Effect of Sowing Date, Plant Density and Phosphorus Fertilization on Seed Yield of Okra

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Received on: 2/3/2014 *Accepted: 11/3/2014*

ABSTRACT

This work was carried out at Disuq district, Kafr El-Sheikh Governorate during the summer seasons of 2012 and 2013 on okra plants (new variety under registration). The main objective of this research was to evaluate the response of okra plants to sowing date, plant density and phosphorus fertilizer levels. A split–split plot in a randomized complete blocks design with three replicates was used. Results are summarized as follows: Okra plants cultivated in mid-April produced the highest mean values of vegetative growth in comparison with the other sowing dates. However, okra seeds which sowing in mid-May caused more earliness of flowering, in both seasons. It was also noticed that, okra plants cultivated in mid-April produced the highest mean values of seed yield and its components, i.e., seed yield plant^{-1}, seed yield fed.$^{-1}$, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100-seeds, pod weight and seed germination percentage. Meanwhile, plants cultivated in mid-March produced the lowest seed yield and its component, in both seasons. Less plant density improved vegetative and flowering traits, as well as, some seed yield components and increased seed germination percentage. The high the plant density the high was seed yield fed.$^{-1}$. The results indicated, also, that increasing applied phosphorus fertilizer rate up to 45 kg P_2O_5 fed.$^{-1}$ was accompanied with significant increases in vegetative and flowering traits, and reflected positively and significantly on increasing seed yield and its components, and seed germination percentage. Okra plants cultivated in mid-April was rather response to less plant density which surpassed in vegetative growth and seed yield plant^{-1}, number of pod plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weigh of 100-seeds, pod weigh and seed germination percentage, in both seasons. However, okra plants cultivated in mid-April with 45 kg P_2O_5 fed.$^{-1}$ produced the highest mean values of vegetative growth, seed yield and its components. Less plant density with increasing applied phosphorus fertilizer rate up to 45 kg P_2O_5 fed.$^{-1}$ produced the highest values of vegetative growth characters, some seed yield and its components, in both seasons. According to the mentioned results, the recommendation for obtaining the highest seed yield from new okra variety under registration is planting in mid-April and plant density 44400 plants fed.$^{-1}$ and applied phosphorus fertilizer rate 45 kg P_2O_5 fed.$^{-1}$.

Key words: Okra, sowing date, plant density, phosphorus fertilizer.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), is an important fruit vegetable crop of the tropical and subtropical regions of the world. In Egypt, it is one of the most popular vegetables and considered a valuable source of calcium, iron and vitamins. It has been grown for its edible green pods which can be used as fresh, canned, frozen, or dried food.

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. Sowing date has a great impact on seed yield and quality of okra (Singh *et al*., 1986; Hossain *et al*., 1999; Yadav and Dhankar 2001; Moniruzzaman *et al*., 2007). Due to change in agroclimatic conditions, periodic evaluation of planting dates is of urgent need. Ariyo (1987) evaluated sowing 15 okra genotypes in 5 different environments and the results showed a significant environmental effect for all studied characters. Olasantan and Olowe (2006) reported that sowing dates significantly affected on vegetative growth, flowering, fruiting and harvesting stages. The result showed that early sowings enhanced earliness to maturity and increased pod yield by 2 – 8% in mixed stands while late sowings did so in monoculture.

Plant density is one of the most important agronomic practices that affect okra seed production, it 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; Sarniak *et al.*, 1986; Naik and Srinivas, 1992 ; Khan and Jaiswal, 1998 and Feleafel and Ghoneim,2005). Absar and Siddique (1982) noted that plant density is another important factor that affects okra seed production. Suitable plant spacing can lead to optimum seed yield while too high or low plant spacing could result to relatively low yield and quality. So, optimum plant spacing can lead to optimum seed yield. (Thakur and Arora, 1986 and Bin-Ishaq, 2009). Generally, increase in planting density results in increased yield per unit area till a certain limit (Weiner, 1990). According to Mangual and Martin (1980) and Baruah (1995), the optimal population density for high yielding okra cultivars is 6-8 plants m.$^{-2}$.

Fertilization, in general and particularly with phosphorus, is considered one of the major factors that greatly affect seed yield and quality of okra (Gupta *et al.,* 1981; Mohanta, 1998; Sadat, 2000). The response of okra to phosphorus fertilizer levels was studied by Majanbu *et al.* (1985), Arora *et al.* (1994) and Lenka *et al.* (1989), who reported that plant height, number of fruits, fruit size and total green fruit yield were significantly improved by application of phosphorus from 0-60 kg P_2O_5/ha. El-Maziny *et al.* (1990) and Naik and Srinivas (1994) found that fruit length, number of fruits/plant, number of seeds/fruit and 1000-seed weight recorded the highest mean values with the highest phosphorus rate. The same general trend was found by Naik and Singh (1999), Amjad *et al.* (2001), Chattopahyay and Sahana (2001), Patton *et al.* (2002), Singh (2002) and El-Shaikh (2005).

Hence, among the several factors affecting seed yield of okra, nutrition especially phosphorus, sowing date and planting density play an important role in okra seed production and need to be studied more precisely. Therefore, the present study was initiated to find out the optimum sowing date, planting density and level of phosphorus for achieving the highest seed production with good quality in okra plants.

MATERIALS AND METHODS

This work was carried out at Disuq district, Kafr El-Sheikh Governorate, during the summer seasons of 2012 and 2013. Two field experiments were conducted to clarify the effects of phosphorus fertilizer levels, under different plant density and sowing date, on vegetative growth and flowering traits, early and total pods yield and pod characteristics of okra. The soil in the experimental farm has a loamy clay texture (some properties of the experimental soil are presented in Table 1).

The average monthly temperature for the two years ranged from 19.9 and 29.3 °C to 20.9 and 30.4 °C, while the average relative humidity ranged from 79.68 and 53.09 % to 78.23 and 51.87 % for the two years (Table 2).

Great variations in plant vigor, earliness, productivity and pod characteristics are present in local cultivars of okra plants grown in Kafr El-Sheikh Governorate. Selection of individual plants based on earliness, high number of pods, uniformity of plant phenotype with moderate vegetative growth and uniformity of fruit color (pale green) and shape was carried out. Inbreeding and selection for chosen plants were carried out for six successive generations; the pollination technique method described by Lee (1980) was followed.

Table 1: Some characteristics of the experimental soils.

Seasons	Mechanical analysis			Texture	pH*	EC** dSm^{-1}	OM (%)	Available elements (ppm)		
	Sand (%)	Silt (%)	Clay (%)					N	P	K
1st	10.0	50	40.0	Loamy Clay	7.18	0.56	1.70	25	5.0	432
2nd	9.5	51	39.5	Loamy Clay	7.9	0.70	1.68	23	5.5	419

* 1: 2.5 soil: water suspension.
** Soil past extract

Table 2: Meteorological information data for Kafr El-Sheikh Governorate (March–September) 2012, 2013.

Months	*Average monthly Temperature (^{0}C)		**Average relative humidity (%)		Average monthly Temperature (^{0}C)		Average relative humidity (%)	
	1st				2nd			
	Maximum	Minimum	7.30h	13.30h	Maximum	Minimum	7.30h	13.30h
March	19.5	11.3	77.11	59.83	24.4	12.4	79.56	50.91
April	27.1	17.0	73.53	53.53	26.0	15.9	74.20	43.90
May	30.8	20.8	75.70	50.05	31.4	21.8	75.03	45.78
June	33.6	23.5	79.60	50.77	32.4	23.9	74.63	51.27
July	33.2	25.3	84.05	53.02	32.3	24.3	79.57	54.70
August	34.7	25.0	84.90	52.14	33.8	24.8	83.63	60.52
September	32.3	22.7	82.87	52.30	32.5	22.9	81.00	56.60

* Rice Research and Training Center (RRTC), Sakha Agriculture Research Station, Monthly weather observations.
** Average relative humidity (%), at 7.30 and 13.30 hour.

After six generations of inbreeding and selection, six strains were selected. The six selected strains as well as the original cultivars were evaluated during the summer season of 2006 at a private farm in Disuq district, Kafr El-Sheikh Governorate. In isolation area, seeds of the best strain were produced in summer seasons of 2007 and 2008. The best strain was selected as a new cultivar of okra (Masoud *et al*, 2007). In the summer seasons of 2009 and 2010, the new cultivar of okra designated as Sakha -1 besides Sabahia -1 and Balady Green cultivars of okra were evaluated in the Experimental Farm of Sakha Agricultural Research Station (Metwally *et al*, 2011).

In the summer seasons of 2012 and 2013, the seeds of the new cultivar of okra; Sakha -1 were sown at three dates (March 15, April 15 and May 15) under four levels of phosphorus; i.e., 0, 15, 30 and 45 kg P_2O_5 fed.$^{-1}$. Phosphorus fertilizer, in the form of calcium super phosphate (15% P_2O_5) was applied to the soil as one dose before sowing. Seeds were sowing at three interplant spacings;15, 30 and 45 cm to represent three different plant densities of about 11.1, 5.5 and 3.6 plants m^2 , which equal to 44400, 22200 and 14400 plants fed.$^{-1}$, respectively. Each experiment unit included 36 treatments representing the combination of three sowing date, three planting density and four phosphorus levels. The experiments were conducted using split–split plot system in a randomized complete block design, with three replicates. The three sowing dates were assigned for the main plots, whereas the sub–plots were devoted for the plant density, and the phosphorus fertilizer levels were in the sub–sub plots. The experimental plot contained 6 ridges; each ridge was 4.5 m length and 0.6 m width, comprising an area of 16.2 m^2. The other recommended agricultural practices were used.

The following data were recorded:

1. Vegetative traits

Number of days from sowing to seedling emergence was recorded. After 120 days from sowing, five plants were uprooted from each plot and the following data were measured or counted: 1) Stem length (cm), 2) Number of nodes on main stem, 3) Internode length (cm), 4) Number of branches plant^{-1}, and 5) Number of leaves plant^{-1}.

2. Earliness traits

Earliness was recorded as number of nodes to the first flower and number of elapsed days from sowing to first flower anthesis.

3. Seed Yield and its components

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

Seed germination (%) was recorded from 36 days old dry pods as suggested by Anitha *et al.* (2001). For seed germination, seeds collected from middle position pods (5 to 8 nodes) were placed on filter paper (Whatman No.1) moistened with distilled water in 155 mm glass Petri dishes. Three replicates of 50 seeds from each sowing were kept in an incubator at 25°C. Germination of seeds was recorded up to 10 days and then evaluated according to ISTA (1985).

Statistical Analysis

Data of the studied characters were statistically analyzed, using the standard methods of the randomized complete blocks design, using M-stat-C software (1996), and Duncan's Multiple Range test was used for comparison among treatment means (Duncan, 1955).

RESULTS AND DISCUSSION

I. Vegetative and flowering traits

a. Effect of sowing date

The average daily maximum and minimum air temperatures as shown in Table 2, were decreased in March. It increases progressively till reached the maximum level in May. The emergence of the seedlings (Table 3) show that there was significant difference among sowing dates. The late sowing date (middle of May) enhanced the emergence of the seedlings more than the early one (March 15). The late of the sowing, the fast was the emergency of the seedling.

Data presented in Table (3) show that sowing date in mid-April recorded the highest mean values of stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem in comparison with the other sowing dates in mid-March or/and mid-May, in both seasons. On the other hand, the late sowing date (mid-May) was statistically responsible for the earliness in flowering than the other sowing dates as it need fewer days to flowering (48.5 days as an average of two seasons). Such significant differences among the sowing date in the vegetative and flowering traits could be attributed to air temperatures difference (Table 2). Ahmed (2007) reported that the effect of sowing date on growth and yield depends mainly on the prevailing environmental conditions especially temperature and relative humidity. Perkins *et al.* (1952) suggested that environmental factors could explain the delicate balance between vegetative growth and reproductive growth in okra. Pundarkia *et al.* (1972), in India, showed that the maximum temperature and sun shine hours affected okra initial growth and flower production. Several studies showed that sowing date significantly affected crop growth and flowering which was mainly attributed to influences of temperature (Khalifa, 1981, Yadev and Dhankhar, 1999, Incalaterra *et al*., 2000, Sharif *et al.* 2003, Chattopadhyay *et al.* 2011 and Ossom *et al.* 2011.

Olasantan and Olowe (2006) reported that sowing dates significantly affected phenology (time to vegetative growth, flowering, fruiting and harvesting stages).

Okra plants which bear the first flower on a lower node, and need fewer days to flowering will be earlier than those bearing the first flower on a higher node and need more days to flowering (Metwally *et al.* 1988 and 2011).

b. Effect of plant density

Data in Table (3) showed that stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem, were, significantly, increased as the plant density was decreased, in both seasons. Also, the low plant population had the lowest number of nodes to the first flower (3.7 and 3.6), while, high plant density had the highest number of nodes to the first flower (4.2 and 3.9). Likewise, lowering the plant density (wide plant spacing) resulted in the lowest number of days from sowing to flowering (48.8 and 48.2) in 2012 and 2013, respectively. The wider spacing was the best choice for better 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 (Feleafel and Ghoneim, 2005). The obtained results seemed to be in close agreements with those recorded by El-Maziny *et. al.* (1990), Farag and Damarany (1994) and Bin-Ishaq (2009), who indicated that the wider spacing between plants enhanced number of branches plant^{-1}.

c. Effect of phosphorus fertilizer levels

Data presented in Table (3) show that all growth parameters were significantly affected by increasing rate of phosphorus fertilization, in both growing seasons. The highest phosphorus rate (45 kg P_2O_5 fed.$^{-1}$) gave the tallest plants and the highest number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem. However, unfertilized treatment (control) or the low phosphorus rate (15 kg P_2O_5 fed.$^{-1}$) recorded the lowest mean values of each character. It is obvious from Table (3) that the highest phosphorus fertilization rate, significantly, caused earlier flowering than the other phosphorus rates. Furthermore, the highest phosphorus fertilization rate initiated the first flower to bear at lower number of nodes (3.8 and 3.5) in 2012 and 2013, respectively. Many researchers proved the importance of phosphorus in plant vegetative growth and flowering such as Salih (1981), Patton *et al.* (2002), El-Shaikh (2005), Omotoso and Shituu (2007), El-Shaikh and Mohammed (2009) and Firoz (2009).

d. Effect of sowing date and plant density interaction

Data presented in Table (4) show that the interaction between sowing dates and plant density significantly affected number of days to emergence, stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem, in both seasons. However, the internode length and number of nodes to the first flower was significantly affected in the first seasons of 2012 and 2013, respectively. Sowing okra seeds in mid-April with low plant density (14400 plants fed.$^{-1}$) exhibited the highest mean values of stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem. On the other hand, the late sowing date (mid-May) and low plant density accelerated the earliness as it gave lowest number of days from sowing to flowering and lowest number of nodes to the first flower than the other treatments. In this respect, Palanisamy *et al.* (1986), Singh *et al.* (1986), Amjad *et al.* (2001), Olasantan and Olowe (2006), Chattopadhyay *et al.* (2011) and Nagwa (2012) reported that there was a significant effect of sowing time and plant density interaction on vegetative and flowering traits of okra plants.

e. Effect of sowing date and phosphorus fertilizer levels interaction

Data tabulated in Table (5) show that the interaction between sowing date and phosphorus rates had highly significant effect on stem length, number of branches plant^{-1}, number of leaves plant^{-1}, number of nodes on main stem and, internode length, in both seasons, and number of days from sowing to flowering, in the second season only. The intermediate sowing date in mid-April and highest phosphorus fertilization rate (45 kg P_2O_5 fed.$^{-1}$) gave the highest mean values of stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem, in both seasons. Meanwhile, the late sowing date in mid-May and application of 45 kg P_2O_5 fed.$^{-1}$ resulted in the lowest number of days from sowing to flowering in the second season. These results are in agreement with those obtained by Olasantan and Olowe, (2006), Ahmed (2007) and Chattopadhyay *et al.* (2011).

f. Effect of plant density and phosphorus fertilizer levels interaction

Data in Table (6) show that the interaction between plant density and phosphorus rates reflected significant effect on stem length, number of branches plant^{-1}, number of leaves plant^{-1}, number of nodes on main stem and number of nodes to the first flower and number of days from sowing to flowering ,in the second season.

Table 3: Effect of sowing date, plant density and phosphorus fertilizer levels on vegetative and flowering traits of okra plants in 2012 and 2013 seasons.

Treatments		Vegetative traits												Flowering traits			
		No. of days to emergence		Stem length (cm)		No. of branches $plant^{-1}$		No. of leaves $plant^{-1}$		No. of nodes on main stem		Internode length (cm)		Nodes to first flower		Days to flowering	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing date (A)	March 15	8.1 a	7.3 a	75.1 c	79.0 c	0.4 b	0.5	21.5 b	23.6 b	24.9 c	25.9 c	3.0	3.1	4.1	3.9	55.7 a	52.8 a
	April 15	5.0 b	4.4 b	108.0 a	114.3 a	0.8 a	1.0	29.2 a	31.9 a	42.3 a	44.1 a	2.7	2.5	3.9	3.7	49.2 bc	48.6 ab
	May 15	4.4 b	3.6 b	96.7 b	101.7 b	0.6 ab	0.8	25.3 ab	27.8 ab	33.6 b	35.1 b	2.8	2.9	3.8	3.6	48.8 c	48.2 b
F. test		**	**	**	**	*	NS	**	**	**	**	NS	NS	NS	NS	*	*
Plant density (B)	44400 plants $fed.^{-1}$	5.7 b	5.0 c	89.0 c	94.2 c	0.5 c	0.5 c	23.0 c	24.9 c	31.1 c	31.9 c	2.9 a	3.0 a	4.2 a	3.9 a	51.9 a	49.8 b
	22200 plants $fed.^{-1}$	5.9 a	5.1 b	93.3 b	97.5 b	0.7 b	0.7 b	25.2 b	27.2 b	33.8 b	35.3 b	2.7 b	2.7 b	3.9 b	3.7 b	51.2 b	50.4 a
	14400 plants $fed.^{-1}$	5.9 a	5.2 a	97.7 a	103.3 a	0.8 a	1.0 a	27.8 a	31.2 a	35.9 a	37.9 a	2.7 b	2.7 b	3.7 c	3.6 c	50.6 c	49.4 c
F. test		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Phosphorus fertilizer levels (C)	0 kg P_2O_5 $fed.^{-1}$	5.8 b	5.0 c	87.4 d	91.7 d	0.3 d	0.5 d	22.0 d	24.2 d	31.1 d	32.1 d	2.9 a	2.8 ab	4.1 a	3.8 a	51.8 a	50.5 a
	15 kg P_2O_5 $fed.^{-1}$	5.8 b	5.0 c	92.1 c	96.9 c	0.5 c	0.6 c	24.1 c	26.4 c	32.6 c	34.0 c	2.9 a	2.9 a	4.0 b	3.7 b	51.4 b	50.0 b
	30 kg P_2O_5 $fed.^{-1}$	5.8 b	5.1 b	94.9 b	99.9 b	0.7 b	0.9 b	26.2 b	28.8 b	34.7 b	35.8 b	2.7 b	2.8 ab	3.9 c	3.6 c	51.0 c	49.7 c
	45 kg P_2O_5 $fed.^{-1}$	5.9 a	5.2 a	98.8 a	104.8 a	0.9 a	1.1 a	29.0 a	31.6 a	36.0 a	38.2 a	2.7 b	2.7 b	3.8 d	3.5 d	50.6 d	49.2 d
F. test		**	**	**	**	**	**	**	**	**	**	**	*	**	**	**	**
Interaction	A x B	*	**	*	**	**	**	**	**	**	**	**	NS	*	NS	**	**
	A x C	NS	NS	**	**	**	**	**	**	**	**	**	**	NS	NS	NS	**
	B x C	NS	NS	**	**	**	**	**	**	**	**	NS	**	**	*	NS	**
	A x B x C	NS	NS	NS	**	**	**	**	**	**	**	NS	**	NS	NS	NS	**

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 4: Effect of sowing date and plant density interaction on vegetative and flowering traits of okra plants in 2012 and 2013 seasons.

Treatments		Vegetative traits												Flowering traits			
		No. of days to emergence		Stem length (cm)		No. of branches plant^{-1}		No. of leaves plant^{-1}		No. of nodes on main stem		Internode length (cm)		Nodes to first flower		Days to flowering	
Sowing date	Plant density	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
March 15	44400 plants fed.$^{-1}$	8.0 a	7.2 b	70.3 l	74.2 l	0.3 f	0.4 d	19.5 h	21.0 f	21.9 l	22.8 h	3.3 a	3.3	4.3 a	4.0	56.6 a	54.3 a
	22200 plants fed.$^{-1}$	8.2 a	7.3 b	74.9 h	78.5 h	0.4 e	0.5 c d	21.2 g	23.3 e	25.6 h	26.5 g	2.9 bc	3.0	4.2 ab	3.8	55.7 b	52.4 b
	14400 plants fed.$^{-1}$	8.1a	7.5 a	80.2 g	84.4 g	0.6 c	0.7 c	23.6 f	26.6 d	27.2 g	28.4 f	2.9 bc	3.0	4.1 b	3.8	54.8 c	51.8 b
April 15	44400 plants fed.$^{-1}$	5.0 c	4.3 e	104.3 c	110.9 c	0.6 c	0.7 c	26.5 d	28.8 c	40.1 c	40.7 c	2.6 d	2.7	4.1 bc	3.8	49.8 d	49.0 cd
	22200 plants fed.$^{-1}$	5.1 bc	4.4 de	108.0 b	113.1 b	0.8 b	0.9 bc	29.2 b	31.0 b	42.1 b	44.0 b	2.6 d	2.3	4.0 cd	3.7	49.1 e	48.7 de
	14400 plants fed.$^{-1}$	5.1 bc	4.5 cd	111.8 a	118.8 a	1.1 a	1.3 a	31.9 a	35.8 a	44.6 a	47.5 a	2.5 d	2.4	3.8 ef	3.6	48.7 f	48.1 de
May 15	44400 plants fed.$^{-1}$	4.3 e	3.5 h	92.3 f	97.6 f	0.5 d	0.6 cd	23.0 f	24.9 de	31.1 f	32.2 e	2.9 bc	3.0	3.9 de	3.7	49.3 e	48.6 de
	22200 plants fed.$^{-1}$	4.4 e	3.6 gh	96.9 e	100.9 e	0.6 c	0.7 c	25.2 e	27.2 cd	33.9 e	35.3 d	2.8 c	2.9	3.8 ef	3.6	48.7 f	48.3 de
	14400 plants fed.$^{-1}$	4.5 de	3.7 fg	101.0 d	106.7 d	0.8 b	1.0 b	27.8 c	31.2 b	35.9 d	37.8 d	2.8 c	2.8	3.7 f	3.5	48.3 g	47.7 e

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 5: Effect of sowing date and phosphorus fertilizer levels interaction on vegetative and flowering traits of okra plants in 2012 and 2013 seasons.

Treatments		Vegetative traits												Flowering traits			
		No. of days to emergence		Stem length (cm)		No. of branches plant^{-1}		No. of leaves plant^{-1}		No. of nodes on main stem		Internode length (cm)		Nodes to first flower		Days to flowering	
Sowing date	Phosphorus fertilizer levels	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
March 15	0 kg P_2O_5 fed.$^{-1}$	8.1	7.3	68.0 o	71.7 n	0.3 g	o.4 d	18.6 m	20.5 l	21.8 o	22.9 o	3.2 a	3.2 a	4.3	4.0	56.3	53.6 a
	15 kg P_2O_5 fed.$^{-1}$	8.1	7.3	74.0 n	78.2 m	0.4 f	0.5 d	20.4 l	22.5 h	23.7 n	24.9 n	3.1 a	3.2 a	4.2	3.9	56.0	53.1 ab
	30 kg P_2O_5 fed.$^{-1}$	8.1	7.3	77.0 m	80.8 l	0.5 e	0.6 cd	22.2 h	24.8 g	26.2 m	26.8 m	2.9 b	3.0 b	4.1	3.8	55.6	52.6 b
	45 kg P_2O_5 fed.$^{-1}$	8.2	7.4	81.5 l	85.3 h	0.6 d	0.7 cd	24.6 g	26.8 f	27.9 l	29.1 l	2.9 b	2.9 b	4.0	3.8	54.9	52.1 b
April 15	0 kg P_2O_5 fed.$^{-1}$	5.0	4.4	103.5 d	108.3 d	0.5 e	0.6 cd	25.4 f	27.9 f	40.3 d	40.9 d	2.7 de	2.5 d	4.1	3.8	49.9	49.1 cd
	15 kg P_2O_5 fed.$^{-1}$	5.0	4.4	106.9 c	112.2 c	0.6 d	0.7 cd	27.8 d	30.3 d	41.5 c	43.2 c	2.6 e	2.5 d	4.0	3.7	49.3	48.7 cd
	30 kg P_2O_5 fed.$^{-1}$	5.1	4.4	109.0 b	115.7 b	0.9 b	1.1 b	30.2 b	32.8 bc	43.2 b	44.9 bc	2.6 e	2.5 d	3.8	3.7	49.0	48.4 de
	45 kg P_2O_5 fed.$^{-1}$	5.1	4.5	112.8 a	120.9 a	1.2 a	1.4 a	33.4 a	36.5 a	44.0 a	47.3 a	2.6 e	2.5 d	3.8	3.6	48.7	48.0 de
May 15	0 kg P_2O_5 fed.$^{-1}$	4.4	3.6	90.8 h	95.1 g	0.3 g	0.5 d	22.0 h	24.2 gh	31.1 h	32.5 h	2.9 bc	2.7 c	3.9	3.8	49.3	48.7 cd
	15 kg P_2O_5 fed.$^{-1}$	4.4	3.6	95.4 g	100.2 f	0.5 e	0.6 cd	24.1 g	26.4 f	32.6 g	34.0 gh	2.9 bc	2.9 b	3.8	3.6	49.0	48.4 de
	30 kg P_2O_5 fed.$^{-1}$	4.3	3.6	98.6 f	103.3 e	0.7 c	0.9 b	26.2 e	28.8 ef	34.7 f	35.7 fg	2.8 cd	2.9 b	3.7	3.6	48.6	48.0 de
	45 kg P_2O_5 fed.$^{-1}$	4.5	3.7	102.2 e	108.2 d	0.9 b	1.1 b	29.0 c	31.6 cd	36.0 e	38.2 e	2.8 cd	2.9 b	3.7	3.5	48.2	47.6 e

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 6: Effect of plant density and phosphorus fertilizer levels interaction on vegetative and flowering traits of okra plants in 2012 and 2013 seasons.

Treatments		Vegetative traits												Flowering traits			
		No. of days to emergence		Stem length (cm)		No. of branches plant^{-1}		No. of leaves plant^{-1}		No. of nodes on main stem		Internode length (cm)		Nodes to first flower		Days to flowering	
Plant density	Phosphorus fertilizer levels	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
44400	0 kg P_2O_5 fed.$^{-1}$	5.8	5.0	82.1 n	86.5 m	0.2 g	o.3 d	20.0 g	21.7 f	28.3 h	28.0 f	3.0	2.9 b	4.4 a	4.0 a	52.5	51.0 a
plants	15 kg P_2O_5 fed.$^{-1}$	5.8	5.0	86.9 m	92.7 hl	0.4 e	0.5 d	22.0 f	23.6 ef	29.7 g	30.9 e	3.0	3.1 a	4.3 a	3.9 ab	52.1	50.6 ab
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	5.8	5.0	91.5 h	96.6 fg	0.5 d	0.6 cd	23.9 e	26.0 d	32.4 e	32.7 de	2.9	3.0 ab	4.1 b	3.8 b	51.7	50.2 ab
	45 kg P_2O_5 fed.$^{-1}$	5.8	5.1	95.5 e	101.1 d	0.7 c	0.8 c	26.2 cd	28.3 c	33.8 d	36.0 b	2.9	3.0 ab	4.0 bc	3.7 bc	51.2	49.9 b
22200	0 kg P_2O_5 fed.$^{-1}$	5.8	5.1	88.0 l	91.8 l	0.3 f	0.4 d	22.2 f	23.8 ef	31.1 f	32.5 de	2.9	2.9 b	4.1 b	3.8 b	51.7	50.6 ab
plants	15 kg P_2O_5 fed.$^{-1}$	5.8	5.1	92.7 g	95.7 g	0.5 d	0.6 cd	23.8 e	25.3 d	33.1 d	34.1 cd	2.8	2.7 c	4.0 bc	3.7 bc	51.3	50.1 ab
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	5.8	5.1	93.7 fg	98.6 e	0.7 c	0.9 bc	25.8 d	28.1 cd	35.0 c	36.5 bc	2.7	2.6 c	3.9 cd	3.7 bc	51.0	49.6 bc
	45 kg P_2O_5 fed.$^{-1}$	6.0	5.2	98.7 c	103.7 c	0.9 b	1.0 bc	29.0 b	31.5 b	36.2 b	40.7 a	2.7	2.6 c	3.8 d	3.6 c	50.7	49.0 c
14400	0 kg P_2O_5 fed.$^{-1}$	5.9	5.2	92.2 g	96.8 f	0.5 d	0.7 c	23.9 e	27.0 d	33.8 d	35.8 c	2.8	2.7 c	3.9 cd	3.7 bc	51.3	49.9 bc
plants	15 kg P_2O_5 fed.$^{-1}$	5.9	5.2	96.7 de	102.3 c	0.7 c	0.8 c	26.6 cd	30.3 b	35.1 c	37.0 bc	2.8	2.8 bc	3.7 de	3.6 c	50.9	49.6 bc
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	5.9	5.2	99.4 b	104.5 bc	0.9 b	1.1 b	28.9 b	32.4 b	36.8 b	38.2 b	2.7	2.7 c	3.6 e	3.6 c	50.5	49.2 bc
	45 kg P_2O_5 fed.$^{-1}$	6.0	5.3	102.3 a	109.6 a	1.1 a	1.4 a	31.8 a	35.1 a	37.8 a	40.7 a	2.7	2.7 c	3.6 e	3.5 c	49.8	48.9 c

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Reducing the plant density to 14400 plants fed.$^{-1}$ and raising the phosphorus fertilization to the highest rate (45 kg P_2O_5 fed.$^{-1}$) showed the highest mean values of stem length, number of branches plant^{-1}, number of leaves plant^{-1}, number of nodes on main stem and the lowest number of nodes to the first flower, in both seasons. Furthermore, this treatment produced accelerated the flowering, in the second season. The present results matched well those obtained by Salih (1981) and Amjad *et al.* (2001).

The comparisons among treatment combination means reflected clear significant differences among the three studied factors on stem length, number of branches plant^{-1}, number of leaves plant^{-1} and number of nodes on main stem ,in both seasons, and internode length and lowest number of days from sowing to flowering, in the second season one.

II. Seed yield and its components

a. Effect of sowing date

Data in Table (7) indicate that the sowing date in mid-April, had highly significant increase in seed yield plant^{-1}, seed yield (kg) fed^{-1},number of pods plant^{-1} , number of seeds pod^{-1} and seed germination (%) as compared with sowing date in mid-March or /and mid-May, in both seasons. Seed index, pod weight, pod length and pod diameter, however, appeared not significant. Seed yield in okra is affected by three major yield components, i.e., number of pods plant^{-1} and number of seeds pod^{-1}. In this concern, Chattopadhyay *et al.* (2011) found that seed yield was strongly affected by number of pods plant^{-1} and number of seeds pod^{-1} which was carried due to variety. These results are in harmony with thos e of Akinyele and Osekita (2006), Abduljabbar *et al.* (2007), Moniruzzamam *et al.* (2007) and Nagwa (2012) who worked on different sowing date of okra.

b. Effect of plant density

Data presented in Table (7) show that okra plants grown at high plant density (44400 plants fed.$^{-1}$) produced the highest seed yield, i.e., 1257.9 and 1617.5 kg fed.$^{-1}$ in the first and the second seasons, respectively. On the other hand, okra plants grown at low plant density (14400 plants fed.$^{-1}$) produced the highest mean values of seed yield plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100-seeds, pod weight, pod length and seed germination (%), while, growing okra plants under high plant density produced the lowest values of the previous characters. The differences were highly significant, in both seasons. In this respect, many investigators reported that seed yield per feddan significantly increased as plant density increased. Saleh *et al.* (1980), on cowpea, found that less crowded plants led to higher seed yield per plant but lower seed yield per feddan. Zanin and Kimoto (1984), Sarnaik and Baghel (1986), El-Maziny *et. al.* (1990), Farag and Damarany (1994) and Bin-Ishaq (2009) on okra, reported that the higher seed yield was obtained from high plant population per unit area.

c. Effect of phosphorus fertilizer levels

Data in Table (7) indicate that phosphorus fertilization with 45 kg P_2O_5 fed.$^{-1}$, significantly, increased seed yield plant^{-1}, seed yield fed.$^{-1}$, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1},weight of 100-seeds, pod weight, pod length and diameter and seed germination percentage, in the both seasons, as compared with 15 or 30 kg P_2O_5 fed.$^{-1}$. The obtained increments in the seed yield as a result of 45 kg P_2O_5 application might be directly attributed to the increase of pod number per plant, number of seeds per pod and weight of 100-seed. These results seemed to be in accordance with those reported by El-Maziny *et al.* (1990), Naik and Srinivas (1994), who found that seed yield of okra and its components, were significantly increased with increasing phosphorus rates. The same general trend was found by Naik and Singh (1999), Amjad et al. (2001), Chattopahyay and Sahana (2001), Patton et al. (2002), Singh (2002) and El-Shaikh (2005) who observed significant increases in seed yield with phosphorus application. El-Shaikh and Mohammed (2009) reported that the increase in seed yield may be related to the increments on number of pods plant^{-1} rather than to increase in weight of seeds pod^{-1}). Moreover, Marschner (1995) mentioned that, phosphorus positively effect on metabolic processes including cell division, expansion and formation and movement of carbohydrate. Also, encouraging blooming, pod setting, fertility, weight of 1000-seed, seed yield and germination percentage. These results in harmony with those found by Majanbu *et al.* (1985), Lenka *et al.* (1989), El-Shaikh (2005) and Firoz (2009).

d. Effect of sowing date and plant density interaction

Data presented in Table (8) show that the seed yield and its components were highly significant affected by the interaction between sowing date and plant density, in both seasons. It is clear that sowing date in mid-April produced the highest seed yield fed.$^{-1}$ under high plant density. On the other hand, sowing okra seeds in mid-April and 14400 plants fed.$^{-1}$ produced the highest seed yield plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1},weight of 100-seeds, pod weight, pod length and seed germination percentage, in the both seasons. Meanwhile, the early sowing date (mid-March) which grown under low or high plant density produced the lowest seed yield, in both seasons. In this respect, Gupta *et al.* (1981), Singh *et al.* (1986), Hossain *et al.* (1999) and Nagwa (2012) reported that there was a significant effect of both sowing time and plant density interaction on seed yield of okra.

Table 7: Effect of sowing date, plant density and phosphorus fertilizer levels on mature pods characteristics, seed yield and seed yield components of okra plants in 2012 and 2013 seasons.

Treatments		No. of pods plant^{-1}		Pod weight (g)		Pod length (cm)		Pod diameter (cm)		No. of seed Pod^{-1}		Seed yield Pod^{-1} (g)		Total seed yield: Seed yield plant^{-1} (g)		Total seed yield: Seed yield Kg fed.$^{-1}$		100 seed Weight (g)		Seed germination (%)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Sowing date (A)	March 15	11.4 b	12.9 c	6.0	6.6	11.1	11.7	1.8	1.9	53.2 b	57.5 b	2.4	2.6	28.0 c	33.7 c	673.0 c	811.9 c	4.3	4.5	79.0 b	80.5 b
	April 15	18.4 a	20.9 a	7.5	8.1	12.7	13.1	2.1	2.2	63.2 a	68.3 a	2.9	3.3	55.5 a	70.2 a	1337.4 a	1685.0 a	4.6	4.8	83.8 a	85.4 a
	May 15	13.9 ab	16.5 b	6.5	7.3	11.6	12.3	2.0	2.0	60.3 ab	65.2 a	2.7	3.1	38.4 b	52.0 b	917.5 b	1254.7 b	4.5	4.7	83.6 a	84.7 ab
F. test		**	**	NS	NS	NS	NS	NS	NS	*	**	NS	NS	**	**	**	**	NS	NS	*	*
Plant density (B)	44400 plants fed.$^{-1}$	11.8 c	13.8 c	5.4 c	6.0 c	10.8 c	11.4 c	1.9	2.0	55.6 c	58.8 c	2.3 c	2.6 c	28.3 c	36.4 c	1257.9 a	1617.5 a	4.1 c	4.4 c	81.1 c	81.9 c
	22200 plants fed.$^{-1}$	14.7 b	17.0 b	6.7 b	7.5 b	11.8 b	12.6 b	2.0	2.1	59.5 b	63.8 b	2.7 b	3.0 b	41.3 b	53.0 b	916.4 b	1176.7 b	4.5 b	4.8 b	82.3 b	83.4 b
	14400 plants fed.$^{-1}$	17.2 a	19.5 a	7.9 a	8.6 a	12.8 a	13.3 a	2.0	2.2	61.6 a	68.4 a	2.9 a	3.3 a	52.3 a	66.5 a	753.6 c	957.4 c	4.7 a	4.8 a	83.0 a	85.2 a
F. test		**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	**	**	**	**
Phosphorus fertilizer levels (C)	0 kg P_2O_5 fed.$^{-1}$	11.2 d	13.1 d	6.0 d	6.7 d	11.0 d	11.7 d	1.9	2.0	54.2 d	57.8 d	2.3 d	2.6 d	27.0 d	35.6 d	653.2 d	864.6 d	4.2 c	4.5 d	81.5 d	82.6 d
	15 kg P_2O_5 fed.$^{-1}$	13.3 c	15.9 c	6.4 c	7. 1 c	11.6 c	12.1 c	1.9	2.0	56.1 c	61.7 c	2.5 c	2.9 c	34.0 c	47.3 c	830.2 c	1125.9 c	4.4 b	4.6 c	81.9 c	83.2 c
	30 kg P_2O_5 fed.$^{-1}$	15.9 b	17.9 b	6.8 b	7.4 b	12.0 b	12.6 b	2.0	2.1	59.2 b	65.6 b	2.7 b	3.0 b	44.4 b	55.9 b	1070.6 b	1348.5 b	4.6 a	4.7 b	82.4 b	83.8 b
	45 kg P_2O_5 fed.$^{-1}$	17.8 a	20.2 a	7.5 a	8.1 a	12.7 a	13.2 a	2.1	2.2	66.1 a	69.6 a	3.1 a	3.3 a	57.2 a	69.0 a	1349.8 a	1663.2 a	4.6 a	4.9 a	82.8 a	84.5 a
F. test		**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	**	**	**	**
Interaction	A x B	**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	*	**	**	**
	A x C	**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	**	*	**	**
	B x C	**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	NS	*	**	**
	A x B x C	**	**	**	**	**	**	NS	NS	**	**	**	**	**	**	**	**	**	NS	**	**

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 8: Effect of sowing date and plant density interaction on mature pods characteristics, seed yield and seed yield components of okra plants in 2012 and 2013 seasons.

Treatments		No. of pods plant^{-1}		Pod weight (g)		Pod length (cm)		Pod diameter (cm)		No. of seed Pod^{-1}		Seed yield Pod^{-1} (g)		Total seed yield: Seed yield plant^{-1}(g)		Total seed yield: Seed yield Kg fed.$^{-1}$		100 seed Weight (g)		Seed germination (%)	
Sowing date	Plant density	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
March 15	44400 plants fed.$^{-1}$	8.9 l	10.1 l	4.9 g	5.4 f	10.3 d	10.8 f	1.7	1.8	50.7 g	54.9 l	2.2 e	2.3 d	19.5 h	23.8 l	865.8 f	1055.5 f	4.0 e	4.3 b	77.9 h	79.3 h
	22200 plants fed.$^{-1}$	11.5 gh	13.0 h	5.9 e	6.6 d	11.2 cd	11.9 d	1.8	1.9	53.0 f	57.1 h	2.5 d	2.6 cd	28.6 f	34.0 h	634.0 h	755.1 h	4.4 c	4.7 ab	79.2 g	80.2 g
	14400 plants fed.$^{-1}$	13.9 f	15.5 f	7.1 c	7.7 c	11.8 c	12.5 c	1.9	2.0	56.0 e	60.7 f	2.6 cd	2.8 c	36.1 e	43.4 f	519.3 l	625.1 l	4.5 c	4.6 b	79.8 f	81.8 f
April 15	44400 plants fed.$^{-1}$	15.5 d	17.3 d	6.0 e	6.6 d	11.4 cd	11.9 d	2.1	2.1	59.2 d	62.8 e	2.5 d	2.8 c	39.2 d	48.4 e	1741.1 a	2149.4 a	4.2 d	4.5 b	82.9 de	83.5 d
	22200 plants fed.$^{-1}$	18.4 b	21.4 b	7.8 b	8.4 b	12.8 b	13.2 b	2.1	2.2	64.1 b	69.0 c	3.0 b	3.4 ab	56.2 b	73.3 b	1246.6 b	1627.5 c	4.7 b	4.9 ab	84.0 bc	85.2 c
	14400 plants fed.$^{-1}$	21.4 a	24.1 a	8.7 a	9.3 a	13.9 a	14.3 a	2.2	2.3	66.4 a	73.1 a	3.3 a	3.6 a	71.2 a	88.8 a	1024.6 d	1278.1 d	4.9 a	5.0 a	84.6 a	87.5 a
May 15	44400 plants fed.$^{-1}$	11.2 h	13.9 g	5.3 f	5.8 e	10.6 d	11.4 e	2.0	2.0	57.0 e	58.9 g	2.3 e	2.6 cd	26.3 g	37.1 g	1166.6 c	1647.5 b	4.2 d	4.4 b	82.6 e	83.0 e
	22200 plants fed.$^{-1}$	14.3 ef	16.5 e	6.4 d	7.4 c	11.5 c	12.6 c	2.1	2.1	61.5 c	65.4 d	2.7 c	3.1 bc	39.1 d	51.7 d	868.7 ef	1147.6 e	4.6 bc	4.7 ab	83.8 c	84.8 c
	14400 plants fed.$^{-1}$	16.3cd	19.1 c	7.8 b	8.7 b	12.7 b	13.1 b	2.1	2.2	62.5 c	71.4 b	2.9 b	3.5 a	49.8 c	67.3 c	717.1 g	969.0 g	4.6 bc	4.9 ab	84.5 a	86.3 b

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 9: Effect of sowing date and phosphorus fertilizer levels interaction on mature pods characteristics, seed yield and seed yield components of okra plants in 2012 and 2013 seasons.

Treatments		No. of pods plant^{-1}		Pod weight (g)		Pod length (cm)		Pod diameter (cm)		No. of seed Pod^{-1}		Seed yield Pod^{-1} (g)		Total seed yield: Seed yield plant^{-1} (g)		Total seed yield: Seed yield Kg fed.$^{-1}$		100 seed Weight (g)		Seed germination (%)	
Sowing date	Phosphorus fertilizer levels	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
March15	0 kg P_2O_5 fed.$^{-1}$	8.7 h	10.0 l	5.4 l	6.0 g	10.3 g	11.0 g	1.7	1.8	48.2 l	51.9 m	2.2 f	2.3 c	19.4 m	23.6 n	470.7 o	567.7 o	4.1 d	4.4 b	78.3h	79.6 l
	15 kg P_2O_5 fed.$^{-1}$	10.6 g	12.4 h	5.7 hl	6.4 f	10.9 f	11.6 f	1.8	1.9	51.1 h	55.5 l	2.3 ef	2.4 c	24.5 l	30.7 m	586.9 n	737.6 n	4.4 c	4.5 b	78.7 gh	80.1 h
	30 kg P_2O_5 fed.$^{-1}$	12.3 f	13.5 g	6.1 fg	6.7 ef	11.4 e	12.0 e	1.8	1.9	54.1 g	59.2 h	2.4 e	2.6 c	30.0 h	35.3 l	720.3 l	844 .7 m	4.4 c	4.6 b	79.3 f	80.7 g
	45 kg P_2O_5 fed.$^{-1}$	14.0 e	15.6 f	6.6 de	7.2 d	11.8 d	12.3 e	1.9	2.0	59.5 e	63.6 f	2.7 cd	2.9 bc	38.2 f	45.4 h	914.2 f	1097.8 g	4.4 c	4.7 b	79.6 ef	81.4 f
April 15	0 kg P_2O_5 fed.$^{-1}$	14.1 e	16.5 e	6.7 d	7.4 d	11.7 de	12.2 e	2.0	2.0	57.9 f	62.3 g	2.5 de	2.9 bc	35.6 g	48.5 f	864.3 g	1176.5 f	4.3 c	4.6 b	83.2 d	84.5 d
	15 kg P_2O_5 fed.$^{-1}$	17.2 c	20.2 c	7.3 c	7.9 c	12.3 b	12.7 d	2.1	2.2	60.1 de	66.1 e	2.7 cd	3.2 b	46.7 d	64.8 d	1146.9 d	1546.4 d	4.5 bc	4.7 b	83.5 cd	85.1 c
	30 kg P_2O_5 fed.$^{-1}$	20.2 b	22.4 b	7.8 b	8.3 b	13.1 b	13.5 b	2.2	2.3	64.1 c	70.7 c	3.1 b	3.5 a	62.7 b	76.4 b	1509.3 b	1829.6 b	4.7 ab	4.8 ab	84.1 a	85.7 b
	45 kg P_2O_5 fed.$^{-1}$	22.1 a	24.6 a	8.2 a	8.9 a	13.6 a	14.1 a	2.2	2.3	70.8 a	74.1 a	3.4 a	3.7 a	77.0 a	91.0 a	1829.3 a	2187.5 a	4.8 a	5.1 a	84.5 a	86.4 a
May 15	0 kg P_2O_5 fed.$^{-1}$	10.8 g	12.9 h	5.9 g	6.6 f	10.8 f	11.8 f	2.0	2.0	56.5 f	59.2 h	2.4 e	2.7 c	25.8	34.8 l	624.6 m	849.7 l	4.3 c	4.5 b	82.9 d	83.7 e
	15 kg P_2O_5 fed.$^{-1}$	12.2 f	15.0 f	6.2 f	6.9 ef	11.4 e	12.1 e	2.0	2.0	57.2 f	63.5 f	2.5 de	3.0 bc	30.8 h	46.4 gh	756.8 h	1093.6 h	4.4 c	4.6 b	83.5 c	84.7 c
	30 kg P_2O_5 fed.$^{-1}$	15.2 d	17.7 d	6.4 e	7.4 d	11.6 de	12.4 de	2.1	2.1	59.6 e	66.9 de	2.6 d	3.1 bc	40.4 e	56.2 e	982.4 e	1371.1 e	4.5 bc	4.7 b	83.9 b	85.0 c
	45 kg P_2O_5 fed.$^{-1}$	17.3 c	20.3 c	7.5 c	8.2 b	12.6 c	13.1 c	2.1	2.2	68.0 b	71.3 b	3.1 b	3.4 a	56.5 c	70.8 c	1306.1 c	1704.3 c	4.6 b	4.8 ab	84.3 a	85.7 b

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

Table 10: Effect of plant density and phosphorus fertilizer levels interaction on mature pods characteristics, seed yield and seed yield components of okra plants in 2012 and 2013 seasons.

Treatments		No. of pods plant^{-1}		Pod weight (g)		Pod length (cm)		Pod diameter (cm)		No. of seed Pod^{-1}		Seed yield Pod^{-1} (g)		Total seed yield: Seed yield plant^{-1} (g)		Total seed yield: Seed yield Kg fed.$^{-1}$		100 seed Weight (g)		Seed germination (%)	
Plant density	Phosphorus fertilizer levels	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
44400	0 kg P_2O_5 fed.$^{-1}$	9.0 h	10.5 l	5.1 m	5.4 h	9.9 m	10.8 l	1.8	1.9	51.8 m	54.2 l	2.1 g	2.4 c	19.3 o	25.4 n	858.5 g	1128.8 g	3.9	4.3 b	80.5 h	81.2 l
plants	15 kg P_2O_5 fed.$^{-1}$	10.7 g	12.9 h	5.3 lm	5.7 gh	10.6 l	11.1 hl	1.9	1.9	54.2 l	57.5 h	2.3 f	2.5 c	25.3 n	32.5 m	1124.2 d	1444.2 d	4.2	4.3 b	80.9 gh	81.7 h
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	13.0 e	14.5 g	5.5 hl	5.9 g	11.0 h	11.6 g	1.9	2.0	56.8 fg	60.3 g	2.4 f	2.7 c	31.5 l	39.4 h	1396.4 b	1747.3 b	4.2	4.4 b	81.4 f	82.1 g
	45 kg P_2O_5 fed.$^{-1}$	14.7 de	17.2 e	5.8 gh	6.6 fg	11.5 g	11.9 fg	2.0	2.1	59.7 d	63.2 e	2.5 ef	2.8 bc	37.2 g	48.4 g	1652.3 a	2149.6 a	4.3	4.6 b	81.7 ef	82.8 f
22200	0 kg P_2O_5 fed.$^{-1}$	11.3 fg	13.8 gh	5.9 fg	6.8 f	11.0 h	11.9 f	1.9	2.0	54.9 hl	57.5 h	2.4 f	2.6 c	27.6 m	37.3 l	612.6 n	827.6 m	4.3	4.6 b	81.6 ef	82.3 g
plants	15 kg P_2O_5 fed.$^{-1}$	13.2 e	15.9 f	6.4 e	7.2 e	11.6 f	12.4 de	2.0	2.1	56.5fg	62.0 f	2.5 ef	2.9 bc	33.5 h	46.2 e	743.0 l	1025.3 h	4.5	4.7 ab	82.1 d	83.1 f
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	16.2 c	18.2 d	6.8 d	7.7 d	12.1 e	12.7 d	2.0	2.1	58.9 de	65.2 d	2.7 d	3.1 b	45.0 d	57.4 d	999.5 f	1275.5 e	4.7	4.8 ab	82.6 bc	83.8 e
	45 kg P_2O_5 fed.$^{-1}$	18.1 b	20.0 c	7.7 c	8.3 c	12.6 cd	13.2 c	2.1	2.2	67.8 b	70.6 c	3.2 b	3.5 ab	59.0 b	71.1 b	1310.5 c	1578.5 c	4.7	5.0 a	83.0 b	84.4 d
14400	0 kg P_2O_5 fed.$^{-1}$	13.4 e	15.1 fg	6.9 d	7.8 d	11.9 ef	12.3 e	2.0	2.0	55.9 gh	61.8 f	2.5 e	2.9 bc	33.9 f	44.2 f	488.4 o	637.3 n	4.4	4.6 b	82.3 cd	84.2 d
plants	15 kg P_2O_5 fed.$^{-1}$	16.1 c	18.8 d	7.6 c	8.4 c	12.4 de	12.9 cd	2.0	2.1	57.7 ef	65.5 d	2.7 d	3.3 ab	43.3 e	63.1 c	623.4 m	908.1 l	4.6	4.8 ab	82.7 bc	84.9 c
fed.$^{-1}$	30 kg P_2O_5 fed.$^{-1}$	18.6 b	20.9 bc	8.0 b	8.6 bc	13.0 b	13.5 bc	2.1	2.2	62.1 c	71.3 bc	3.0 c	3.3 ab	56.7 c	71.1 b	816.0 h	1022.7 h	4.8	4.9 ab	83.2 a	85.5 b
	45 kg P_2O_5 fed.$^{-1}$	20.7 a	23.3 a	8.8 a	9.4 a	13.9 a	14.4 a	2.1	2.3	70.8 a	75.1 a	3.5 a	3.7 a	75.5 a	87.6 a	1086.7 e	1261.5 f	4.8	5.0 a	83.6 a	86.2 a

Means designated by the same letter at each column are not significantly different at the 0.05 level, according to Duncan's Multiple Range Test.

e. Effect of sowing date and phosphorus fertilizer levels interaction

Data presented in Table (9) show that the productivity of okra plants were affected by sowing date and phosphorus fertilizer levels interaction, in both seasons. It is clear that the intermediate sowing date (mid-April) and the highest phosphorus (45 kg P_2O_5 fed.$^{-1}$) produced the highest values of seed yield plant^{-1}, seed yield fed.$^{-1}$, number of pod plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100–seed, pod length and seed germination percentage. However, sowing okra seeds too early in mid-March and 15 or 30 kg P_2O_5 fed.$^{-1}$ produced the lowest seed yield and its components, in both seasons. These results are in agreement with those obtained by Abduljabbar *et al.* (2007) and Amjad *et al.* (2001).

f. Effect of plant density and phosphorus fertilizer levels interaction

Data presented in Table (10) show that seed yield plant.$^{-1}$, seed yield fed.$^{-1}$, number of pod plant^{-1} , number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100–seed, pod weight, pod length and seed germination percentage were significantly affected by the interaction between the plant density and phosphorus fertilizer levels, in both seasons. Plants grown under the highest density with the highest P_2O_5 fertilizer level produced the highest seed yield (1652.3 and 2149.6 kg fed.$^{-1}$) in the first and the second seasons, respectively. On the other hand, plants grown under low density with high P_2O_5 fertilizer level, produced the highest seed yield plant^{-1}, number of pod plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100–seed, pod weight, pod length and seed germination percentage in the first and second seasons, respectively. On the other extreme, plants grown under high density with low P_2O_5 fertilizer level produced the lowest seed yield and its components, in both seasons. In this respect, Salih (1981), Dwievedi *et al*. (1993) and Amjad *et al*. (2001) found that there were significant interactions between plant density and phosphorus levels on seed yield and its components of okra plants.

The interaction among the three factors affected significantly seed yield plant^{-1}, seed yield fed.$^{-1}$, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield pod^{-1}, weight of 100-seeds, pod weight, pod length and seed germination percentage, in both seasons., as average of seed yield plant^{-1}, seed yield fed^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, pod length, weight of 100–seeds.

In view of the obtained results, it could be concluded that for obtaining the highest seed yield from new okra cv. Sakha -1 (under registration), sowing seeds in mid-April under high plant density (44400 plants fed.$^{-1}$) and application of phosphorus fertilizer rate at 45 kg P_2O_5 fed.$^{-1}$.

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الملخص العربى

تأثير ميعاد الزراعة والكثافة النباتية والتسميد الفوسفاتى على انتاج البذور فى الباميه

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أجريت التجربة على محصول الباميه خلال العروة الصيفية لعامى ٢٠١٢ ، ٢٠١٣م فى فى منطقة دسوق – محافظة كفر الشيخ لدراسة استجابة نباتات الباميه(صنف جديد تحت التسجيل) لثلاث مواعيد زراعيه مختلفه(منتصف مارس ومنتصف ابريل ومنتصف مايو) وثلاثة كثافات نباتيه(١٤٤٠٠ و٢٢٢٠٠ و٤٤٤٠٠ نبات/فدان) واربعة مستويات من التسميد الفوسفاتى(صفر، ١٥، ٣٠، ٤٥كجم فو٢أ٥/ فدان). وكان التصميم المستخدم هو نظام القطع المنشقة مرتين فى أربع مكررات حيث وزعت معاملات مواعيد الزراعة عشوائيا على القطع الرئيسية بينما وزعت معاملات الكثافة النباتية داخل القطع المنشقة وكذلك وزعت المعاملات السمادية داخل القطع المنشقة مرتين.

وتتلخص أهم النتائج المتحصل عليها فى الآتى:-

تفوقت نباتات البامية المنزرعه فى منتصف ابريل عن باقى مواعيد الزراعه حيث أعطت أعلى القيم لصفات النموالخضرى بينما كانت نباتات البامية المنزرعه فى منتصف مايو أبكر فى التزهير، حيث أعطت النباتات أقل القيم فى عدد الأيام من الزراعة وحتى التزهير وذلك فى الموسمين. وبالنسبة لمحصول البذور ومكوناته معبرا عنه بالمحصول البذرى للنبات والمحصول الكلى للفدان وعدد القرون للنبات وعدد البذور للقرن ووزن البذور بالقرن ووزن ١٠٠ بذرة ووزن القرن ونسبة الأنبات فقد تفوقت النباتات المنزرعه فى منتصف ابريل عن باقى مواعيد الزراعه، بينما أعطت النباتات المنزرعه فى منتصف مارس أقل القيم فى محصول البذور ومكوناته وذلك فى الموسمين.

بينت النتائج أن قلة الكثافة النباتية قد أدى إلى تحسين صفات النمو الخضرى والزهرى ومكونات المحصول، علاوة على زيادة نسبة الانبات للبذور، بينما محصول البذور قد استجاب بالزيادة كنتيجة لزيادة الكثافة النباتية.

أوضحت النتائج أن زيادة معدل التسميد الفوسفاتى المضاف حتى ٤٥ كجم/فدان صاحبه زيادة معنوية فى صفات النمو الخضرى والزهرى والمحصول البذرى ومكوناته وأيضا نسبة الانبات للبذور.

هذا ولقد أعطت النباتات المنزرعه فى منتصف ابريل و قلة الكثافة النباتية أعلى القيم لصفات النموالخضرى وكذا المحصول البذرى للنبات وعدد القرون للنبات وعدد البذور للقرن ووزن البذور بالقرن ووزن ١٠٠ بذرة ووزن القرن ونسبة الأنبات وذلك فى الموسمين، بينما تفوقت النباتات المنزرعه فى منتصف ابريل مع التسميد الفوسفاتى ٤٥ كجم/فدان أعلى القيم فى صفات النمو الخضرى ومحصول البذور ومكوناته. هذا ولقد وجد أن قلة الكثافة النباتية مع زيادة معدل التسميد الفوسفاتى المضاف حتى ٤٥ كجم/فدان أعطت أعلى نمو خضرى وزهرى ومحصول البذور ومكوناته وذلك فى الموسمين.

من نتائج البحث يتضح أنه للحصول على أعلى محصول بذرى من صنف الباميه تحت التسجيل يوصى بزراعتة فى منتصف ابريل تحت كثافة نباتيه ٤٤٤٠٠ نبات/فدان مع التسميد الفوسفاتى بمعدل ٤٥ كجم/فدان.