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Some agricultural treatments for okra (*abelmoschus esculentus* l.) Production under low temperature conditions

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ABSTARCT

Two experiments were conducted during 2007- 2008 and 2008 – 2009 growing seasons at Mariut farm of the Desert Research Center. The aim of the experiments was to compare growth, yield and its component and nitrogen and carbohydrate contents as well as to determine base temperature and accumulated heat units of okra as influenced with transplanting date and nitrogen source. Five transplanting dates were investigated which were; Jan.15th, Febr.1st, Febr.15th, March.1st and March.15th. Four nitrogen sources were studied which were: Urea, ammonium nitrate, ammonium sulfate and compost; the applied quantity of each source contained 90 nitrogen unit; beside control treatment which was ammonium nitrate at rate of 60 nitrogen unit (the recommended dose). Seeds of okra were sown in artificial media under greenhouse for 40 days before transplanting in the field. Results revealed that survival ratio and the investigated growth parameters, chlorophyll content, yield and its components, nitrogen and carbohydrates of pods and nitrogen use efficiency were increased with delaying planting date. Compost followed by urea treated plants gave the highest values. Interaction results showed that compost treated plants transplanted on March 15th had the best growth and yield. Base temperature of okra, Balady cultivar was 6.55 °C (43.8 °F). Accumulated heat units above base temperature required till the first flower was 982.8 ± 44.5 heat units without insignificant differences among different transplanting dates. This indicated that flowering time was dependent upon accumulated heat units rather than number of days required for the first flower. High significant positive correlations were found between yield of pods and either plant dry weight, leaves area, number of leaves / plant or number of pods per plant. Regression coefficients indicated that for each increase of one pod / plant, yield of okra pods correspondingly increased by 140.18 kg pods / fed.

Keywords: Transplanting date; nitrogen sources; okra (*Abelmoschus esculentus* L.); growth; yield; pod quality; nitrogen use efficiency; base temperature; accumulated heat units.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the most important and favorite vegetable crop to Egyptian customers. It is grown mainly for its pods which are used either, fresh or dried and sometimes mixed as a powder with wheat flour. Okra pods are rich in pectin, vitamins, fibers and mineral nutrients (Chopra *et al*., 1986). Okra plants originated in Asia and Africa (Thompson and Kelly, 1979) and classified as a very sensitive to low temperatures. It requires above 18 °C and lower than 35 °C with optimum range of 21 -29 °C during growing season. Anonymous (2004) reported that, air and soil temperatures played a major role in success of okra plants.

Proper sowing time is of great importance to synchronize production season and optimum range of temprature. In this respect, Al-Harbi (1999) evaluated three planting dates, *i.e*., 3rd February, 23rd February and 5th March in Saudi, Riyadh region. His results showed that morphological measurements expressed as shoot length and leaves number of plants sown on 5th of March were significantly increased while plant shoot fresh and dry weight were higher in the early planting date (3rd February). In addition, Amjad *et al*., (2001) in Pakistan in an evaluation of different sowing dates found that maximum germination of okra seeds was recorded with sowing on April 25 or May 5, while significantly minimum germination was recorded with sowing on April 15. Also, Sharif *et al*. (2002) showed that okra plant height and leaf number were significantly higher in March sowings compared to May sowings. While in Bangladesh, Moniruzzaman *et al*. (2007) investigated four sowing dates starting from February to May at monthly intervals. Their results indicated that the highest seed yield (2.97 t/ha) was recorded with 15 April sowing followed by 15 March sowing (2.77 t/ha), whereas the best seed quality was obtained with sowing on 16 February (88.7% germination and 29.75 seed vigour index) and 15 March (83.7% germination and 28.80 seed vigour index). In addition, Ekwu and Nwokwu (2012) in Nigeria reported that The 15th July sowing gave least values in all measured vegetative parameters except plant height and number of days to 50% anthesis (flowering) which were obtained with sowing on 15th May, 15th June or 15th July. In Sudan, Elhaj and Afrah Ahmed (2014) studied the effects of three sowing dates, *i.e*., 1st and 20th of July and 10th of August on seed yield. Their results showed that late sowings (20th of July and 10th of August) had significant negative effects on both vegetative growth and seed yield in both studied seasons.

The different sources of chemical and organic fertilizers as soil application were studied with many investigators. Tyler *et al*. (1993) reported that increasing concentrations of composted turkey litter added to a plant container medium increased pH substrate. In addition, Amjad *et al.,* (2001) found that maximum plant height, number of leaves per plant, number of days to flowering and number of pods per okra plant were obtained with the highest fertilizer dose (150 kg N + 80 kg Pps ha-^{I}). For instance, incorporating composts into a commercial bedding plant medium significantly decreased total porosity, percentage air space, pH and ammonium concentrations whilst bulk density, container capacity, electrical conductivity, overall microbial activity and nitrate concentrations were increased significantly in response to increasing substitutions of composts (Atiyeh *et al*., 2001). Also, Omotoso and Shittu (2007) pointed out that 150 NPK kg ha^{-1} increased growth parameters of okra plants (plant height, leaf area, root length, number of leaves), yield and yield components compared with other NPK rates (0 and 300 NPK kg ha^{-1}). Also, Singh *et al.* (2008) found that the okra vegetative growth expressed as height and diameter of plant, number of leaves and nodes and leaf area were increased to the maximum at 140 kg N per acre. Furthermore, Adewole and Ilesanmi (2011) cleared that 6 t ha^{-1} of compost resulted in a significant higher nutrient uptake [N (0.0034 mg kg^{-1}), K (0.0160 mg kg^{-1}), Na (0.9753 mg kg^{-1}), Ca (0.0130 mg kg^{-1}) and Cu (0.01136 mg kg^{-1})] in the okra roots than in the other treatments which were NPK (12-12-17) and *Glomus mosseae* mycorrhiza. The same authors (2012) found that growth parameters such as plant height, stem girth and number of leaves of okra were increased with addition of 6 t ha^{-1} of compost at four weeks after planting as soil amendments.

An interesting agronomic application of temperature effect on plant in the heat unit concept which is based on the idea that plants have a temperature requirement for their development. The heat unit systemis used as a guide in planting schedules for orderly harvest of conning crops and multiple cropping system for effective land use as well as other purposes such as synchronizing the flowering time of parent varieties in cross pollination of crops for breeding and seed production. The point of temperature above which it is accumulated for the summations is called the base temperature. The summation of accumulated temperature above base temperature to reach a particular stage of development is expressed as degree- day or heat unit.

This study was conducted to evaluate the effect of transplanting dates and some sources of nitrogen on okra survival ratio, growth parameters, yield and its component and nutritional values under low temperature conditions in addition to the accumulated heat units above base temperature required for okra plants.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of the Desert Research Center at Mariut (31° 00' 44" N – 29° 47' 44" E), Alexandria Governorate during two successive seasons of 2007-2008 and 2008 – 2009. The aim of the investigation was to study the effect of five planting dates and some nitrogen fertilizer sources on growth characters, yield and its components and mineral contents as well as the accumulated heat units required for flowering of okra plants (*Abelmoschus esculentus* L.) Balady cultivar plants.

Okra seeds were sown in artificial media under greenhouse conditions for 40 days before transplanting in the experimental field of both investigated seasons. The seedlings were transplanted on January 15th , February1st, February 15th, March 1st and March 15th.

The used nitrogen sources were:

1. Control (recommended dose of okra fertilization included 180 kg ammonium nitrate / fed. which contain about 60 unit of N).
2. Urea 46.5 % N (195 kg/ fed. which contain about 90 unit of N).
3. Ammonium nitrate 33.5 % N (270 kg / fed. which contain about 90 unit of N).
4. Ammonium sulfate 20.5 % N (440 kg / fed. which contain about 90 unit of N).
5. Compost 1.4 % N (6.5 ton/fed. which contain about 90 unit of N).

20 cubic meters of organic fertilizer and 100 kg of calcium super phosphate per fed. were added to the experimental field during the equipping then the soil plowed twice orthogonally and divided into 75 experimental units every unit was 10.5 m^2 (3 m wide x 3.5 m long) ridged to 6 ridge with length 3 meter and 0.5 meter wide. Each assigned quantity of nitrogen treatment divided into 4 equal parts applied after 10, 30, 50, 70 days from transplanting while the compost quantity was applied under the ridges before transplanting. 60 seedlings were transplanted in each plot. A common cultural practices were followed *i.e.*, fertilization with other mineral fertilizers, irrigation and disease, insects and weeds control.

The physical and chemical analysis of the experimental soil were estimated by methods of Piper (1950) and Jackson (1962) respectively, as shown in Tables (A and B), While the chemical analysis of the irrigation water (Table, C) was determined by methods of Richards (1954). Also, some properties of used compost represented in Table (D). Metrological data during both growing seasons in and out of greenhouse was tabulated in Table (E).

Data recorded:

I . Survival ratio:

Was calculated after 20 days from transplanting.

II. Vegetative growth:

A random five plants of okra were taken from each experimental unit after 20, 40 and 60 days from transplanting to estimate the following characters:-

Leaves area using leaf area meter, No. of leaves per plant and vegetative fresh and dry weights.

Table A: Mechanical properties of the experimental soil.

Seasons	Soil depth (cm)	Coarse sand	Fine sand	silt	clay	Classtexture
				%		
1st	0-30	24.51	31.84	22.84	20.81	Sandy clay loam
	30-60	23.58	32.09	22.66	21.67	Sandy clay loam
2nd	0-30	24.05	31.97	22.75	21.23	Sandy clay loam
	30-60	23.50	32.16	22.61	21.73	Sandy clay loam

Table B: Chemical analysis of the experimental soil.

Seasons	Soil depth (cm)	pH	EC dS/m^2	$CaCO_3$ %	Saturation soluble extract							
					Soluble anions (meq/L)				Soluble Cations (meq /L)			
					CO_3^{-2}	HCO_3	SO_4^{-2}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
1st	0-30	7.41	2.77	26.46	-	1.64	7.58	18.48	4.30	1.95	20.62	0.83
	30-60	7.36	2.41	28.12	-	1.86	17.59	4.65	4.81	1.34	17.55	0.40
2nd	0-30	7.43	2.75	25.99	-	1.53	18.05	7.92	5.65	2.07	18.47	1.31
	30-60	7.35	2.56	28.73	-	2.10	17.95	5.55	5.62	1.57	17.83	0.58

Table C: Chemical analysis of the irrigation water.

Season	pH	EC dS/m	Soluble anions (meq/L)				Soluble cations (meq/L)			
			$CO_3^{=}$	HCO_3^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
1st	7.07	2.12	-	0.94	3.06	17.2	2.46	2.56	15.65	0.42
2nd	7.11	2.03	-	0.91	3.96	15.43	2.22	3.65	13.89	0.54

Table D: Some properties of used compost.

Season	pH	EC dS/m	Organic Matter	Total organic Carbon %	Total N	C/N ratio	Water holding capacity (w/%)	Density (g/cm^3)
1st	7.41	2.24	60.32	31.70	1.39	22.81	109.5	0.72
2nd	7.43	2.14	61.32	33.67	1.41	23.88	117.5	0.66

Table E: Average of the meteorological data of Mariut in and out of greenhouse during the investigated seasons of 2007/2008 and 2008/2009.

		December		January		February		March		April	May
		In	Out	In	Out	In	Out	In	Out	Out	Out
Air temp. C°	Day	23.2	19.2	23.1	18.8	25.0	20.3	28.6	24.5	26.2	29.4
	Night	16.4	10.1	16.5	9.5	17.2	10.9	21.2	13.8	16.4	19.1
	Mean	19.8	14.7	19.8	15.2	21.1	15.6	24.9	19.2	21.3	24.3
Soil temp. C°	Day	21.5	15.2	19.3	14.2	20.9	16.2	25.1	19.8	22.6	23.2
	Night	17.3	13.5	16.5	12.1	16.5	13.7	19.8	16.4	18.8	19.9
	Mean	19.4	14.4	17.9	13.2	18.7	19.9	22.5	18.1	20.2	21.6
(RH%)		84.6	68.4	82.8	63.9	86.2	64.6	87.1	59.9	63.5	62.8

Meteorological Laboratory, Desert Research Center at Mariut.

In = the temperature inside greenhouse. Out = the temperature outside greenhouse.

Also, absolute growth rate (AGR) was determined according to the equation described by Radford (1967) as follow:

$$AGR\ (gm/day) = \frac{W_2 - W_1}{T_2 - T_1}$$

Where:

W_1 = plant dry weight of the first sample (gm/plant).

W_2 = plant dry weight of the second sample (gm/plant).

T_1 = first sample time (days).

T_2 = second sample time (days).

III. Flowering:

No. of days from seed sowing until the first flower was recorded.

Base temperature according to **Arnold (1959)** for okra during the period from seed sowing to first flower was determined using two items of information from each planting; the mean temperature and the mean rate of growth. The latter was calculated as follows:

$$\text{Rate of growth} = \frac{100}{\text{Number of days from seed sowing to first flower}}$$

The values from a series of plantings were then used to calculate a regression equation in which the mean temperature was in X axis and mean rate of growth was Y axis. The base temperature was obtained as the value of X and Y equals zero**.** The accumulated heat units required for okra plants from seed sowing to first flower were the summation of mean daily temperature above the base temperature according to the formula:

$$\text{Heat unit} = \frac{\text{Minimum temperature} + \text{Maximum temperature}}{2} - \text{Base temperature}$$

IV. Yield and its components:

At harvesting time, pods of 3 – 5 cm were harvested. Total yield was estimated as ton/fed. The yield components were determined *i.e.* No. of pods/plant, pods weight/plant, average of pod diameter, pod size and average of pod weight in addition to specific gravity of pods

V. Nitrogen use efficiency:

Nitrogen use efficiency was calculated according to Singh *et al.* (2002) as the following equation:

$$\text{Nitrogen use efficiency, NUE (kg okra fruits / nitrogen unit)} = \frac{\text{FY in N treatment - FY in zero N}}{\text{Quantity of N fertilizer applied (kg/fed)}}$$

Where:

FY = fruit yeild

VI. Chemical composition:

Chlorophyll content of plant leaves at 60 days from transplanting was, also, calorimetrically determined as described in AOAC (1990). Nitrogen content of leaves and pods were determined according to the methods of Peach and Tracey (1959). Total carbohydrates percentage of pods was determined according to the method described by Chaplin and Kennedy (1994).

VII. Experiment design and statistical analysis:

A split plot design with 3 replicates was used; the transplanting dates were arranged in main plots, while nitrogen source fertilizers treatments were randomly distributed in subplots. Homogeneity test revealed that the results of both investigated seasons were homogeny. Therefore, combined analysis of two seasons was applied. Also the correlation and regression between some parameters were done. The obtained data were statistically analyzed according to Gomes and Gomes (1984).

RESULTS AND DISCUSSION

Effect of transplanting date and nitrogen source on survival ratio and growth of okra plants:

Obtained data concerned with the effect of date of transplanting and nitrogen source on survival ratio and growth of okra plants expressed as number of leaves and leaves area per plant and fresh and dry weight / plant as well as chlorophyll content of plant leaves were presented in Table 1 and 2. Results revealed that all the investigated parameters were higher with the late transplanting date compared with earlier plantings. The best growth was obtained with transplanting on March 15th. These results were in agreement with those obtained by Al-Harbi (1999), Incalcaterra *et al.*, (2000) and Sharif *et al.* (2002).

As for the effect of nitrogen on the above mentioned parameters, Table 1 and 2 showed that the investigated parameters were increased with the investigated nitrogen sources as compared with the control treatment; the highest significant values were obtained, generally, with compost followed by urea application. In addition results presented in Tables 1 and 2 revealed that the highest values of the above mentioned growth parameters were obtained with plants transplanted on March 15th and treated with compost fertilizer. Obtained results were in agreements with those of Tyler *et al*. (1993), Atiyeh *et al*., (2001) and Singh *et al*. (2008) and Arancon *et al*. (2002).

Absolute growth rate as influenced by transplanting date and nitrogen source presented in Tables 1 and 2 and illustrated in Figures 1 and 2 cleared that absolute growth rate was increased with delaying transplanting date. The highest values were obtained with transplanting on March 15th. The increments were more obvious as plant age was progressed. The investigated nitrogen sources surpassed control treatment.

Compost treatment gave the highest absolute growth rate values. Interaction values indicated that the highest growth rate was obtained with plants transplanted on March 15th followed by that transplanted on March 1st whether treated with compost or ammonium sulfate. Obtained results were expected since okra was classified as a very tender plant with optimum temperature range of 21 – 29 C (Thompson and Kelly, 1979). Such optimum range was prevailed at Mariut only during March to May (Table, E). The superiority of compost and urea may be due to the increased soil temperature as a result of increased microbial activity and decreased soil pH which in turn led to release more available nutrients for plants in the soil solution. Also, compost may supply plants with beneficial compounds such as plant growth regulators or nutrients that enhancing plant growth.

Compost fertilization can supply plants with nutrients required for their growth , not only nitrogen element but also potassium, phosphorus, sulfur, …. etc. The impact of compost fertilizer dose not falls short of excellence such as chemical fertilizers which have temporal quick impact and this is probably due to the weakness of microbial activity in organic fertilizers during the cold climate. When climate become warm, the compost organic nitrogen are mineralizing gradually and set out in soil solution with less quantity can lose in leaching (Tyler *et al*., 1993; Amjad *et al*., 2001;Adewole and Ilesanmi, 2011and Ekwu and Nwokwu,2012).

Table 1: Effect of transplanting date and different nitrogen sources on leaves number and leaves area per plant after 20, 40 and 60 days from transplanting date.

Characters	Treatments	SR (%)	Leaves number/ plant after 20 days	40 days	60 days	Leaves area (cm^2)/ plant after 20 days	40 days	60 days
Effect of transplanting dates	15 January	57.9	6.3	8.3	12.9	179.8	260.9	428.8
	01-February	61.6	7.4	9.0	14.5	232.0	311.2	531.4
	15-February	66.3	8.7	10.7	16.6	287.8	385.8	640.9
	01-March	74.4	9.9	12.3	17.6	342.8	463.1	698.4
	15-March	90.4	11.7	14.6	21.6	422.5	573.8	869.2
LSD at 0.05		1.3	0.5	0.6	1.4	15.7	20.7	50.0
Effect of nitrogen sources	Control	66.3	8.0	9.7	13.4	233.3	309.9	456.3
	Urea	69.6	9.2	11.5	17.9	325.5	441.1	725.3
	A. Nitrate	69.2	9.0	11.1	16.9	301.7	405.6	646.3
	A. Sulfate	68.9	8.9	11.2	16.9	290.5	398.2	637.7
	Compost	76.7	8.9	11.5	18.1	313.9	439.9	703.2
LSD at 0.05		2.5	0.5	0.6	1.4	15.9	21.4	52.8
Effect of interaction between transplanting dates and nitrogen sources – 15 January	Control	54.4	5.3	6.3	10.1	135.1	178.3	306.5
	Urea	57.2	6.7	8.3	13.0	203.6	277.5	457.9
	A. Nitrate	56.7	7.1	8.6	13.0	207.9	277.2	443.7
	A. Sulfate	56.7	6.4	9.3	13.8	178.7	288.1	451.8
	Compost	64.4	6.2	9.1	14.4	173.8	283.3	484.1
01-February	Control	57.8	6.5	7.7	11.7	179.5	236.9	392.1
	Urea	61.1	7.8	9.6	16.0	265.9	358.6	632.4
	A. Nitrate	61.1	7.5	9.3	14.5	247.3	332.0	540.1
	A. Sulfate	60.0	7.8	9.3	15.2	244.4	321.2	548.1
	Compost	67.8	7.3	9.1	15.3	223.1	307.3	544.3
15-February	Control	61.1	7.9	9.4	12.5	227.5	301.4	426.5
	Urea	65.6	9.3	11.5	18.9	330.7	444.6	780.2
	A. Nitrate	67.2	9.0	11.0	17.2	300.6	399.6	662.4
	A. Sulfate	65.0	9.1	11.1	18.0	301.6	401.2	690.5
	Compost	72.8	8.4	10.5	16.6	278.6	382.3	645.0
01-March	Control	69.4	9.9	12.0	15.6	293.1	392.3	535.0
	Urea	72.2	10.3	12.9	18.6	382.9	518.4	785.6
	A. Nitrate	71.7	9.8	12.1	18.0	340.9	460.0	712.7
	A. Sulfate	73.3	9.7	11.9	17.4	332.3	446.3	681.2
	Compost	85.6	9.8	12.4	18.4	364.8	498.5	777.4
15-March	Control	88.9	10.6	12.8	17.2	331.3	440.9	621.3
	Urea	91.7	11.9	15.0	23.0	444.6	606.3	970.2
	A. Nitrate	89.4	11.7	14.7	21.5	411.8	559.4	872.3
	A. Sulfate	89.4	11.4	14.2	20.3	395.4	534.4	816.8
	Compost	92.8	12.8	16.4	25.8	529.3	728.0	1065.4
LSD at 0.05		NS	NS	NS	3.2	35.5	47.9	118.0

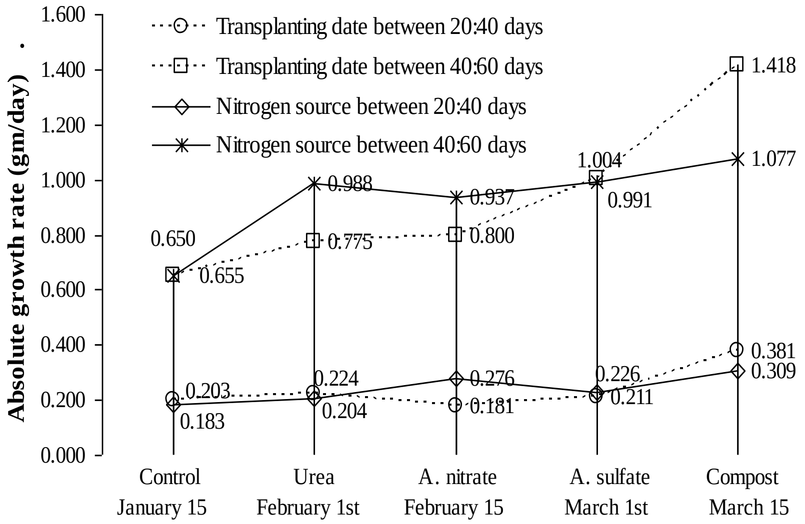
SR = Survival ratio

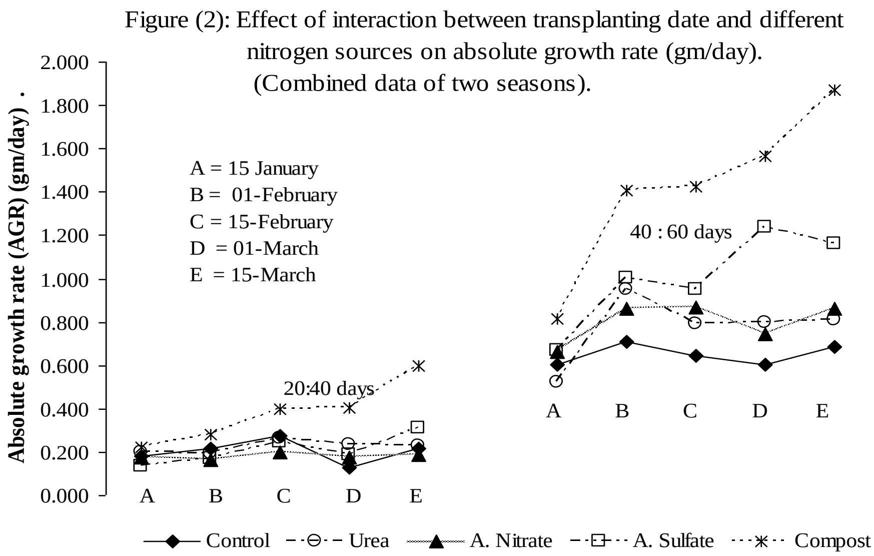
Table 2: Effect of transplanting dates and different nitrogen sources on foliage fresh and dry weights and total chlorophyll content (mg/100g of fresh leaves) after 20, 40 and 60 days of okra transplanting.

Characters		Treatments	FFW (gm)/plant 20 days	FFW (gm)/plant 40 days	FFW (gm)/plant 60 days	FDW (gm)/plant 20 days	FDW (gm)/plant 40 days	FDW (gm)/plant 60 days	Chloro-phyll
Effect of transplanting dates		15 January	78.9	100.2	165.9	14.3	18.4	31.4	34.79
		01-February	81.1	104.3	182.0	14.6	19.1	34.6	36.15
		15-February	86.3	104.3	184.9	15.2	18.9	34.9	37.37
		01-March	92.5	118.3	218.2	17.2	21.4	41.5	40.98
		15-March	112.5	151.3	287.2	22.2	29.8	58.2	46.64
LSD at 0.05			2.5	3.1	5.8	0.6	0.6	1.2	0.93
Effect of nitrogen sources		Control	76.3	96.9	161.1	14.6	18.2	31.3	35.17
		Urea	101.4	127.5	230.2	18.3	22.4	42.1	41.72
		A. Nitrate	98.2	126.6	224.9	17.2	22.8	41.5	38.49
		A. Sulfate	90.3	114.9	213.3	16.1	20.6	40.5	38.33
		Compost	85.1	112.4	208.7	17.3	23.5	45.1	42.23
LSD at 0.05			3.8	4.3	8.2	0.8	0.8	1.7	1.21
Effect of interaction between transplanting dates and nitrogen sources	15 January	Control	68.0	85.6	143.9	11.9	15.5	27.6	30.6
		Urea	92.1	118.1	192.7	17.0	21.3	35.5	37.9
		A. Nitrate	86.8	111.6	176.4	14.9	20.5	33.3	35.4
		A. Sulfate	77.8	96.8	164.1	14.2	16.8	28.9	35.5
		Compost	69.8	89.1	152.3	13.4	17.8	31.5	34.5
	01-February	Control	70.4	88.9	140.4	13.2	17.2	27.7	33.1
		Urea	93.5	119.1	212.0	16.6	20.5	39.6	38.9
		A. Nitrate	90.1	115.7	196.4	15.6	20.8	36.7	36.5
		A. Sulfate	80.9	105.4	192.7	13.7	18.4	34.4	35.5
		Compost	70.6	92.6	168.2	13.9	18.4	34.6	36.7
	15-February	Control	74.0	89.9	154.8	13.5	17.1	30.3	33.3
		Urea	101.9	120.6	212.5	17.6	20.8	38.1	40.4
		A. Nitrate	95.5	116.5	208.4	15.8	19.9	37.2	36.1
		A. Sulfate	85.3	101.0	179.2	14.6	18.2	33.1	36.1
		Compost	75.1	93.4	169.7	14.7	18.4	35.6	41.1
	01-March	Control	78.3	99.8	161.2	15.5	18.2	31.6	36.4
		Urea	103.7	129.4	240.6	18.5	21.9	41.9	44.9
		A. Nitrate	97.7	126.7	232.6	17.7	22.6	41.7	38.4
		A. Sulfate	91.6	117.8	233.9	15.5	19.3	44.1	38.5
		Compost	91.3	117.8	222.8	18.6	24.8	48.0	46.6
	15-March	Control	90.9	120.5	205.0	18.8	23.2	39.5	42.5
		Urea	116.0	150.2	293.1	21.6	27.3	55.5	46.4
		A. Nitrate	120.8	162.4	310.5	22.0	30.0	58.5	46.1
		A. Sulfate	116.0	153.8	296.8	22.4	30.5	61.9	46.0
		Compost	118.8	169.4	330.5	26.1	38.1	75.5	52.2
LSD at 0.05			8.6	9.4	18.4	1.6	1.8	3.8	2.07

FFW = Foliage fresh weight FDW = Foliage dry weight

Figure (1): Effect of transplanting date and different nitogen sources on absolute growth rate (gm/day). (Combined data of two seasons).





Effect of transplanting date and nitrogen source on accumulated heat units required for flowering of okra:

Number of days from seed sowing to the first flower of okra plants as influenced by transplanting date and nitrogen source presented in Table 3 and Figure 3 cleared that flowering of plants was enhanced with delaying transplanting. The least number of days till the first flower was recorded with transplanting on March 15th. The first transplanting date (January 15th) required the highest number of days for the first flower. As for nitrogen source, control and compost treated plants took fewer days till the first flower. No significant difference was detected for the effect of the interaction on number of days till the first flower.

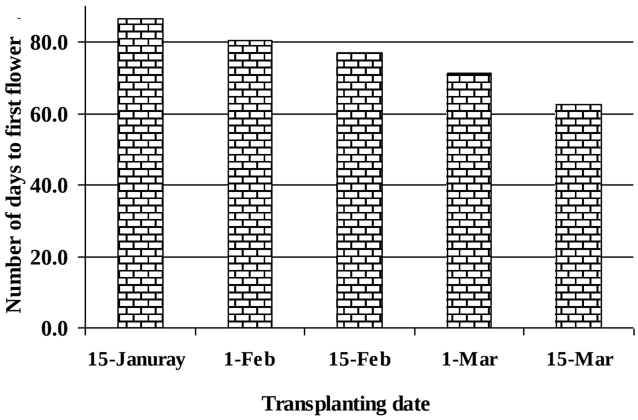


Figure (3): Effect of transplanting date on number of days to the first flower of okra .

As for the accumulated heat units from seed sowing till the first flower, it was necessary to determine base temperature at first. Base temperature is the point of temperature above which it is accumulated for the summations. Accumulated temperature above base temperature is effective for plant growth and expressed as degree-day or heat unit. Calculated base temperature for okra plants, Balady cultivar grown at Mariut region, Alexandria, Egypt was 6.55 ^{0}C (43.8 ^{0}F) accumulated heat units above base temperature till the first flower as affected by transplanting date illustrated in Figure (4) showed that it was ranged from 958.6 to 1044.8 units with mean of 982.8 ± 44.5 heat units. This indicate that flowering time of the investigated cultivar depended on accumulated heat units above base temperature rather than number of days since there was no significant differences among accumulated heat units of different transplanting dates.

Table 3: Effect of interaction between transplanting date and different nitrogen sources on number of days from seeds sown to first flower.

Treatments	Control	Urea	A. Nitrate	A. Sulfate	Compost	Mean
15 January	84.0	88.7	89.0	88.3	83.0	86.6
01-February	76.7	82.7	82.7	82.0	77.7	80.3
15-February	74.0	80.3	78.7	79.7	73.3	77.2
01-March	67.0	74.3	72.7	72.7	69.0	71.1
15-March	61.0	65.0	63.7	63.3	60.3	62.7
Mean	72.5	78.2	77.3	77.2	72.7	
LSD at 0.05 for Date				= 2.1		
LSD at 0.05 for Nitrogen				= 1.8		
LSD at 0.05 for D X N				= NS		

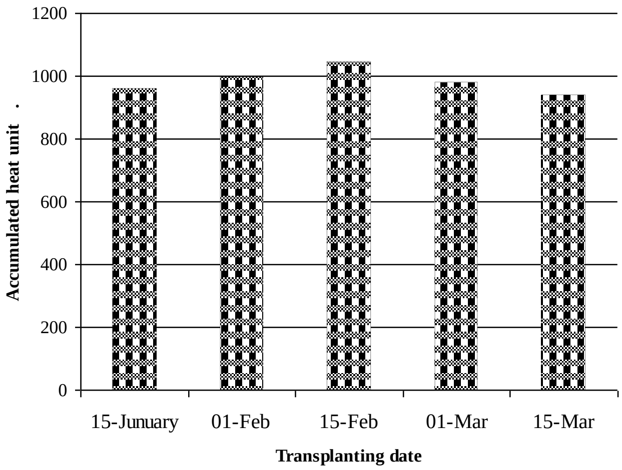


Fig. (4): Effect of transplanting date on accumulated heat units from seed sowing to first flower .

Effect of transplanting date and nitrogen source on okra yield and its components:

Obtained data concerned with okra yield and its components expressed as number of pod / plant, weight, volume, and specific gravity of pods presented in Table 4 revealed that number, volume and yield of okra pods were increased with delaying transplanting date; while pod weight and its specific gravity behaved apposite trend. Regarding to the effect of nitrogen source, compost and urea treated plants gave, generally, the highest values. As for the interaction effect, compost treated plants transplanted on March 15th gave the highest number of pod / plant and yield of pods whether expressed as per plant, per plot or per fed.. Interaction results gave insignificant differences with respect to average weight and volume of pod. Obtained results were in agreement with those reported by Sharif *et al.* (2002), Ekwu and Nwokwu (2012) and Elhaj and Afrah Ahmed (2014)

Table 4: Effect of transplanting date and different nitrogen sources and there interaction on some pod characters and okra yield.

Treatments		Characters	No. pods/ plant	Average of pod weight (gm)	Volume of 10 pods (cm^3)	Pod specific gravity (gm/cm^3)	Yield (gm)/ plant	Yield (kg)/ plot	Yield (ton)/ feddan
Effect of transplanting dates		15 January	16.1	4.9	62.7	0.785	80.1	2.80	1.118
		01-February	18.7	4.8	63.7	0.748	89.5	3.32	1.327
		15-February	21.4	4.8	67.7	0.704	102.0	4.08	1.631
		01-March	23.2	4.7	69.4	0.675	109.2	4.89	1.957
		15-March	28.1	4.5	72.6	0.620	126.7	6.89	2.755
LSD at 0.05			0.7	0.2	0.2	0.029	4.6	0.15	0.060
Effect of nitrogen sources		Control	18.5	4.3	65.9	0.648	79.3	3.27	1.308
		Urea	22.8	5.0	68.8	0.724	112.5	4.18	1.925
		A. Nitrate	21.6	4.8	67.9	0.715	103.0	4.39	1.754
		A. Sulfate	21.9	4.7	67.8	0.695	101.6	4.25	1.698
		Compost	22.8	4.9	65.6	0.749	111.2	5.26	2.105
LSD at 0.05			0.9	0.2	1.1	0.033	4.7	0.27	0.107
Effect of interaction between transplanting dates and nitrogen sources	15 January	Control	13.1	4.0	61.7	0.655	52.9	1.73	0.691
		Urea	16.7	5.4	63.9	0.846	90.4	3.10	1.241
		A. Nitrate	15.9	5.3	63.4	0.841	84.4	2.87	1.148
		A. Sulfate	17.4	5.0	62.4	0.796	86.5	2.94	1.177
		Compost	17.6	4.9	62.3	0.789	86.3	3.34	1.335
	01-February	Control	16.5	4.1	62.5	0.661	68.1	2.36	0.944
		Urea	20.3	4.9	65.2	0.746	98.8	3.62	1.447
		A. Nitrate	18.2	4.8	64.4	0.750	87.9	3.22	1.288
		A. Sulfate	19.5	5.0	64.3	0.772	96.6	3.48	1.390
		Compost	19.1	5.0	62.1	0.810	96.3	3.91	1.566
	15-February	Control	17.7	4.4	66.4	0.668	78.3	2.88	1.150
		Urea	23.4	4.7	69.3	0.678	110.1	4.33	1.733
		A. Nitrate	21.9	4.9	68.4	0.712	106.4	4.30	1.720
		A. Sulfate	23.5	4.8	68.3	0.696	111.6	4.36	1.742
		Compost	20.6	5.0	66.0	0.763	103.7	4.53	1.811
	01-March	Control	21.3	4.5	68.1	0.666	96.6	4.03	1.611
		Urea	24.6	5.1	71.1	0.718	125.5	4.44	2.174
		A. Nitrate	23.3	4.6	70.1	0.654	106.6	4.58	1.834
		A. Sulfate	22.6	4.5	70.0	0.640	101.4	4.46	1.784
		Compost	24.5	4.7	67.7	0.698	115.9	5.96	2.384
	15-March	Control	23.9	4.2	71.0	0.591	100.4	5.36	2.143
		Urea	29.1	4.7	74.7	0.634	137.8	7.57	3.028
		A. Nitrate	28.6	4.5	73.3	0.620	129.6	6.95	2.780
		A. Sulfate	26.4	4.2	74.2	0.572	111.7	5.99	2.397
		Compost	32.2	4.8	69.7	0.685	153.9	8.57	3.426
LSD at 0.05			1.5	NS	NS	0.064	10.6	0.60	0.238

Yield and its components results were in agreement with those of growth parameters and may be due to the optimum temperature range for okra plants in 21 – 29 °C reported by Thompson and Kelly (1979) was prevailed at Maruit only during March to May (Table, E). In addition, the superiority of compost treated plants may be due to increased soil temperature during its decomposition and as a result of increased microbial activity as well as decrease soil pH which, in turn, led to release more available nutrients for plants in the soil solution (Tyler *et al*., 1993; Atiyeh *et al*., 2001 and Singh *et al*., 2008). Also, compost may be considered a slow release fertilizer with low loss of its nutrients through leaching (Atiyeh *et al*., 2001). Moreover, compost may supply plants with beneficial compounds such plant growth regulators (Arancon *et al*., 2002).

Of great importance is the question in how for the different investigated parameters are correlated with each other. It can be seen from Figure 5 that yield of okra pods (kg/fed.) was significantly correlated positively with either dry weight of plants (gm/plant), leaves area (cm^2/plant),number of leaves per plant or number of pods per plant. Corresponding liner correlation coefficients (r) were 0.918, 0.957, 0.968 and 0.971, respectively. The corresponding coefficients of determination (r^2) were 0.843, 0.917, 0.936 and 0.943, respectively which indicated that 84.3, 91.7, 93.6 and 94.3 %, respectively of the variation in yield of okra pods per fed. were related to the correlated parameters. On the other hand, the regression coefficients were 5.81, 3.4, 177.21 ans 140.18, respectively. This indicated that for each increase of one gram of dry matter, one cm^2 of leaf area, one leaf or one pod per plant, the yield of okra pods increased by 51.81, 3.4, 177.21 or 140.18 kg/fed., respectively.

Effect of transplanting date and nitrogen source on nitrogen use efficiency:

The effect of transplanting date and nitrogen source on nitrogen use efficiency (NUE) shown in Table 5 indicated that its was increased with late transplanting; the highest NUE was obtained with March 15th transplanting (28.8 kg okra pods / fed./ one nitrogen unit. Compost treated plants gave the highest NUE (27.41 kg okra pods / one nitrogen unit), while ammonium nitrate gave the lowest NUE (15.76 kg pods / nitrogen unit). Interaction results showed that compost treated plants transplanted on March 15th gave the highest value.

Shahbaz *et al. (*2014) calculated the agronomic use efficiency or nitrogen use efficiency (g g^{-1}). They found that each unit of bioslurry (biogas plant) nitrogen increased okra yield by 22.61 units while each unit of inorganic nitrogen increased yield by 5.66 units. Akanbi *et al*. (2010) added that compost reduced soil pH, changed soil organic matter, nutrient concentrations, bulk density، water-holding capacity and soil temperature and ultimately increased NUE. Also, enhancing extend plants with macro and micro-nutrients which led to improving plant growth and productivity (Tyler *et al*.,1993 and Atiyeh *et al*., 2001).

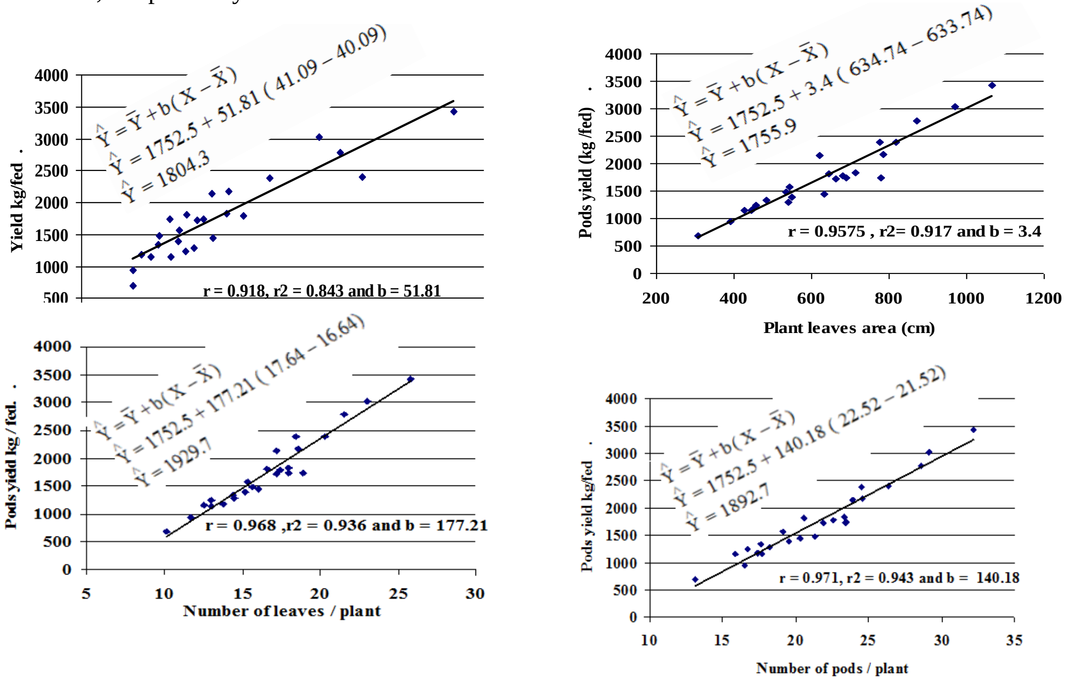


Figure 5: Correlation coefficients (r), coefficient of determination (r^2) and regression coefficients (b) of yield of okra kg / fed. on some independent variables.

Table 5: Effect of transplanting date and different nitrogen sources and there interaction on nitrogen use efficiency (kg pods/ N unit).

Treatments	Urea	A. Nitrate	A, Sulfate	Compost	Mean
15 January	18.31	15.24	16.19	21.46	17.80
01-February	16.78	11.49	14.89	20.73	15.97
15-February	19.41	18.98	19.73	21.85	19.99
01-March	23.22	11.86	10.20	30.23	18.88
15-March	29.48	21.22	19.25	42.76	28.18
Mean	21.44	15.76	16.05	27.41	
LSD at 5% for dates				= 4.88	
LSD at 5% for nitrogen				= 4.07	
LSD at 5% for interaction				= 9.10	

Effect of transplanting date and nitrogen source on nitrogen and carbohydrate contents:

The effect of transplanting date and nitrogen source on nitrogen content of okra leaves and pods as well as carbohydrate content of pods presented in Table 6 indicated that plants transplanted on March 15th gave the highest values of nitrogen and carbohydrate contents. Plants treated with urea and ammonium nitrate contained the highest values of nitrogen within their leaves and pods where as those treated with compost contained the highest values of carbohydrates within their pods. As for the interaction effect, plants transplanted on March 15th and treated with either ammonium nitrate or compost gave the highest nitrogen content and those treated with compost gave the highest carbohydrate content. Similar results were obtained by Tyler *et al*. (1993), Al-Harbi (1999), Sharif *et al*. (2002) and Elhaj and Afrah Ahmed (2014)) on okra.

Obtained results may be due to climate enhancing effect on availability of soil nutrients which, in turn, increased plant uptake and increased plant metabolism. These results are in conformity with those obtained by Amjad *et al*., (2001), Adewole and Ilesanmi (2011) and Adewole and Ilesanmi (2012).

It can be concluded that okra productivity under low temperature condition could be improved by sowing the seeds on Feb. 5th under green house conditions for 40 days and transplanting on March 15th and fertilized with 6.5 ton compost contained 90 nitrogen unit/ fed. during soil preparation before transplanting.

Table 6: Effect of transplanting date and nitrogen source on some chemical components of okra (Combined data of two seasons).

	Control	Urea	A. Nitrate	A. Sulfate	Compost	Mean
			Leaves nitrogen (%) in the last sample			
15 January	1.123	1.522	1.435	1.286	1.153	1.304
01-February	1.163	1.545	1.489	1.337	1.168	1.340
15-February	1.223	1.684	1.578	1.410	1.241	1.427
01-March	1.294	1.715	1.615	1.513	1.509	1.529
15-March	1.502	1.918	1.997	1.918	1.964	1.860
Mean	1.261	1.677	1.623	1.493	1.407	
LSD at 0.05 for Date	=		0.044			
LSD at 0.05 for Nitrogen	=		0.063			
LSD at 0.05 for D X N	=		0.140			
			Pod nitrogen (%)			
15 January	0.65	0.88	0.80	0.75	0.69	0.75
01-February	0.64	0.96	0.89	0.88	0.76	0.83
15-February	0.70	0.97	0.95	0.81	0.77	0.84
01-March	0.73	1.09	1.06	1.06	1.01	0.99
15-March	0.76	0.98	1.04	0.99	1.10	0.97
Mean	0.70	0.98	0.95	0.90	0.87	
LSD at 0.05 for Date	=		0.026			
LSD at 0.05 for Nitrogen	=		0.032			
LSD at 0.05 for D X N	=		0.071			
			Pod carbohydrate (%)			
15 January	7.12	6.82	7.00	6.52	7.66	7.02
01-February	7.31	6.91	6.92	6.60	7.62	7.07
15-February	7.25	6.64	6.61	6.84	7.77	7.02
01-March	7.26	6.46	6.64	6.98	7.89	7.04
15-March	7.13	7.01	6.98	7.72	8.46	7.46
Mean	7.21	6.83	6.83	6.93	7.88	
LSD at 0.05 for Date	=		0.015			
LSD at 0.05 for Nitrogen	=		0.013			
LSD at 0.05 for D X N	=		0.030			

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"بعض المعاملات الزراعية لإنتاج البامية تحت ظروف درجات الحرارة المنخفضة"

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أجريت تجربتان حقليتان خلال موسمي الزراعة ٢٠٠٧ – ٢٠٠٨ و ٢٠٠٨-٢٠٠٩ م بمزرعة مركز بحوث الصحراء بمريوط ، محافظة الإسكندريه. وكان هدف التجربه هو دراسة تأثير ميعاد الزراعة ومصدر التسميد الأزوتى على النمو، والمحصول ومكوناته، والمحتوى الأزوتي والكربوهيدراتى وكفاءة استخدام النتروجين للباميا الصنف البلدى. بالإضافة إلى تحديد صفر النمو والوحدات الحرارية المتجمعة فوق صفر النمواللازمة من الزراعة حتى أول إزهار. تم دراسة خمسة مواعيد لشتل الباميا هى : ١٥ يناير – ١ فبراير – ١٥ فبراير – ١ مارس – ١٥ مارس. كما تم دراسة تأثير تسعين وحدة أزوت من أربعة مصادر من الأسمدة النتروجينيه هى اليوريا – نترات الأمونيا – سلفات الأمونيا أو الكمبوست بالإضافة إلى معاملة المقارنة الموصى بها وهى ٦٠ وحدة أزوت من نترات الأمونيا. وقد تم زراعة البذور فى بيئة صناعية داخل صوبه بلاستيكيه لمدة أربعين يوماً قبل الشتل فى الحقل المستديم. أستخدم تصميم القطع المنشقه مره واحدة فى ثلاث مكررات. وكانت أهم النتائج ما يلى :١- أوضحت النتائج زيادة نمو النباتات ، المحصول ومكوناته ، المحتوى النتروجينى والكربوهيدراتى ، كفاءة استخدام النتروجين بتأخير الشتل. وأعطت النباتات المسمدة بالكمبوست أعلى القيم للصفات المدروسه ويليه المسمدة باليوريا. وأظهرت نتائج التفاعل أن النباتات المسمدة بالكمبوست والمشتوله فى ١٥ مارس أفضل نمو ومحصول.٢- اتضح أن صفر النمو للباميا الصنف البلدى والمنزرعه فى مريوط، محافظة الإسكندرية هى ٦.٥٥ درجة مئويه(٤٣.٨ درجة فهرنهيتيه) ، وأن الحرارة المتجمعة فوق صفر النمو اللازمه من الزراعة حتى أول إزهار هى ٩٨٢.٨ ± ٤٤.٥ وحدة حرارية بدون فروق معنوية بين مواعيد الشتل مما يدل على أن ميعاد التزهير أعتمد على الوحدات الحرارية المتجمعة فوق صفر النمو وليس على عدد الأيام من الزراعة حتى أول إزهار.٣- دل معامل الإرتباط على وجود علاقات عالية المعنويه بين محصول القرون وكل من وزن النبات الجاف ، مساحة أوراق النبات ، عدد أوراق النبات أو عدد قرون النبات. ودل معامل انحدار محصول قرون البامية على عدد قرون النبات أنه كلما ازداد عدد قرون النبات قرن واحد ، زاد بالتالى محصول قرون الباميا بمعدل ١٤٠.١٨ كجم / فدان.