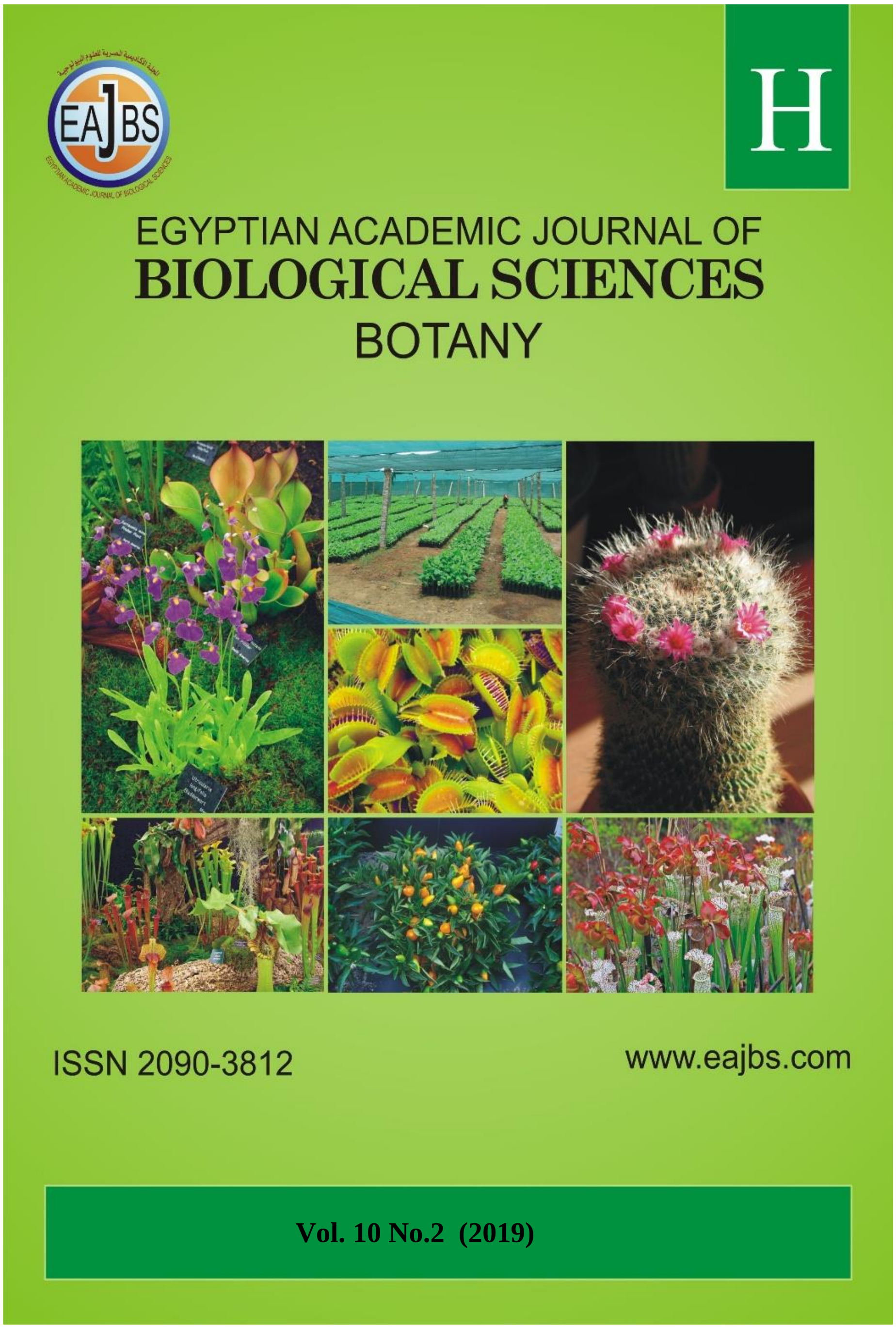

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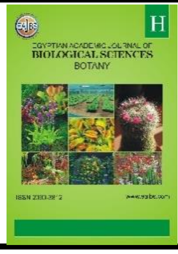

Maize Response to Population under High Levels of Nitrogen Fertilization

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ABSTRACT

To investigate the response of maize hybrids to plant population and nitrogen fertilization rates. Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture (Saba Basha), Alexandria University during 2018 and 2019 seasons. Factorial experiments (two factors) in randomized complete block design (RCBD). Whereas, the first factor was plant population (50000, 75000, 100000 plant/ha), while, the second factor was nitrogen fertilization rates (216, 288, 360, and 432 kg N/ha). The results revealed that ear length (cm), number of rows/ear, number of grains/row, number of grains/ear, 100-grains weight (g), grain yield (t/ha), straw yield, biological yield (t/ha), harvest index (%) and grain protein content (%) of maize hybrid were, significantly, affected by plant population and nitrogen fertilizer rates, where the highest grain yield was obtained by growing maize plant hybrid 3444 at a population of 75000 plant/ha under the application of 360 kg N/ha under the environmental conditions of Alexandria, Egypt.

INTRODUCTION

Maize or corn is the third most important staple food crop in terms of area and production after wheat and rice in Egypt. Also, in the world, it is one of the important cereal crops in the world after wheat and rice (Gerpacio and Pingali, 2007).

The plant population is an important factor that affects crop yield. The yield was increased by 4% with increasing plant density (Shapiro and Wortmann, 2006). Higher plant density produces 25% more grain yield and 38% more biomass as compared with low plant density and early sown crop produce 19% more grain yield and 11 % more biomass than late-planted crop (Abdul- Rehman *et al.*, 2007).

Matching the functions of optimum plant density and adequate N fertilizer application to produce the highest possible yields with the greatest maize hybrid efficiency has been the aim of many researchers (Bahatt, 2012; Clark, 2013; Tajul *et al.*, 2013). Modern hybrids have shown tendencies to withstand higher levels of stresses (such as low N and high plant densities), allowing them to better sustain suitable photosynthetic rates and sufficient assimilate supplies and to maintain plant growth rates attributable to enhanced nitrogen use efficiency (O'Neill *et al.*, 2004).

Cultural practices can play an important role in augmenting the yield of corn crops. Suitable plant spacing for optimum leaf growth by controlling water, fertilizer and chemical inputs is essential for improving the growth variables responsible for high yield. Optimum plant densities ensure the plants to grow in their aerial and underground parts through different utilization of solar radiation and nutrients. The optimum plant population recorded the highest mean values for most studied characters and protein %., and reduced weeds spread (Kandil, 2014, Shrestha, 2015, Shoaib *et al*., 2018 and Xuelian *et al*., 2018). High plant population with crowding stress decrease the ability of plants to use soil N through the post-silking period, and high rate of N- fertilizer was needed to rise grain yield. Selecting the appropriate plant density combined with optimal N management could enhance grain yields (Yan *et al*., 2017).

Nitrogen is an essential nutrient for maize crop growth. It is the principal nutrient required for the growth of plants and is an essential constituent of metabelian of active compounds such as amino acids, proteins, enzymes, coenzymes, and some non-proteinaceous compounds (Brady and Weil, 2002). N- Consider a key factor for plant photosynthesis, ecosystem productivity and leaf respiration (Martin *et al.*, 2008). Low N stress is one of the factors most frequently occurring under high plant density and limits maize production. Low N availability in soils is an important yield-limiting factor frequently found in farmers' fields where fertilization is not commonly used and organic matter is rapidly mineralized (Banziger and Lafitte, 1997). Nitrogen stress may affect the light use efficiency and consequently influence long-term changes in vegetation biomass and carbon sequestration (Peng *et al.*, 2012). Increase nitrogen fertilization levels increased plant height, grain and straw yields of maize (Dawadi and Sah, 2012, and Shrestha, 2015). The highest ear weight was recorded by the highest nitrogen rate, while there was no significant difference among nitrogen levels was observed on the harvest index (Hoshang, 2012). Nitrogen fertilization levels and their interactions showed significant effects on yield and its components of maize. The maximum plant height, number of rows/ear, number of kernels/row, number of kernels/ear, 1000 grain weight, stover, grain, biological yields, harvest index, and protein content were produced by the application either of 429 or 357 kg N/ha (Kandil, 2013). There were gradual and significant increases in grain yield by raising N- fertilizer. The maize hybrid treated with 288 N/ha., produced the maximum values of plant height and grain yield (Faheed *et al*., 2016).

Keeping in view the importance of plant density and nitrogen fertilization levels, this study was conducted to find out the optimum plant population and nitrogen fertilization level for getting the higher yield of maize.

MATERIALS AND METHODS

This present investigation was conducted at the Experimental Farm, Faculty of Agriculture (Saba Basha), Alexandria University, Egypt, during the two successive summer seasons of 2018 and 2019, to study the response of maize to plant population and nitrogen fertilization rates at factorial experiments (two factors) in randomized complete block design (RCBD). Whereas, the first factor was the plant population (50000, 75000 and 100000 plants/ha), while, the second-factor nitrogen fertilization rates (216, 288, 360, and 432 kg N/ha).

The preceding crop was Egyptian clover (berseem) in the first season and second season.

A surface sample (0-30 cm) was collected before planting to identify some physical and chemical properties of this soil, as shown in Table (1) according to Page *et al.* (1982) and Klute (1986).

The grains of the hybrids (3444) were obtained from Maize Research Section Agriculture Research Center, Ministry of Agriculture. The grains were sown on May 10^{th} and 8^{th} of 2018 and 2019 seasons, respectively.

Phosphorus fertilizer was added at rate of 200 kg calcium superphosphate (12.5% P_2O_5) just before sowing. Mineral nitrogen fertilizer at the different rates (216, 288, 360, and 432 kg N/ha) was given at two equal doses in the form of urea (46% N) the first one after thinning before the first irrigation and the second dose was before the second irrigation.

Each plot size was 10.50 m^2 included 5 ridges each 3.5 m in length and 0.60 m.

Table 1. Some Physical and chemical properties of the experimental soil in 2018 and 2019 seasons.

Soil properties	Season	
	2018	2019
A) Mechanical analysis :		
Clay %	41.00	40.00
Sand %	29.00	28.00
Silt %	30.00	32.00
Soil texture	Clay loam soil	
B) Chemical properties		
pH (1 : 1)	8.00	8.01
E.C. (dS/m) (1:2)	2.60	2.50
1) Soluble cations (1:2) (cmol/kg soil)		
K^+	1.52	1.44
Ca^{++}	8.40	9.11
Mg^{++}	12.03	12.20
Na^{++}	11.30	10.50
2) Soluble anions (1 : 2) (cmol/kg soil)		
$CO_3^{--} + HCO_3^-$	1.90	1.80
Cl^-	19.4	18.90
SO_4^{--}	12.00	12.5
Calcium carbonate (%)	6.50	6.00
Total nitrogen %	1.00	0.91
Available phosphate (mg/kg)	3.70	3.55
Organic matter (%)	1.41	1.40

The most important yield and yield components traits: Grain yield and yield components as ear length (cm), number of rows/ear, number of kernels/row, number of kernels/ear,100- kernel weight (g), straw yield (t/ha), grain yield (t/ha), biological yield (t/ha), harvest index (H.I.%) are measurements were measured average mean values of yield of the two middle ridges of each plot.

Protein percentage was determined by estimating the total nitrogen in the grains and multiplied by 6.25 to obtain the percentage according to grains protein percentage to A.O. A.C. (1990).

Data obtained was exposed to the proper method of statistical analysis of variance as described by Gomez and Gomez (1984). The treatment means were compared using the least significant differences test (L.S.D.) at 5% level of probability by using the RCBD model as obtained by CoStat 6.311 (2005) as statistical program.

RESULTS AND DISCUSSION

The results obtained in Tables (2 and 3) showed that the ear length (cm), number of rows/ear, number of grains/row, number of grains/ear, 100-grains weight (g), grain yield (t/ha), straw yield, biological yield (t/ha), harvest index (%) and grain protein content (%) of maize hybrid were, significantly, affected by plant population and nitrogen fertilizer rates in 2018 and 2019 seasons.

Results presented in the same Tables (2 and 3) demonstrated that planting maize hybrid at 75000 plants/ha spacing had higher value for the yield and its components i.e. ear length (cm), number of rows/ear, number of grains/row, number of grains/ear, 100-grains weight (g), grain yield (t/ha), straw yield, and biological yield (t/ha) except harvest index (%), and grain protein content (%) followed by Plant population 100000/ha plants/ha which had no significant difference between plant population (75000 plants/ha) as compared with plant population (Plant population 100000/ha) which gave the lowest values of these traits in the first and second seasons. However, the highest harvest index (HI%) was observed with plant population (75000 plants/ha) in the first season, and with 100000 plants/ha in the second season. On the other hand, the highest values of protein were recorded with spacing between hill (100000 plants/ha), while the lowest ones obtained with plant population 100000/ha between plants in both seasons. The difference may be attributed to plant population which plays an important role in the maize hybrids. These findings are in agreement with those obtained by Kandil (2014), Shrestha (2015), Yan *et al*. (2017), Shoaib *et al*. (2018) and Xuelian *et al*. (2018).

In addition results in Tables (2 and 3) demonstrated that increasing nitrogen fertilizer level up to 432 kg/ha., significantly, increased ear length (cm), number of rows/ear, number of grains/row, number of grains/ear, 100-grains weight (g), grain yield (t/ha), straw yield (t/ha), as well as biological yield (t/ha), except harvest index (%) and grain protein content (%) followed by the rates of nitrogen fertilization at 360 and 288 kg/ha which had significant difference between the higher rate in comparison with 216 kg N/ha.

The results in Table (4) indicated that the highest HI % recorded with the application of nitrogen fertilizer at the rate of 288 kg/ha in both seasons. On the otherwise, the highest protein content in grain was given wit nitrogen application at the rate of 360 followed by the higher rate of nitrogen fertilization in the two seasons. It can be noticed generally that grain yield and its components affected by nitrogen fertilizer which play an important role in plant growth and finally appeared in higher grain yield for two hybrids of maize. These findings were consistent with those obtained by Dawadi and Sah (2012), Kandil (2013) and Shrestha (2015) who indicated that increasing N- level caused an increase in yield and its components of maize.

Table 2. Plant attributes of maize as affected by plant population and nitrogen fertilization rates and their interaction in both seasons.

Treatment	Ear length (cm)		No. of rows/ear		No. of grains/row		No. of grains/ear		100- grain weight	
	Seasons									
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
A) Plant population (cm):										
100000	16.67	17.54	14.17	14.17	38.50	41.30	677.57	585.17	42.54	42.34
75000	18.17	19.35	14.83	14.83	41.25	43.77	801.88	651.77	47.35	48.77
50000	14.25	14.93	14.00	14.00	33.42	35.18	498.88	492.57	39.45	39.23
$LSD_{0.05\ (A)}$	0.98	0.92	0.39	0.39	1.89	1.80	51.56	32.50	2.34	1.52
B) Nitrogen levels										
216	16.44	17.61	14.00	14.00	37.11	38.96	666.10	545.38	38.27	39.08
288	16.33	16.87	14.22	14.22	35.22	37.42	598.03	533.20	43.11	43.13
360	15.89	16.71	14.44	14.44	40.78	40.58	633.94	588.22	43.47	43.56
432	16.78	17.90	14.67	14.67	49.78	43.38	739.70	639.20	47.60	48.00
$LSD_{0.05\ (B)}$	0.01	0.6	0.45	0.46	2.18	2.08	59.53	37.53	2.71	1.76
A x B	*	*	*	*	*	*	*	*	*	*

Table 3. Plant attributes of maize as affected by plant population, and nitrogen fertilization rates and their interaction in both seasons.

Treatments	Grain yield (t/ha)		Straw yield (t/ha)		Biological yield (t/ha)		Harvest index (%)		Grain Protein (%)	
	Seasons									
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
A) Plant population (cm):										
100000	7.33	7.30	8.81	8.33	16.14	15.63	45.42	46.71	9.03	8.74
75000	8.27	7.93	9.55	9.16	17.82	17.09	46.41	46.40	8.64	8.12
50000	5.83	5.54	7.73	7.15	13.56	12.69	42.99	43.66	7.53	7.34
$LSD_{0.05\ (A)}$	0.40	0.44	0.48	0.26	0.58	0.47	2.02	1.73	0.49	0.58
B) Nitrogen fertilization levels (kg/ha):										
216	6.36	6.40	7.92	7.50	14.28	13.9	44.54	46.04	7.49	7.32
288	7.38	7.06	8.59	8.17	15.97	15.23	46.21	46.36	8.45	7.79
360	7.35	7.11	9.13	8.58	16.48	15.69	44.60	45.32	9.03	8.81
432	7.49	7.14	9.14	8.60	16.63	15.74	45.04	45.36	8.64	8.36
$LSD_{0.05\ (B)}$	0.47	0.51	0.55	0.30	0.67	0.55	2.33	2.00	0.57	0.67
Interaction:										
A x B	*	*	*	*	*	*	*	*	*	*

The interaction between plant population and nitrogen fertilization levels significantly affected plant traits under this study as shown in Tables (4 and 5). In this respect, the results in Table (4) revealed that the highest mean values of all studied characters i.e. plant attributes, grain, straw, and biological yields were obtained with plant maize at 75000 plants/ha with soil application of nitrogen fertilizer at the rate of 432 kg N/ha which had no significant difference between it and the rate of 360 kg N/ha. In contrast, growing maize plants at Plant population 100000/ha with nitrogen rate at 216 kg/ha produced the lowest ones during two cropping seasons (Table 5). On the other side, planting maize at spacing 10 with nitrogen rate at 288 kg/ha gave the highest harvest index (HI%) followed by plant population (75000 plants/ha) + 216 kg N/ha gave the same trend in both seasons. On the other hand, Plant population 100000/ha plants/ha + 360 kg N/ha recorded the highest protein % followed by the same plant population (100000 plants/ha) + 432 kg N/ha in both seasons.

Table 4. The interaction effect between plant populations of plant attributes for maize hybrid in both seasons.

Treatments		Ear length (cm)		No. of rows/ear		No. of grains/row		No. of grains/ear		100- grain weight	
Plant population:	N- rate (kg/ha)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
100000	216	15.67	16.80	14.00	14.00	38.00	40.80	638.50	571.20	36.67	38.3
	288	17.33	17.57	14.67	14.67	39.67	42.47	697.40	622.40	46.33	45.02
	360	15.67	16.90	14.00	14.00	36.00	38.80	608.50	543.20	44.00	42.00
	432	18.00	18.90	14.00	14.00	40.33	43.13	765.87	603.87	43.15	44.00
75000	216	19.67	21.47	14.00	14.00	42.67	5.47	912.70	636.53	41.00	42.67
	288	17.00	17.80	14.00	14.00	35.67	37.93	635.60	531.07	45.33	47.67
	360	17.33	18.00	15.33	15.33	41.00	43.80	739.67	673.60	46.73	48.73
	432	18.67	20.13	16.00	16.00	45.67	47.87	919.57	765.87	56.33	56.00
50000	216	14.00	14.57	14.00	14.00	30.67	30.60	447.10	428.40	37.13	36.23
	288	14.67	15.23	14.00	14.00	30.33	31.87	461.10	446.13	37.67	38.00
	360	14.67	15.23	14.00	14.00	36.33	39.13	553.67	547.87	39.67	38.67
	432	13.67	14.67	14.00	14.00	36.33	39.13	533.67	547.87	43.33	44.00
$LSD_{0.05\ (A\ x\ B)}$		1.96	1.84	0.78	0.77	3.77	3.61	103.11	65.00	4.69	3.04

Table 5. The interaction effect between plant populations of plant attributes for maize hybrid in both seasons.

Treatments		Grain yield (t/ha)		Straw yield (t/ha)		Biological yield (t/ha)		Harvest index (%)		Grain Protein (%)	
Plant population	N- rate (kg/ha)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
100000	216	6.55	6.95	7.92	7.40	14.47	14.35	45.27	48.43	7.92	7.67
	288	7.94	7.64	8.60	8.10	16.54	15.74	48.00	48.54	9.04	8.83
	360	7.07	7.17	9.21	8.74	16.28	15.91	43.43	45.07	9.79	9.33
	432	7.79	7.47	9.52	9.07	17.31	16.54	45.00	45.16	9.38	9.13
75000	216	7.72	7.53	8.58	8.03	16.30	15.56	47.36	48.39	7.38	7.38
	288	6.33	7.00	9.15	9.10	15.48	16.10	46.52	45.64	8.76	7.29
	360	7.96	7.64	9.74	9.34	17.70	16.98	39.39	46.14	9.40	9.15
	432	9.06	8.59	10.72	10.15	19.78	18.74	45.80	45.84	9.04	8.67
50000	216	4.81	4.72	7.27	7.06	12.08	11.78	39.82	40.07	7.17	6.92
	288	6.23	5.91	8.03	7.31	14.26	13.22	43.69	44.70	7.56	7.23
	360	6.66	6.15	8.44	7.66	15.10	13.81	44.11	44.53	7.90	7.94
	432	5.61	5.37	7.19	6.57	12.80	11.94	43.83	44.97	7.50	7.29
$LSD_{0.05\ (A\ x\ B)}$		0.81	0.88	0.96	0.53	1.17	0.95	4.04	3.46	0.98	1.15

Conclusions

Considering the observed results, it can be concluded that the application of 432 kg N/ha and with plant population of 75000 plants/ha to the maize hybrid ‘3444’ is optimal for obtaining a higher grain yield of maize under the conditions of Alexandria governorate, Egypt

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ARABIC SUMMARY

إستجابة الذرة الشامية الكثافات الزراعة تحت المعدلات العالية من التسميد النتيروجيني

محمود عبد العزيز جمعة[1] ، عصام إسماعيل قنديل[1] ، جوهرة عبد السلام الصردي[1] ، صلاح حامد فرحان المحمدي[2]

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أجريت تجربتان حقليتان بالمزرعة البحثية بكلية الزارعة سابا باشا بمنطقة أبيس جامعة الإسكندرية خلال الموسمين 2018 و 2019 ،وذلك لدراسة تأثير الكثافات النباتية ومستويات السماد النيتروجيني علي محصول بعض هجن الذرة الشامية ومكوناته. ووزعت المعاملات في تصميم القطاعات العشوائية الكاملة في ثلاث مكررات ، حيث كان العامل الأول الكثافات النباتية (100000 ، 75000 ، 50000) ، والعامل الثاني كان مستويات السماد النيتروجيني (216 و288 و 360 و 432 كجم ن/هكتار) ووزعت المعاملات عشوائياً على القطاعات بحيث يشمل كل قطاع جميع المعاملات.

ولخصت أهم النتائج فيما يلي:

- أظهرت النتائج أن مسافات الزراعة (الكثافة النباتية) ومعدلات التسميد النتروجيني والتداخل بينهما أثرت معنوياً على صفات المحصول ومكوناته ومحتوى الحبوب من البروتين لهجين فردي 3444 من الذرة الشامية.
- وجد أن زراعة النباتات بكثافة 750000 نبات/هكتار حققت أعلى قيم للصفات تحت الدراسة وتليها مسافة الزراعة بكثافة نباتية 100000 نبات/هكتار حيث لا يوجد فروق معنوية بينهما ، بينما الكثافة النباتية 75000 نبات/هكتار لنباتات الذرة الشامية أعطت أقل قيم بالنسبة لصفات المحصول ومكوناته في موسمي الزراعة. في حين أن أعلى دليل حصاد ونسبة البروتين سجل مع الزراعة بكثافة 75000 نبات/هكتار سم خلال موسمي الزراعة.
- أدى زيادة معدل التسميد النتروجينى من 216 الى 360 كجم ن/هكتار الى زيادة معنوية في محصول الذرة الشامية ومكوناته في حين أن التسميد بمعدل 360 كجم ن/هكتار لم يختلف معنوياً مع المعدل 432 كجم ن/ هكتار. بينما أعلى دليل حصاد سجل مع التسميد بمعدل 288 كجم نتروجين/هكتار. بينما أعلى نسبة بروتين سجلت مع المعدل 360 كجم نتروجين/هكتار في موسمي الدراسة.
- زراعة الذرة الشامية على بكثافة 75000 نبات/هكتار مع معدل التسميد 432 أو 360 كجم نتروجين للهكتار سجل أعلى قيم للصفات المدروسة خاصة محصول الحبوب ، والقش والمحصول البيولوجى فى الموسمين 2018 ، و2019. بينما التسميد بمعدل 216 كجم/هكتار + الكثافة النباتية 100000 نبات/هكتار حققت أقل قيم لمحصول الحبوب والقش والبيولوجي خلال موسمي الدراسة. في حين أن أعلى دليل حصاد سجل مع زراعة الذرة الشامية بكثافة نباتية 100000 نبات/هكتار ومعدل نتروجين 288 كجم/فدان ولم يختلف زراعة الذرة الشامية بكثافة نباتية 750000 نبات/هكتار + 360 كجم نتروجين/هكتار خلال موسمي الزراعة. في حين أن أعلى محتوي حبوب من البروتين تحقق مع زراعة الذرة على بكثافة نباتية 100000 نبات/هكتار + 360 كجم نتروجين/هكتار يليها المعدل الأعلى 432 كجم نتروجين/هكتار خلال الموسمين.

التوصية:

يوصي البحث للحصول على أعلى محصول حبوب ومكوناته وجودة من الذرة الشامية هجين 3444 يزرع بكثافة نباتية 75000 نبات/ هكتار مع التسميد النتروجيني بمعدل 360 كجم/هكتار تحت ظروف الأسكندرية.