EffectT OF Plant Density And Nitrogen Fetili3ation On Vegetative Growth, Seed Yield And Quality OF Okra Plants.

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ABSTRACT

Two field experiments were carried out during the summer seasons of 2004 and 2005 at El-Qaten region, Hadramout governorate, to study the effects of different plant densities (9.5, 4.8 and 3.2 plant m^{-2} and varying N levels (0, 15, 30 and 45 kg N fed.$^{-1}$) on vegetative growth characters, chemical composition, seed yield and quality of okra plants. The results indicated that increasing plant density from 3.2 to 9.5 plant m^{-2} was accompanied with progressive and significant reductions in number of branches, number of leaves and leaf area plant^{-1}. On the contrary, plant height, significantly increased with the high plant density (9.5 plant m^{-2}). Meanwhile, nitrogen contents of leaves and pods were not affected. Results also revealed that decreasing plant density from 9.5 to 3.2 plant m^{-2} associated with corresponding and successive increments in the average seed yield plant^{-1} and seed index. On the other hand, total seed yield m^{-2} reflected a significant decrease as a result of reducing plant density. Number of pods plant^{-1}, number of seeds pod^{-1} and germination percentage, however, were not significantly affected by the different plant densities. The results, also, showed that increasing N applied rate up to 45 Kg N fed^{-1}was associated with significant progressive increases in plant height, number of branches, number of leaves and leaf area plant^{-1}.Moreover, leaves and pods N contents were positively and significantly responded to such N treatments. It was, also, noticed that the dry matter content exhibited significant reduction due to N application. Application of N fertilizer, significantly, increased seed yield plant^{-1}, number of pods plant^{-1} and seed index. The highest N level (45 Kg N fed^{-1}) was effective, in these respects. Total seed yield m^{-2}, number of seed pod^{-1} and germination percentage, however, were not significantly affected by N fertilizer rate. The highest plant density (9.5 plant m^{-2}) and the application of 45 Kg N fed^{-1} appeared to be the most efficient treatment combination which gave a better vegetative growth and a higher seed production of okra plants.

Key Words: Plant density, nitrogen levels, vegetative growth, chemical composition**,** seed yield, quality, okra.

INTRODUCTION

The seed is the prime factor that determines the quantitative and qualitative characteristics of the crop that is going to be harvested later on. Therefore; more attention must be directed towards increasing seed yield with good quality. Successful production of okra seed is conditional to certain agricultural practices. Plant density is one of the most important agronomic practices that affects okra seed production. Plant density has been found to have an enhancing influence on growth characters, yielding ability and quality of seed (Zanin and Kimoto, 1980; Rastogi *et al.*,1987; Khan and Jaiswal, 1988; Sarniak *et al.*, 1986; Naik and Srinivas, 1992).Fertilization, in general and particularly with nitrogen, is considered one of the major factors that greatly affect seed yield and quality of okra (EL-Bakry *et al*.,1978; Moussa and Hegazi, 1994; Olasantan, 1999; Ghoneim, 2000). Ghoneim (2000) showed that application of 60 kg N fed^{-1} to the grown okra plants increased seed yield $plant^{-1}$ and fed^{-1}. The present study was conducted, in order to find out the best interactive effect of plant density and nitrogen level on yielding ability and quality of okra seeds.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2004 and 2005 at El-Qaten region, Hadramout governorate. The scope of this investigation was to study the influence of different plant densities and varying nitrogen levels on vegetative growth, chemical composition and seed yield and quality of okra plants. Each experiment included 12 treatments representing the combination of three plant densities (3.2, 4.8 and 9.5 plants m^{-2}) and four N levels (0, 15, 30 and 45 kg N fed^{-1}).

Preceding the initiation of each experiment, soil samples of 25 cm depth were collected and analyzed according to the published procedures described by (Black, 1985). The results of the soil analyses revealed that the experimental sites were sandy loam in texture having pH 8.1 and 8.00; total N content 0.025 and 0.028; EC. 3.27 and 3.25dsm^{-1} and organic matter 0.62 and 0.75 % in 2004 and 2005, orderly. Seeds of okra cv. Clemson spineless were sown on 10^{th} of January in 2004, and14^{th} of January in 2005, in ridges 4m long , 70cm wide and the row spacing were 15, 30 and 45 cm to give plant densities 9.5, 4.8 and 3.2 plants m^{-2}, respectively. Ammonium nitrate (33.5 % N) was the respective N source and was side banded in 3 equal portions at 2, 5 and 8 weeks after seed sowing. Plants were thinned to one plant per hill. A seasonal total of 300 kg calcium super phosphate (15.5 % P_2o_5) were broadcasted during soil preparation, while 150 kg potassium sulphate (48% K_2o) fed^{-1} was applied at the same time of N applications.

The experiments were carried out using a split- plot system in a randomized complete blocks design with three replications. Main plots consisted of plant densities whereas sub-plots were allocated to N levels. Each two adjacent sub-plots were separated by a guard row. All other recommended cultural practices for growing okra plants were followed.

Data Recorded

Vegetative Growth Characters

Sixty days after seed sowing, a random sample of five plants from each sub-plot was collected to record the data concerning plant height, number of branches, leaf area and number of leaves plant $^{-1}$.

Chemical Composition

Leaf samples from the fourth upper leaf, after 60 days of seed sowing, were collected, washed in distilled water and dried at $70^{o}C$ in an forced air-oven till the weight became constant and the dry matter contents were calculated. The dried materials were ground and used to determine leaf N content using the procedure outlined in A.O.A.C (1992). Random samples of immature pods were collected, dried at $70^{o}C$ to a constant weight and ground to determine pod N content using the same previously mentioned analytical method.

Seed Yield and Quality

At the end of each experiment, dry pods were picked and seeds were manually extracted. Seed yield plant^{-1} and m^{-2}, number of seed pod^{-1} and number of pods plant^{-1} were recorded. Seed index (100 seeds weight, in gm) and germination percentage were calculated.

All obtained data, were statistically analyses using Costat Software (1985). The comparisons among the means of the different treatments were carried out, using the Revised L.S.D. test at $P = 0.05$ level as illustrated by El-Rawy and Khalf-Allah (1980).

RESULTS AND DISCUSSION

Vegetative Growth Characters

Data in Table (1) showed that number of branches, leaf area and number of leaves plant^{-1} were, significantly, increased as the plant density was decreased, in both 2004 and 2005 seasons. On the contrary, plant height, significantly, decreased with the reduction of plant density from 9.5 to 4.8 or 3.2 plants m^{-2}, in the second season only. The wider was the plant spacing; the better was the plant vegetative growth. Such results might be expected on the assumption that competition among the growing plants for nutrition and light intensity would be more in the case of high plant densities.

Accordingly, the less available nutrients under the conditions of high plant density would not allow for excessive rates of photosynthesis and accumulation of stored food in the leaves of okra plants. Also, under high plant density, the low light intensity seemed to encourage somewhat the stem elongation of okra plants. The obtained results seemed to be in close agreements with those recorded by El-Mazny *et. al.* (1990) and Farag and Damarany (1994), who indicated that the closer spacing between plants longer was the plant height. However, the wider spacing enhanced number of branches plant.

Table 1: Vegetative growth characters of okra plants as affected by plant density and nitrogen levels during the summer seasons of 2004 and 2005.

Treatments		2004				2005			
Plant density (plant m^{-2})	Nitrogen rate (kg N fed^{-1})	Plant height $Plant^{-1}$ (cm)	No. Branches $Plant^{-1}$	No. leaves $Plant^{-1}$	Leaf area $Plant^{-1}$ (m^2)	Plant height $Plant^{-1}$ (cm)	No. Braches $Plant^{-1}$	No. leaves $Plant^{-1}$	Leaf area $Plant^{-1}$ (m^2)
9.5		98.97A*	2.30C	20.15C	0.799C	97.57A	2.28C	19.11C	0.793C
4.8		96.00A	3.23B	22.72B	0.926B	91.48B	3.10B	20.23B	0.823B
3.2		97.52A	3.61A	24.68A	0.975A	90.40B	3.42A	22.96A	0.920A
	0	86.71D	2.48D	20.40C	0.740D	83.72D	2.38D	19.42D	0.714D
	15	94.04C	2.88C	22.26B	0.877C	88.82C	2.72C	2.16C	0.798C
	30	100.57B	3.23B	22.92B	0.955B	96.91B	3.08B	21.19B	0.893B
	45	107.72A	3.62A	24.49A	1.027A	103.16A	3.57A	21.94A	0.978A
	0	85.47h	2.13h	19.33h	0.677g	91.33e	2.10f	18.47f	0.668g
9.5	15	91.97fg	2.30gh	20.17gh	0.794ef	93.50de	2.20f	18.60f	0.771e
	30	103.37bc	2.30gh	19.80h	0.824e	100.17c	2.30ef		0.837d
								19.60de	
	45	112.17a	2.47fg	21.30ef	0.900cd		2.50de		0.897c
						105.30a		19.77de	
	0	86.26h	2.60ef	20.33fg	0.747f	81.93g	2.50de	19.13ef	0.704fg
4.8	15	94.60ef	2.97d	22.27e	0.890d	85.53f	2.67d		0.738ef
								19.60de	
	30	97.83de	3.43c	23.57d	0.978b	95.23d	3.43c		0.873cd
								20.40cd	
	45	105.30b	3.93b	24.70bc	1.087a	103.23ab	3.83b		
								21.80b	0.978b
	0	88.30gh	2.70e	21.53e	0.796ef	77.90h	2.53d	20.67c	0.769e
	15	95.57ef	3.3c	24.33cd	0.948bc	87.43f	3.30c	22.27b	0.884cd
3.2	30	100.52cd	3.97b	25.40b	1.063a	95.33d	3.50c	23.57a	0.970b
	45	105.70b	4.40a	27.47a	1.094a	100.93bc	4.37a	24.27a	1.057a

***Values marked with the same alphabetical letter(s), within a comparable group of means, are not significantly different, using revised L.S.D. test at p =0.05**

Table (1) shows that the application of N up to 45 kg N fed^{-1} associated progressively significantly increased plant height, number of branches, number of leaves and leaf area $plant^{-1}$, in both years. The enhancing effect of N on plant growth characters may be attributed to the beneficial effect of N on stimulating the meristemic activity and producing more tissues and organs. Moreover, N plays a major role in protein and nucleic acids synthesis and protoplasm formation (Marschner, 1986). These results matched well with those reported by El-Mazny *et. al.*(1990) and Olasantan (1999). Ghoneim (2000), working on okra, clarified that increasing N applied rate accompanied with progressive and significant increases in plant height, number of branches and leaves plant^{-1} and leaf area plant^{-1}.

The interaction effect of N level and plant density on vegetative growth characters appeared significant, in both seasons (Table,1). The response of N level was more evident at the wide spacing (low plant density) compared to those of the closer spacing (high density). The combined treatment which included 3.2 plant m^{-2} and 45 kg N fed^{-1} was the best as it, significantly, gave the highest mean values for number of branches, number of leaves and leaf area plant^{-1}, in both years. On the other hand, the tallest plants were obtained from the treatment combination having the highest plant density combined with the highest N level (9.5 plant m^{-2} plus 45 kg N fed^{-1}). Similar findings concerning the effects of N levels under varying plant densities on vegetative growth characters of okra plants were reported by El-Habbasha *et al.* (1973) and Farag and Damarany (1994).

Table 2 : Chemical composition of okra plants as affected by plant density and nitrogen levels during the summer seasons of 2004 and 2005.

Treatments		2004			2005		
Plant density (Plant m^{-2})	*Nitrogen* rate (kg N fed^{-1})	Leaf dry Matter (%)	N (%) leaves	N (%) Pods	Leaf dry Matter (%)	N (%) leaves	N (%) Pods
9.5		17.70A*	3.40A	2.19A	16.82A	3.05C	2.09A
4.8		16.96B	3.39A	2.24A	16.68A	3.17B	2.17A
3.2		16.62B	3.51A	2.30A	16.71A	3.35A	2.25A
	0	17.54A	2.93D	2.07D	17.51A	2.63C	1.96B
	15	17.28A	3.22C	2.15C	16.61B	3.10B	2.11B
	30	16.85B	3.44B	2.31B	16.35B	3.27B	2.24A
	45	16.79B	4.16A	2.44A	16.48B	3.75A	2.39A
9.5	0	17.76a	2.87f	2.08f	17.55a	2.52f	1.93f
	15	18.27a	3.17e	2.10f	16.86a	3.01g	1.99e
	30	17.46a	3.52c	2.26de	16.29a	3.19ef	2.14d
	45	17.32a	4.05b	2.33cd	16.60a	3.47c	2.30bc
4.8	0	17.53a	2.94f	2.08f	17.38a	2.53i	1.96ef
	15	17.13a	3.21de	2.13f	16.52a	3.14f	2.14d
	30	16.57a	3.31d	2.9de	16.38a	3.26e	2.27c
	45	16.62a	4.14b	2.44b	16.46a	3.76b	2.33b
3.2	0	17.07a	2.99f	2.06f	17.59a	2.85h	1.98ef
	15	16.44a	3.28de	2.22e	16.47a	3.15f	2.19d
	30	16.53a	3.49c	2.38bc	16.39a	3.38d	2.31bc
	45	16.43a	4.28a	2.54a	16.40a	4.03a	2.53a

***Values marked with the same alphabetical letter(s), within a comparable group of means, are not significantly different, using revised L.S.D. test at p =0.05**

Chemical Composition

Regarding the effects of plant density on leaf dry matter content as well as leaves and pods N contents, it was noticed that decreasing the plant densities from 9.5 to 4.8 or 3.2 plant m^{-2} were accompanied by a significant decrease on the percentage of leaf dry matter, in the first season. However, the differences were not so high to be significant, in the second season (Table,2). Leaves and pods N contents were not affected, in both seasons. The only exception was noticed in the second season, where leaf N content, significantly, increased by wider spacing (low density).

Application of N fertilizer at 15, 30 and 45 kg N fed^{-1}, significantly, reduced the dry matter content compared to the unfertilized control plants, in both seasons with the exception that in 2004 season the difference between the unfertilized treatment and the application of 15 kg N fed^{-1} was not significant(Table,2).. On the other hand, leaf and pod N contents were positive function of the amount of N applied up to 45 kg N fed^{-1} (Table, 2). The effect was constant in both years. The highest mean values of leaf and pod N contents were obtained from the application of 45 kg N fed^{-1}. The obtained results appeared to be in a close agreement with those reported by El-Bakry *et al.* (1978), Farag and Damarany (1994) and Ghoneim (2000).

The interaction effects between plant density and N levels, as shown in Table (2), illustrated significant increments in leaf and pod N contents with the successive increases in nitrogen when the lowest plant density was performed, in both seasons. However, such an interaction effect disappeared in terms of dry matter content where, nitrogen levels gave similar trends at the three different plant densities indicating the absence of an interaction effects between the two main factors, in both seasons.

Seed Yield and Quality

Concerning the effect of plant density on seed yield and its components, it was noticed that decreased plant densities from 9.5 to 4.8 and 3.2 plant m^{-2} was associated with corresponding and successive increments in the average seed yield $plant^{-1}$and seed index, in both seasons(Table,3). Such a result might be attributed to the resultant favorable effects on growth characters (Table, 1). On the other hand, total seed yield per square meter reflected significant and successive decrements as a result of decreasing plant density. This is actually expected on the basis of that increasing the plant density means increased the number of growing plant per unit area. Number of pods plant^{-1}, number of seed pod^{-1} and germination percentage, however, were not significantly affected, in both experiments. Similar results were reported by Zanin and Kimoto (1980), who reported that as the distance between plants was reduced (high plant density) seed yield per unit area was increased, and Rastogi *et. al.* (1987), who indicated that germination percentage of okra seeds was unaffected by spacing between plants.

Regarding, the effects of N levels on seed yield and its components, application of N fertilizer at 15, 30 and 45 kg N fed^{-1} ,significantly, increased seed yield plant^{-1} , number of pods plant^{-1} and seed index over the control, in both years (Table, 3).It was obvious that the increment in seed yield plant^{-1} mainly achieved at the expense of the increase in average seed weight and partially No. pod plant^{-1}. On the other hand, seed yield m^{-2}, number of seeds pod^{-1}and germination percentage, were not significantly affected. These results clearly indicated a synergistic effect of N on seed production. The current results are in general agreement with those reported by Naik and Srinivas (1992), who indicated that the highest seeds yield was obtained from the highest N level. In Egypt, similar trend was noticed on okra by Moussa and Hegazi (1994) and Ghoneim (2000) who, indicated that application of N fertilizer, significantly, increased seed yield plant^{-1}, whereas number of seeds pod^{-1} was not affected. Similar results in regard to seed yield m^{-2} were reported by Sarniak *et. al.* (1986), who indicated insignificant differences as a result of N application. Rastogi *et. al*. (1987) found that application of N up to 30 kg N fed^{-1} had no appreciable influence on germination percentage of okra seeds.

Table 3: Seed yield and its quality of okra plants as affected by plant density and nitrogen levels during the summer seasons of 2004 and 2005.

Treatments		2004						2005					
Plant density (plant m^{-1})	N rate (kgN fed^{-1})	Seed yield $Plant^{1}$	Seed yield m^{-2} (g)	No. Pods $plant^{-1}$	No. Seed pod^{-1}	Seed index (g)	Germination (%)	Seed Yield $plant^{-1}$ (g)	Seed Yield m^{-2} (g)	No. pods $plant^{-1}$	No. seed pod^{-1}	Seed index (g)	Germination (%)
9.5		63.64C*	406.08A	16.37A	70.50A	5.42C	86.17A	57.08C	543.55A	14.50A	70.11A	5.25C	88.49A
4.8		64.97B	309.38B	16.46A	70.36A	5.59B	86.76A	59.24B	282.10B	15.79A	69.94A	5.38B	89.23A
3.2		66.01A	207.80C	17.03A	70.45A	5.81A	86.77A	64.14A	203.60C	16.69A	69.90A	5.58A	89.04A
	0	63.50D	367.93A	14.93D	70.44A	5.40D	85.79A	58.39C	332.85A	14.38B	69.66A	5.20D	88.17A
	15	64.60C	370.98A	16.79A	70.44A	5.52C	86.43A	59.80B	342.68A	15.56A	70.02A	5.28C	88.76A
	30	65.37B	377.93A	17.17A	70.37A	5.66B	86.83A	60.68B	346.38A	16.15A	70.24A	5.49B	89.27A
	45	66.03A	380.85A	17.60A	70.52A	5.84A	87.23A	61.73A	350.43A	16.56A	70.00A	5.64A	89.48A
	0	62.69a	597.03c	14.91a	70.60a	5.29a	84.92a	55.20a	525.68b	13.57a	69.37a	5.08a	87.80a
	15	63.31a	602.85b	16.57a	70.61a	5.38a	86.41a	57.45a	547.15a	14.34a	70.19a	5.13a	88.55a
9.5	30	64.16a	611.05a	16.80a	70.26a	5.43a	86.71a	57.74a	549.80a	14.78a	70.46a	5.33a	88.71a
	45	64.40	613.35a	17.19a	70.51a	5.60a	86.64a	57.92a	551.58a	15.30a	70.40a	5.45a	88.89a
	0	63.65a	303.08e	14.62a	70.27a	5.37a	86.16a	57.95a	275.95d	14.68a	70.24a	5.19a	88.34a
4.8	15	64.81a	308.60d	16.78a	70.40	5.51a	86.41a	59.07a	281.30d	15.79a	70.22a	5.26a	89.09a
	30	65.44a	311.60d	17.13a	70.33a	5.65a	86.68a	59.70a	284.25c	16.20a	70.00a	5.46a	89.80a
	45	65.99a	314.23d	17.30a	70.45a	5.83a	87.78a	60.24a	286.85c	16.50a	69.28a	5.62a	89.70a
	0	64.16a	203.68g	15.25a	70.38a	5.54a	86.28a	62.03a	196.93g	14.89a	69.35a	5.34a	88.36a
	15	6568a	201.45g	17.01a	70.31a	5.67a	86.46a	62.88a	199.60g	16.54a	69.66a	5.45a	88.64a
3.2	30	66.51a	211.10f	17.56a	70.52a	5.89a	87.09a	64.60a	205.08f	17.27a	70.27a	5.69a	89.30a
	45	67.71a	214.65f	18.31a	70.59a	6.12a	87.27a	67.04a	212.83e	17.86a	70.33a	5.84a	89.85a

***Values marked with the same alphabetical letter(s), within a comparable group of means, are not significantly different , using revised L.S.D. test at p =0.05**

The comparisons among the means of various treatment combinations of plant densities and nitrogen levels showed that the general performances of seed yield $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1} and germination percentage did not suggest the presence of any interaction effects since, similar general trends were noticed for the effects of different nitrogen levels under the various plant densities, in both seasons (Table, 3). On the other hand, the interaction of plant density by N level for seed yield $m^{-2}$was significant. At any plant density, fertilizing with 30 or 45kg N fed^{-1}, significantly, increased seed yield m^{-2} compared to the control or 15 kg N fed^{-1}. The combined treatment of 9.5 plants m^{-2} and 30 or 45 kg N fed^{-1}, significantly, gave the highest mean values for seed yield m^{-2}. Similar results were obtained by Khan and Jaiswal (1988) and Pandy and Manocha (1990), who reported that the highest seed yield was obtained from plants spaced at closest space, receiving N at the highest rate.

In view of the previously mentioned results, it could be concluded that the highest plant density 9.5 plant m^{-2} and the fertilizing with the 45 kg N fed^{-1} is considered as an adequate treatment combination for the production of high seed yield of okra, under the prevailed environmental conditions of the present study

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الملخص العربي

تأثير الكثافة النباتية والتسميد النتروجينى على النمو الخضري والمحصول البذري وجودته لنباتات الباميا

أجريت دراسة حقلية خلال الموسم ين الصيفيين لعامي 2004 و2005 بمنطقة القطن محافظة حضرموت، لدراسة تأثيرات الكثافة النباتية (3.2 ، 4.8، 9.5 نبات / متر مربع) ومعدلات التسميد النتروجينى (صفر، 15، 30، 45كجم ن للفدان) على النمو الخضري والمحتوى الكيماوي ومحصول وجودة بذور نباتات الباميا.

أوضحت النتائج أن زيادة الكثافة النباتية كانت مصحوبة بنقص معنوي متدرج في عدد الأفرع والأوراق والمساحة الورقية لكل نبات وعلى العكس فان ارتفاع النبات قد ازداد معنويا بزيادة الكثافة النباتية حتى (9.5 نبات/متر مربع)، في حين لم تتأثر محتويات الأوراق والقرون من النتروجين ، ولقد لوحظ أن خفض الكثافة النباتية من 9.5الى 3.2 نبات /متر مربع كان ملازما لزيادة متتابعة معنوية في المحصول البذري للنبات ودليل البذور (وزن 100 بذرة)، ومن جهة أخرى فقد عكس المحصول الكلي للبذور للمتر المربع نقصا معنويا كنتيجة لإتباع الزراعة بالكثافة النباتية المنخفضة، بينما لم تؤثر الكثافات النباتية المختلفة على عدد البذور بالقرن والنسبة المئوية لإنبات البذور.

ولقد بينت النتائج أن زيادة معدل التسميد الازوتى المضاف كان ملازما لزيادة معنوية متدرجة في ارتفاع النبات وعدد الأفرع والأوراق والمساحة الورقية لكل نبات، وعلاوة على ذلك فان محتويات الأوراق والقرون من النتروجين قد استجاب ايجابياً و معنويا بزيادة إضافة النتروجين حتى 45 كجم ن للفدان ، ومن ناحية أخرى فقد أدى التسميد النتروجينى لانخفاض في المادة الجافة للأوراق، ولق د أدت إضافة الس ماد النتروجينى لزيادة معنوية في المحصول البذري للنبات وعدد القرون الجافة للنبات ودليل البذور وكان المعدل المرتفع من النتروجين(45 كجم ن للفدان) هو الأكثر فعالية في هذا الصدد ، هذا ولم تعكس النتائج تأثر المحصول البذري للمتر المربع وعدد البذور الجافة للقرن والنسبة المئوية للإنبات بالمعدلات المختلفة من النتروجين. ويمكن القول إن الزراعة بالكثافة النباتية العالية (9.5نبات/متر مرب ع) ومعدل التسميد المرتفع(45كجم ن للفدان) أكثر المعاملات التوليفية كفاءة حيث أعطت أفضل نمو وأعلى محصول بذرى لنباتات الباميا.