahgoub and El-Shenawy (2005), Soliman *et al.* (2005), Tokatlisidis *et al.* (2005), Kamara *et al.* (2006) and El-Mekser *et al.* (2009) reported similar results for plant population density effect and Mehasen *et al.* (2015) for nitrogen fertilization levels effect.

Considering percentage of barren stalks, increasing plant density of maize gradually increased the barren stalk percentage, where the lowest and highest percentages (2.17 and 11.89%) resulted from 19000 and 30000 plants/ fed., respectively. These results were in line with those found by Carena and Cross (2003), Maddonni *et al.* (2004), Ipsilandis and Vafias (2005) and Tokatlisidis *et al.* (2005).

Conversely, increasing nitrogen fertilization levels significantly decreased barren stalks percentage, where 100 and 160 kgN/ fed produced the highest and lowest baren stalk percentages (9.16 and 4.04%), respectively. Considering plant density × nitrogen levels interaction effect on that character, results in Table (3) demonstrated that the lowest percentage of barren stalk (0.97%) resulted from sowing 19000 plants/ fed fertilized with 160 kgN/ fed. However, sowing the highest plant density combined with the lowest nitrogen level (30000 plants/ fed × 100 kgN/ fed) showed the highest barren stalk percentage (14.73%), which could be due to inadequate nitrogen fertilizer for proper plant growth, fewer pollen grains formation and incomplete pollination, and kernel abortion. Similar trend of results was reported by Maddonni *et al.* (2004) and Mehasen *et al.* (2015).

Yield and yield attributes:

Data presented in Table (2) indicated that grain yield and its components, i.e. number of ears/ plant, ear length and diameter, number of rows/ ear, 100-kernel weight and grain yield per plant and feddan were significantly affected by both plant population density, nitrogen fertilization levels and their interactions, except ear length and diameter, and 100-kernel weight.

Increasing plant density from 19000 to 30000 plants/ fed significantly and gradually decreased number of ears/ plant from 1.22 to 0.88. Conversely, increasing nitrogen fertilization level from 100 to 160 kg/ fed. significantly and gradually increased number of ears/ plant from 0.81 up to 1.28 ears/ plant. This trend of results was reported by Sangoi *et al.* (2002), Mahgoub and El-Shenawy (2005), Takatlisidis *et al.* (2005), Abuzar *et al.* (2011) and Dahmardeh (2011) for plant density effect and Patel *et al.* (2006), Suryavanshi *et al*. (2008) and Mehasen *et al.* (2015) for nitrogen fertilizer level effect.

On the other hand, the highest number of ears/ plant (1.58) resulted from the lowest plant density (19000 plants/ fed.) fertilized with the highest nitrogen fertilization level (160 kg/ fed.) as shown in Table (3). That could be due to high light intensity exposure and decrease in the number of barren stalk percentage (Carena and Cross, 2003). In contrast, 30000 plants/ fed fertilized with 100 kgN/ fed produced the lowest number of ears/ plant (0.65) as shown in Table (3).

With regard to ear length and diameter, data in Table (2) illustrated that the maximum ear length and width (26.62 and 4.54 cm), respectively, resulted from the lowest plant population density (19000 plants/ fed.), while the highest plant density (30000 plants/ fed) gave the shortest and thinnest ears (21.14 and 3.36 cm), respectively. These results were in agreement with those reported by Abo-Shetaia *et al.* (2000), Hassan (2000), Sangoi *et al.* (2002), Takatlisidis *et al.* (2005) and Van Roekel and Coulter (2011).

Considering nitrogen fertilizer level effect on ear length and diameter, results presented in Table (2) revealed that increasing nitrogen levels gradually increased both ear traits and the maximum ear length (26.14 cm) and diameter (4.66 cm) resulted from 160 kgN/ fed. application. That could be due to that nitrogen element plays an essential role for plant growth, chlorophyll content and it is considered the key for increasing crop productivity. Similar results were reported by Bharathi *et al.* (2010).

With respect to number of kernels/ row, increasing population density from 19000 to 30000 plants/ fed showed gradual decrease in that trait from 48.74 to 31.38 kernels/ row as shown in Table (2). That could be due to reducing assimilate supply which causes abortion of kernels especially at the ear tip (Mahgoub and El-Shenawy, 2005). These results were in agreement with those reported by Abuzar *et al*. (2011) and Van Roeket and Coulter (2011).

Data presented in the same table, also demonstrated that increasing nitrogen fertilization level from 100 to 160 kgN/ fed. led to significant increase in number of kernels/ row by 47.40%. That might be due to the effect of nitrogen element on plant growth and dry matter production (Bharathi *et al*., 2010). On the other hand, this trait was significantly affected by plant density × nitrogen fertilizer level interaction as shown in Table (3). Results indicated that increasing nitrogen levels at the same plant density, generally increased number of kernels/ row. The lowest plant density (19000 plants/ fed) fertilized by the highest nitrogen level (160 kg/ fed) gave the maximum number of kernels/ row (56.92). On the contrary, the lowest number of kernels/ row (23.98) resulted from 30000 plants fertilized with 100 kgN/ fed.

Results in Table (2) pointed out that increasing plant population density of S.C. 10 above 23000 plants/ fed significantly decreased 100-kernel weight by 13.01 and 20.24% at 27000 and 30000 plants/ fed, respectively, compared with 19000 plants/ fed. Mahgoub and El-Shenawy (2005) reported that higher plant density reduces assimilates supply which causes abortion and decrease kernels weight, especially at the ear tip. Abo-Shetaia *et al*. (2000), Sangoi *et al.* (2002), Maddonni *et al.* (2004), Bruns and Abbs (2005), Ipsilandis and

Vafias (2005), Abuzar *et al.* (2011) and Van Roekel and Coulter (2011) found similar results.

Data in that table, also indicated that increasing nitrogen fertilization levels significantly increased kernel weight. The highest and lowest 100-kernel weight (43.25 and 35.67 g) resulted from fertilization with 160 and 100 kgN/ fed, respectively. These results agreed with those obtained by Singh *et al.* (2003), Bharathi *et al.* (2010) and Iqbal *et al.* (2015).

Concerning plant density effect on grain yield/ plant, data in Table (2) revealed that lower plant densities (19000 and 23000 plants/ fed) produced maximum grain yields/ plant (200.09 and 192.76 g), respectively, while the lowest plant grain weight (143.40 g) resulted from the highest plant density (30000 plants/ fed.). Because grain yield/ plant is considered a resultant of number of ears/ plant, ear characteristics and 100-kernel weight, and those traits had the highest values, besides the lowest barren stalks percentage, at the lowest plant population density (19000 plants/ fed), hence grain yield/ plant was the highest with that plant density. Similar trend of results was reported by Hassan (2000), Carena and Cross (2003), Soliman *et al.* (2005), Sharifi *et al.* (2009), Asif *et al.* (2010) and Van Roekel and Coulter (2011).

Conversely, increasing nitrogen fertilization levels from 100 to 160 kg/ fed significantly increased grain yield/ plant. The lowest grain yield/ plant (147.18 g) resulted from 100 kgN/ fed application, however the highest yield (197.72 g/ plant) resulted from fertilization with 160 kgN/ fed. These findings were in agreement with those reported by Singh *et al.* (2003), Rasheed *et al.* (2004) and Bharathi *et al.* (2010).

Plant population density × nitrogen fertilizer level interactions effect on grain yield/ plant, as shown in Table (2) indicated that the highest grain yield/ plant (225.16 g) resulted from 160 kgN/ fed application and the lowest plant density (19000 plants/ fed), followed by sowing (23000 plants/ fed) treated with 160 kgN/ fed, which produced (215.22 g/ plant). In contrast, using the highest plant population (30000 plants/ fed) fertilized with the lowest nitrogen level (100 kg/ fed) gave the lowest grain yield/ plant (119.38 g). That might be due to the amount of nitrogen applied was not adequate for the essential needs of plants in case of increasing plant population density.

With respect to grain yield/ fed., obtained results in Table (2) pointed out that increasing plant population density over 19000 plants/ fed significantly increased grain yield/ fed, however the differences between the three densities (23000- 30000 plants/ fed) did not reach the significance level. That could be due to the compensation effect between high yield/ plant under lower plant density and low plant yield under higher densities. Abo-Shetaia *et al.* (2000), Hassan (2000), Bruns and Abbas (2005), Soliman *et al.* (2005), Sharifi *et al.* (2009), Dahmardeh (2011) and Van Roekel and Coulter (2011) obtained the same trend of results.

Data in that table also revealed that increasing nitrogen fertilizer levels from 100 to 160 kg/ fed, gradually and significantly increased grain yield from 3.503 to 4.601 ton/ fed. That might be due to the essential role of nitrogen as a key factor for growth and photosynthesis in plants especially maize as cereal crop.

Table 1. Means of plant height, ear height, leaf area index, days to 50% silking and barren stalks (%) as affected by plant density, nitrogen levels and their interactions

Factor	Plant height (cm)	Ear height (cm)	Leaf area index	Days to 50% silking	Barren stalks percentage
Plant density/ fed					
19000	216.38 [d]	139.41 [c]	4.36 [d]	64.11 [c]	2.17 [d]
23000	238.21 [c]	157.62 [b]	5.15 [c]	69.88 [b]	4.54 [c]
27000	249.87 [b]	160.53 [b]	6.47 [b]	72.36 [ab]	7.66 [b]
30000	268.14 [a]	172.10 [a]	8.24 [a]	73.21 [a]	11.89 [a]
$L.S.D_{0.05}$	10.87	3.18	0.47	3.09	1.23
Nitrogen levels (kg/ fed.)					
100	227.02 [d]	139.68 [d]	4.52 [d]	65.34 [c]	9.16 [a]
120	237.42 [c]	149.24 [c]	5.72 [c]	68.18 [b]	7.32 [b]
140	250.12 [b]	167.76 [b]	6.68 [b]	72.93 [a]	5.73 [c]
160	258.02 [a]	172.98 [a]	7.27 [a]	73.11 [a]	4.04 [d]
$L.S.D_{0.05}$	6.13	2.16	0.35	1.97	1.03
Plant density× N. levels	N.S.	N.S.	**	N.S.	**

Means followed by the same letter(s) within the same column are insignificantly different at 0.05 level of probability.
** significant at 0.01 probability level.
N.S.: Not Significant

Table 2. Means of grain yield and its components as affected by plant density, nitrogen levels and their interactions

Factor	Number of ears/ plant	Ear length (cm)	Ear diameter (cm)	Number of kernels/ row	100-kernel weight (g)	Grain yield/ plant (g)	Grain yield (ton/ fed.)
Plant density/ fed							
19000	1.22 [a]	26.62 [a]	4.54 [a]	48.74 [a]	43.29 [a]	200.09 [a]	3.769 [b]
23000	1.09 [b]	23.96 [b]	4.22 [b]	42.17 [b]	41.87 [a]	192.76 [a]	3.346 [a]
27000	0.94 [c]	22.53 [c]	3.92 [c]	36.63 [c]	37.66 [b]	168.25 [b]	4.347 [a]
30000	0.88 [d]	21.14 [d]	3.36 [d]	31.38 [d]	34.53 [c]	143.40 [c]	4.137 [a]
$L.S.D_{0.05}$	0.06	0.79	0.14	2.14	1.89	8.17	0.242
Nitrogen levels (kg/ fed.)							
100	0.81 [d]	20.75 [d]	3.28 [d]	32.32 [d]	35.67 [d]	147.18 [d]	3.503 [d]
120	0.90 [c]	22.34 [c]	3.79 [c]	37.38 [c]	38.19 [c]	173.31 [c]	4.101 [c]
140	1.13 [b]	25.02 [b]	4.31 [b]	41.56 [b]	40.24 [b]	186.28 [b]	4.394 [b]
160	1.28 [a]	26.14 [a]	4.66 [a]	47.64 [a]	43.25 [a]	197.72 [a]	4.601 [a]
$L.S.D_{0.05}$	0.04	0.45	0.06	1.95	1.70	6.52	0.128
Plant density × N. levels	**	N.S.	N.S.	*	N.S.	*	**

Means followed by the same letter within the same column are insignificantly different at 0.05 level of probability.
* and ** significant at 0.05 and 0.01 probability levels, respectively.
N.S.: Not Significant

Table 3. Means of sowing date* hybrid interaction effects on leaf area index, barren stalks (%), number of ears/ plant, number of kernels/ row, grain yield per plant and per fed

Plant density	N levels (kg/fed)	Leaf area index	Barren stalks percentage	Number of ears/ plant	Number of kernels/row	Grain yield (g/ plant)	Grain yield (t/ fed)
19000	100	3.35 [e]	2.98 [g]	0.90 [ef]	40.89 [d]	160.01 [fg]	3.035 [e]
	120	4.14 [e]	2.33 [gh]	1.03 [de]	45.62 [c]	201.95 [c]	3.811 [cd]
	140	4.65 [de]	2.40 [g]	1.37 [b]	51.53 [b]	213.24 [b]	4.019 [c]
	160	5.30 [d]	0.97 [h]	1.58 [a]	56.92 [a]	225.16 [a]	4.211 [bc]
23000	100	4.14 [e]	7.33 [de]	0.91 [ef]	34.42 [e]	158.77 [fg]	3.573 [d]
	120	4.87 [de]	5.70 [ef]	0.97 [de]	40.22 [d]	190.86 [d]	4.329 [bc]
	140	5.40 [cd]	3.24 [g]	1.19 [c]	44.85 [c]	206.19 [bc]	4.673 [a]
	160	6.19 [c]	1.89 [g]	1.29 [bc]	49.19 [b]	215.22 [ab]	4.811 [a]
27000	100	4.92 [de]	11.61 [bc]	0.78 [f]	30.02 [f]	150.57 [g]	3.954 [c]
	120	5.22 [d]	8.23 [d]	0.79 [f]	33.43 [ef]	160.34 [fg]	4.212 [bc]
	140	7.59 [b]	6.14 [e]	1.01 [de]	38.11 [d]	173.22 [e]	4.744 [ab]
	160	8.15 [b]	4.66 [f]	1.18 [c]	44.96 [c]	188.87 [d]	4.841 [a]
30000	100	5.70 [cd]	14.73 [a]	0.65 [g]	23.98 [g]	119.38 [i]	3.451 [d]
	120	8.68 [ab]	13.02 [b]	0.84 [f]	30.25 [f]	140.09 [h]	4.054 [c]
	140	9.11 [a]	11.17 [c]	0.96 [e]	31.77 [ef]	152.48 [fg]	4.405 [b]
	160	9.47 [a]	8.64 [d]	1.07 [d]	39.52 [d]	161.65 [f]	4.640 [ab]
$\mathbf{L.S.D._{0.05}}$		0.88	1.42	0.11	3.42	10.16	0.340

Means followed by the same letter(s) within the same column are insignificantly different at 0.05 level of probability.

The same trend of results was reported by Singh *et al.* (2003), Rasheed *et al.* (2004), Barbieri *et al.* (2006), Patel *et al.* (2006), Bharathi *et al.* (2010), Zhang *et al.* (2014), Iqbal *et al.* (2015), Mehasen *et al.* (2015) and Ali and Anjum (2017).

Concerning plant density × nitrogen level interaction effect on grain yield/ fed, data in Table (3) showed that sowing 23000 plants/ fed under 140 or 160 kgN/ fed, and sowing 27000 plants/ fed fertilized with 160 kgN/ fed, produced the highest grain yields (4.673, 4.811 and 4.841 t/ fed), respectively. That could point out that the limiting factor for grain yield/ fed, under low and high plant densities, are the number of maize plants per feddan and nitrogen fertilization levels, respectively.

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الملخص العربي

إستجابة الذرة الشامية للكثافة النباتية ومستويات التسميد النيتروجينى

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أجريت تجربة حقلية خلال الموسم الصيفى لعام ٢٠١٧ بالمزرعة البحثية لكلية الزراعة (سابا باشا) لدراسة تأثير الكثافة النباتية ومستويات التسميد النيتروجينى المختلفة على نمو وإنتاجية الذرة الشامية (هجين فردى ١٠) وذلك باستخدام تصميم القطع المنشقة مرة واحدة فى ثلاث مكررات حيث مثلت الكثافات النباتية الأربع (١٩٠٠٠، ٢٣٠٠٠، ٢٧٠٠٠، ٣٠٠٠٠ نبات/ فدان) عامل القطع الرئيسية بينما مثلت مستويات التسميد النيتروجينى الأربعة (١٠٠، ١٢٠، ١٤٠، ١٦٠ كجم/ ف) عامل القطع الثانوية وقد أوضحت النتائج أن الكثافة النباتية المنخفضة (١٩٠٠٠ نبات/ ف) أدت إلى الحصول على أقصر النباتات طولاً (٢١٦،٣٨ سم) وأقل إرتفاع للكيزان (١٣٩،٤١ سم) بالإضافة إلى أقل دليل للمساحة الورقية (٤،٣٦) وأبكر النباتات طرداً للحريرة (٦٤،١١ يوماً من الزراعة) وأقل نسبة من النباتات العقيمة (٢،١٧%) وأقل محصول من الحبوب للفدان (٣،٧٦٩ طن)- وعلى النقيض من ذلك فقد أدت هذه الكثافة النباتية إلى زيادة عدد الكيزان على النبات (١،٢٢) وكذلك زيادة طول وقطر الكوز (٢٦،٦٢ سم، ٤،٥٤ سم) على الترتيب وزيادة عدد الحبوب للصف (٤٨،٧٤) وأثقل وزن للمائة حبة (٤٣،٢٩ جم) وأعلى محصول من الحبوب للنبات (٢٠٠،٠٩ جم).

من ناحية أخرى فقد أدى إستخدام أعلى مستوى من التسميد النيتروجينى (١٦٠ كجم/ ف) إلى الحصول على أعلى القيم لجيمع الصفات التى تم دراستها عدا نسبة النباتات العقيمة التى بلغت أقل قيمة لها (٤،٠٤%). وبالنسبة لتأثير التداخل بين كلا العاملين تحت الدراسة فقد أوضحت النتائج أن الكثافة النباتية المرتفعة ٣٠٠٠٠ نبات/ فدان والمسمدة بمعدل ١٤٠ أو ١٦٠ كجم ن/ ف أدت إلى الحصول على أعلى دليل للمساحة الورقية (٩،١١، ٩،٤٧) على الترتيب بينما أدى تسميد نفس الكثافة النباتية بأقل معدل من التسميد النيتروجينى (١٠٠ كجم/ ف) إلى الحصول على أقصى نسبة من النباتات العقيمة (١٤،٧٣%).

من جهة أخرى فقد أدت الزراعة بأقل كثافة نباتية (١٩٠٠٠ نبات/ ف) مع التسميد النيتروجينى المرتفع (١٦٠ كجم ن/ ف) إلى إنتاج أعلى عدد من الكيزان/ نبات (١،٥٨) وأكبر عدد الحبوب للصف (٥٦،٩٢) وأعلى محصول من الحبوب للنبات (٢٢٥،١٦ جم) بينما تم الحصول على أعلى محصول من الحبوب للفدان (٤،٦٧٣، ٤،٨١١ طن/ ف) من استخدام الكثافة النباتية ٢٣٠٠٠ نبات/ فدان بإستخدام ١٤٠ أو ١٦٠ كجم ن/ ف على الترتيب- وكذلك من زراعة ٢٧٠٠٠ نبات/ فدان مسمدة بمعدل (١٦٠ كجم ن/ ف) والتى أنتجت (٤،٨٤١ طن/ ف).