Sudan University of Science and Technology

College of Graduate Studies

Effect of Sowing Date and Nitrogen Fertilizer on Vegetative and Reproductive Growth of Okra

(Abelmoschus esculentus (L.)Meonch.)

تأثير تأريخ الزراعة و السماد النيتروجيني على نمو البامية

A thesis submitted in partial fulfillment of the master of Science in horticulture by courses and research.

By

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Dedication

This work is dedicated to..

My family..

&

Friends.

Acknowledgement

I am greatly indebted to Allah who gave me the fitness and strength and helps me to conduct this work.

My sincere pleasure send to my supervisor Dr. Mohamed Osman Warrag for his kind administration, practical guidance and fruitful criticism that helped very much to continue this work.

I would like also to extend my thanks to the members of the Department of Horticulture for their assistance throughout this work, and am thankful to my friends and any person who helps me during this work.

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Abstract

Due to the poor performance of okra (*Abelmoschus esculentus (L.) Moench.)* in Khartoum area during winter, this study was conducted to find out the cause(s). Four sowing dates, namely the last week of, September, October and November, 2011 and the second week of January, 2012 and three levels of nitrogen, using Urea as the source; 70, 140 and 210 kg ha^{-1} were arranged in a completely randomized design with six replications. Okra cv. Clemson Spineless seeds were sown in 27 x 27 cm. plastic pots. The mean daily air temperature during the experimental period decreased to be minimum in January. Days to seedling emergence increased with the delay in sowing, in contrast to the number of days to flowering. Dry weight of plants also decreased gradually. The number of flowers per plant was not affected by sowing date. However, the number of fruits per plant was significantly decreased . Likewize was pollen grains diameter, reflecting that the excessive flower abscission with delay in sowing could be attributed , at least partially, to low pollen viability. Thus it seems that the low temperature during the winter season has detrimental effects on both vegetative and reproductive growth.Apparently, nitrogen application had no significant role in alleviating the effect of low temperature.

الخلاصة

أجريت هذه الدراسة لمعرفة أسباب تدنى إنتاجية البامية فى ولاية الخرطوم خلال فصل الشتاء بالاضافة لتاثير السماد النتروجيني على نمو البامية، وذلك بالزراعة في اربعة مواعيد ، الإسبوع الاخير لكل من سبتمبر واكتوبر ونوفمبر 2011 والإسبوع الثاني من يناير 2012 مع إضافة ثلاثة مستويات من النيتروجين (70، 140 و 210 كجم للهكتار)باستخدام اليوريا كمصدر للنيتروجين. زرعت بذور الصنف كلمسون في اواني بلاستيكية 27×27 سم باستخدام التصميم العشوائى الكامل بستة مكررات. وأوضحت النتائج ان تاخير الزراعة ادى الى تأخير إنبات البذور وتقليل الفترة حتى تفتح الازهار وإنخفاض الوزن الجاف للنباتات فى حين ان عدد الازهار لم يتاثر بمواعيد الزراعة ولكن إنخفضت حيوية وحجم حبوب القاح و إنخفضت نسبة الثمار العاقدة. فى حين لم يكن لإضافة مستويات السماد النيتروجيني اى تأثير معنوى على النمو الخضري والثمري للبامية . وبالتالي زراعة البامية أثناء فصل الشتاء (درجة الحرارة المنخفضة) لها تاثير سلبى على نمو وإثمار البامية.

Chapter one

Introduction

Okra or lady’s finger (English). Bamya ,Bamia (Arabic) **(**Al-digawi, 1996), Bhindi (India), Ilash (Nigeria) (Shigidi,A.I ,1994), (*Ablemoschus esculentus (L.) Moench),* belongs to the family Malvaceae .

Okra originated in tropical and subtropical areas, in the North-east African center and Asia. It is widely distributed in many tropical areas of the world especially in the Sudan, Egypt and Nigeria. (Tindall, 1983), .In the Sudan wild okra grows along the alluvial bank of the white and Blue Nile rivers and all over the rain land of central Sudan and Kordofan and Darfur States. Now it is grown nearly in all parts of the country, throughout the year except the period of low temperature in winter. A lot of mixed Indian and American cultivars, both smooth and spiny are grown in the Sudan .Some local cultivars known as” Ballade” and each cultivar is named after the area from which it is collected, are also grown.

Okra is an important vegetable crop ranking third after onion and tomato(Siddig,N.S ,1997) , with annual average area and yield of about 58014 feddans (fd) and 291376 tons, respectively (Ahmed,A.A, 2007). Most of the production is consumed in the Sudan, whereas. small amount is exported to Saudi Arabia, China and Egypt (3 tons in 2006, 11 tons in 2004 and 7 tons in 2003) (Taha,S.M 2010)

In the Sudan the edible pods are consumed at the fresh immature stage or dried (weika), making a favorable and popular dish by most of the Sudanese (Umrogaiga and Tagalia). The leaves are also cooked in many areas. The seeds, roasted and ground to powder, are used as a substitute of coffee. Tender pods are used in cases of spermatorrhea. The pods are very useful against fever and problems of genitor –urinary organs such as gonorrhea. The fruit of okra contains the following nutrients in 100g edible portion : water 89 percent, carbohydrates 7.6g, protein 2.4 g, fiber 1.2 vitamin A 520 IU, thiamine 0.17 mg, riboflavin 0.21mg and ascorbic acid 31 mg . (Oscar *et al*.,1980).It is also good source of minerals like calcium and magnesium, potash and iodine.

The yield of okra during winter in Khartoum area and North of Khartoum is very low (Abd alla,1969).

Most plants require nitrogen for normal growth and production ,yet very few soils contain enough native nitrogen to sustain high yields in most crops .The aim of this study was to investigate the suitable rate of added nitrogen and the effect of low temperature on the vegetative and reproductive growth of okra.

Chapter Two
Literature review

2.1. Morphology of okra.

Okra is a herbaceous, annual warm season vegetable crop.
Braun *et al*.(1991). described the morphology of the wild and cultivated okra as an erect, tall, strong and hispid annual herb with 1.5 meter tall stem and with strong root. Its seedling is dicotyledonous .Its first true leaves are ovate acute at apex cordite at base with serrate margin . Purewal and Randhawa (1947). reported that the flower bud appears in the axil of each leaf above the sixth or eighth leaf depending on the variety. The crown of the stem at this time bears 3-4 undeveloped flowers, but later on during period of profuse flowering of the plant there may be as many as ten undeveloped flowers in a single crown. The stem is green or tended red, the leaves are alternate and palmately lobed. Flowers are solitary ,axillary and peduncle about 2 cm long. the root system of okra is extensive, and the stem consists of an erect axis and primary laterals which become woody with age. The leaves are ovate and lobed. The flowers are axillary. Large, showy and contain both stamens and pistils. The fruits are elongated relatively large pods, they vary in colour degree of ribbing. pubescence and presence of spines according to variety and are consumed in the immature stage. When mature the pods are hard and woody. The seeds are relatively large and dark in colour. Walter (1990) reported that okra is grown as an annul. and cultivars differ in their size from dwarf plants 3ft to 10 ft tall. Pod shapes range from round to ridged and short to long. The plants and pods may have small spines that create allergy to some people. Spineless cultivars are available. The cultivars vary in pod colour and in flower colour and shape and may be grown as an ornamental plant. El Balla (1982) reported that the anther dehisces 15 to 20

minutes after flower opening and some of the pollen grains come in contact with the stigma. Immature fruits are pale green or purplish pods and in many cultivars are ridged. There are numerous okra cultivars which vary in colour of leaves, plant height, fruit shape, colour and time to maturation. There are short and long cultivars having short or long spiny or spineless pods ranging in colour from creamy to white to dark green.

2.2. Soil Requirements.

Okra can be grown in a wide range of soil but well drained and fertile soil is more preferable. Windham (1966) showed that okra requires soil with top layer having organic matter content not less than 1.25%. He recommended the use of NPK fertilizer at 24:24:48 Ib/ acre nitrogen phosphorous and potassium , respectively. Khalil and Hamid (1964) found that okra does not respond to applied nitrogenous fertilizers in saline and alkaline soils. They related this negative response of okra to ammonium sulphate application to the high soil alkalinity. Paliwal and Maliwal (1972) observed that okra could tolerate salts up to an electrical conductivity of 6 mm ohs/cm; beyond this limit the plant growth , leaves and fruit decreased with increased soil salinity .The uptake of nitrogen in okra plant and fruits decreased from 1.33% to 0.979% and from 2.16 % to 1.16%, respectively. The decrease of nitrogen is more pronounced in the fruits.

2.3. Fertilization.

All living things grow and reproduce in response to interactions of dynamic factors in their ambient ecological environment. Maximum yield results only when plants compete successfully for the essentials for optimum biological efficiency. One of these positive factors is that the essential elements for adequate nutrition of plant become available when needed and supplied in balanced proportions. When the soil elements essential for efficient plant nutrition and economic production are low in availability or are not in balance, chemical fertilizers and soil amendments are required (Roy et al,1981).

2.3.1 Nitrogen:

Many authors reported about the effect of nitrogen on plants. Walter (1912) reported that nitrogen is essential for plant growth as it is a constituent of all proteins and nucleic acids. It is generally taken up by plants either as ammonium or nitrate ions, but the absorbed nitrate is rapidly reduced. The effect of nitrogen is in increasing leaf growth and hence to have larger surface available for photosynthesis and in increasing the proportion or protoplasm to cell wall material .This increases the size of the cell and gives them thinner wall; hence makes the leaves more succulent and less harsh. Mc Collum (1980) reported that nitrogen is a vital component of protoplasm, chlorophyll, nucleic acids (DNA and RNA) and amino acids from which proteins are made. Nitrogen builds up the vegetative portion, producing large green leaves and also necessary for filling out fruits. If present in large amount in relation to other elements. it can cause excessive vegetative growth and succulence and can seriously delay fruiting. Walter (1990) noticed that nitrogen is made available to the plant for a longer period of time during the season. Chemical fertilization and nitrogen fixation are the most important sources of nitrogen to crops, in respective of the sources. However, nitrogenous fertilizer may be too expensive or may not be available. Furthermore, about 20 to 70 percent of applied nitrogen fertilizer is lost due to volatilization, leaching and nitrification. (IC ARDA,2006). Kamalanathan et al. (1970) reported that excessive quantities of nitrogen deficiency delay flowering and maturity. also Howard et al.(2001) reported that the excess of nitrogen reduced the crop yield by promoting vegetative growth and delaying maturity.

2.3.2. Effect of nitrogen fertilization on okra.

Chenkar and Singh(1963) found that N and P application significantly increased the plant height, stem diameter, leaf number, size and colour of leaves and root development The optimum NPK ratio in okra plant tissue for best growth and yield should be 4.5 :1:5.5 .Bidd et al.(1970) observed similar results. Ferran and Bowden (1963) revealed that application of nitrogen did not affect yields or plant characteristics Hassan. (1969) found that neither time of application nor level of nitrogen significantly affected okra yield . However, okra without nitrogen had the lowest yield . Siambi and Padda(1970) reported that nitrogen application up to 134 Kg/ha was found to increase okra plant height and pod yield significantly. Higher level of nitrogen had no beneficial effect. No significant response to application at both levels of 34Kg or 67 Kg/ha was noticed. Ramu and Muthswamy (1964) found that the yield of okra when sprayed with 2% urea was double that of the control. Salih (1981) showed no significant response from both urea and triple superphosphate fertilization. Chauhan and Gupta(1973) found that plant height, number of leaves , girth of the plant and yield of green bodes increased as the level of nitrogen addition to the soil was increased from 22.5 Kg to 67Kg /ha. There is no significant deference on growth and development of okra crop due to this treatment. There was no beneficial effect of various levels of Phosphorus and Potash. However, application of NPK increases the yield in general. Number of fruits and height of plant were positively correlated with yield of crop. Ahmad and Tulloch(1968) showed that the best yields were obtained with 112 Kg /ha N, 168 kg/ha P and 280 Kg /ha Mg. The levels of N in the leaves decreased rapidly with age. Sutton (1963) studied the effect of different rates and combinations of nitrogen. phosphorus and potassium on yield of okra. A highly significant effect on the yield was shown for the two harvest periods. The yield for the first harvest period showed that increasing the phosphorus rate from 30 to 90 pounds per acre with 23 pounds per acre of nitrogen resulted in highly significant increase in yields. Gupta et al.(1977) showed that the nitrogen and phosphorus fertilization increased plant height. number of nodes per plant and fruit size which finally contributed in increased fruit yield. Application of 100 Kg nitrogen and 60 Kg phosphorus per hectare gave the highest yield as compared to other levels. Power and Schepers,(1989). Applications of N fertilizer between 100 and 215 kg N/ ha are typically required to optimize lint yield of irrigated cotton in Australia (Constable &Rochester, 1988), USA (McConnell *et al*., 1995), China(Jin *et al*., 1997) and Egypt (Hussein *et al*., 1985). In Pakistan, 120-160 kg N ha-1 is recommended depend in soil, climate and crop types. Verma et al.(1970) noticed that the highest yields were obtained from nitrogen at 150 kg/ha in okra cv. Pusa sawani.

2.4. Temperature.

McCollum (1992) reported that the optimum temperature range is defined as the range within which maximum photosynthesis and normal respiration take place throughout the life cycle of the plant and within which the highest marketable yields are obtained. When plants are out of this range net photosynthesis decreases resulting in decreased yields and quality. Flower initiation and fruit set are often affected at non-optimal temperature. Walter (1990) reported that okra is a warm season plant, similar to cucumber and tomato. Oscar and Doland (1980) reported that the optimum temperature of okra is about 21 -24°C, and the maximum temperature is 35°C, minimum temperature is 18°C and the lowest safe temperature is 7°C. Okra is sensitive to low temperatures and develop poorly below 15°C (Marsh, 1992). Reports of MacGillvray (1953) also indicate that okra requires high temperatures and long-day for optimum growth and development. Studies on the optimum weather requirement for high yield okra in the tropics show that okra does best when the minimum and maximum temperatures are 18 and 35°C respectively (Ezeakunne,1984). Grubben (1997) observed temperatures of between 25-40°C for optimum growth and yield of okra, Welby and McGregor (1997) observed an improvement in the performance of okra when rainfall was about 750 mm, evenly distributed and relative humidity was about 90-95%. However, low temperatures of 28.9-29.2°C (maximum) and 17.9-19.8°C (minimum) and short day lengths of 5.2-5.7 hrs resulted in a higher number of flowers (Thamburaj, 1972).

2.4.1. Soil temperature.

Walter(1912) reported that the rate of germination of seeds , seedling growth and root growth depend on the soil temperature. Optimum soil temperature of many temperate crops is about 20°C while for crops such as sorghum and cotton is probably over 30°C. Walter(1990) reported that the soil temperature conditions for okra seed germination is optimum in the range of about 21 to 35°C and the minimum is 15.5°C and the maximum is 40.5°C.

2.4.2. Effect of low temperature.

Successful adaptation of crop species is dependent upon the programming of critical growth stage so that the plant can capitalize on favorable weather periods during the growing season. Plants have evolved a variety of adaptive mechanisms that allow them to optimize growth and development coping with environmental stresses (Fowier and Limin, 2002). Lyons (1973) reported that okra is injured when exposed to temperature below 12°C. Temperature is considered one of the major environmental constraints governing the distribution of plants. The temperature below which chilling injury can occur varies with species and regions of origin ranging from 0 to 4°C for temperate crops, 8°C for subtropical crops and about 12°C for tropical crops such as banana.

Stushnoff et al .(1981) reported that there are two types of plant injuries that can sustain through exposure to low temperature in winter season. Sionit *et al.(*1981) reported seed germination for okra (Clemson spineless) at 16/11, 20/14 and 23/17°C day/night, with the lowest temperature delaying emergence. Christiansen and John(1981) reported that growth and development can be adversely affected by temperatures below 10°C resulting in yield loss or crop failure. chilling during the seedling stage in cotton can reduce plant height. Delay of flowering adversely affects cotton yield and lint quality. seedling can also suffer water stress and leaf desiccation at chilling temperature. Floral initiation is inhibited at 7°C and seed set is inhibited at 15°C. Other crops which suffer stand loss , delayed maturity and reduced yield as result of chilling after planting include tomato, pepper, eggplant, okra and various cereal crops. Dickinson and Bonner (1989) observed that at low temperature cultivated tomato had impediments to anther dehiscence and that these could decrease fruit set. Thamburaj (1972) recorded taller plants, earlier flower production and higher fruit yield at a maximum temperature of 34.4-35.0°C and minimum temperature of 22.5-23.5 °C.

2.5. Effect of sowing date on growth and yield of okra.

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. Several studies showed that sowing date significantly affected crop growth and yield which was mainly attributed to influences of either soil moisture or soil temperature or both(Khalifa, 1981). Singh *et al.* (1974) reported that weather components appeared to affect the yield and quality of okra in

India. Ossom *et al.(*2011) reported that seeds sown in fourth week of September showed significant slow emergence rate than seeds sown at other time. Abdalla and Simpson (1965) and Abdalla (1969) mentioned that okra growth was better in summer compared to winter sowing which gave very poor plant growth . Pundarkia *et al.* .(1972), in India, showed that the variation in rainfall, maximum temperature and sun shine hours affected okra initial growth and flower production . Incalaterra et al. (2000) studied the effect of sowing date on okra growth in Italy .They observed that plant height at the fruit setting was higher in the first of April sowing than that of mid April .

Yadev and Dhankhar, (1999), in India, reported that plant heights were higher in June sowing than those of 12th of August sowing. Studying the effect of sowing dates on okra growth in Nigeria Iremiren and Okey (1986) found that early sowings (1st April) plants were more vigorous than those of late sowings (15th June). Sayeed (1988), in Bangladesh, reported that the first to 17th March sowing had the highest effect on plant height and number of leaves per plant. Similary. Sharif *et al*. (2003) found that okra plant height and leaf number were significantly higher when sown in March compared to May. Iremiren (1986) showed that the optimal sowing date for okra would be late June associated with a greater plant height, pod diameter, number of pod per plant, pod weight, and yield. Ahmed (2007) showed that the late sowing (18/7, 11/8) had significant negative effect on late one (1ST of July).

2.6. Pollen studies.

Pollen grains of okra are large, spherical frequently adhering owing to the presence of mucilaginous substance on the surface. Pollen appeared as yellowish fine powdery mass when seen with the naked eyes, but under the

microscope individual pollen grains were almost round with a number of appendages exile, Diameter of fertile pollen grain ranged from

143.75 to 187.50 micron while that of sterile pollen grain was 79.0 to 125 micron Srivastava and Sachnan (1973), and Chauhan *et al.* (1968) Picken (1984) reported that the low fruit set of tomato is attributable to the reduce viability of the pollen produced under low temperature.

Chapter Three

Materials and Methods

3.1 .Location.

This study was carried out in the College of Agricultural Studies, Sudan University of Science and Technology, Shambat (lat. 15° 40̄ N, long, 32°, 32̄ E. 375 meters above sea level). The soil is a clay loam, pH is7.8. The daily maximum and minimum air temperatures during the growing period were obtained from Jica Striga Project, Shambat office.

3.2. Experiment.

Okra (*Ablemoschus esculentus* (*L.*) *Moench* cv Clemson spineless seeds used for this study were obtained from the local market. The treatments consist of four sowing dates (last week of September, October, November 2011 and second week of January 2012) ,and three levels of urea (150kg/ha, 300kg/ha, 450kg/ha), applied in two doses. 1/3 of the amount was added after 30 days from sowing and 2/3 after 50 days from sowing. The seeds were treated with fungicide Thiram red before sowing. Ten seeds were sown in each of 72 plastic pots (27x27 cm). Resowing was carried out 15 days after sowing . Heavy watering was made three days before sowing and then slight watering as needed. Weeding was done by hand as needed .Protective doses of Folimat 800 2ml/ liter, and confidor 1ml/liter were used for white fly .The seedlings were thinned to three plants per pot.

3.3. Experimental Design.

The treatments were arranged in a completely randomized design (CRD) with six replications. Thus, each treatment was allocated one pot per replicate. The data were subjected to analysis of variance. Mean separation was done by Duncan's multiple range test (Gomez and Gomez, 1984).

3.4. Observations and Measurements.

Number of days from sowing to seedling emergence was recorded. Dry weight of one plant per pot was determined at the end of the experiment using an oven adjusted at 78±2°C for 48 hours. The plants were observed daily for open flowers. The total number of days from sowing to the first flower opening was determined. The number of all open flowers and fruits per plant were counted and percent fruit set was calculated (the percent fruit set = 100 x number of fruits/ number of open flowers (pichen, 1984). Some open flowers were taken from each plant per pot. The anthers were put on a glass slide and a few drops of acetocarmine were added. The slides were covered by cover slips. The cover was pressed gently to crush the tissues and then the slides were examined using a light microscope fitted with an eye piece micrometer to determine colour and shape and diameter of pollen grains. Viable pollen grains were regular in shape and normal in dimensions.

Chapter four

Results

The average daily maximum and minimum air temperatures as shown in fig.1, were highest in September. It decreased progressively till reached the minimal level in January. Then it increased gradually to maximize in April

The emergence of the seedlings (Table1) showed that there was significant difference among sowing dates. It was fast for the first sowing date (fourth week in September), then it slow gradually with the delay in sowing.

The dry weight at the end of experiment was not affected by nitrogen level (Table 2). Likewise was the effect of the sowing date, with the exception of the last one, which decreased the dry weight significantly (Table 2). There is no interaction between the two factors.

The time from sowing to the first flower opening was not affected by nitrogen level. The number of days was almost equal for the three-nitrogen level (Table 3). However, the sowing dates affected the period from sowing to the first flower opening significantly. Plants sown in September took about 2 months to reach this stage, being the longest period. The second and third sowing dates almost had the same effect, which was about a month and a half. The last sowing date plants exhibited the shortest period. The differences between the three periods ie. First, second and third together and forth, were statistically significant at the 5% level by Duncan's multiple range test. There is no interaction between the two factors (Table 3).With the exception of the lowest nitrogen level at the first sowing date and the highest nitrogen level at the second sowing date, there was on nitrogen level effect on number of flower per plant (Table 4). In fact, the plants exhibited the highest number of flowers at the highest nitrogen level, but the differences were not statistically significant.

The effects of the sowing date were almost similar, except the effect at the highest nitrogen level (Table 4). Even at this nitrogen level, the only exception was the second sowing date. Here again there is no interaction between the two factors.

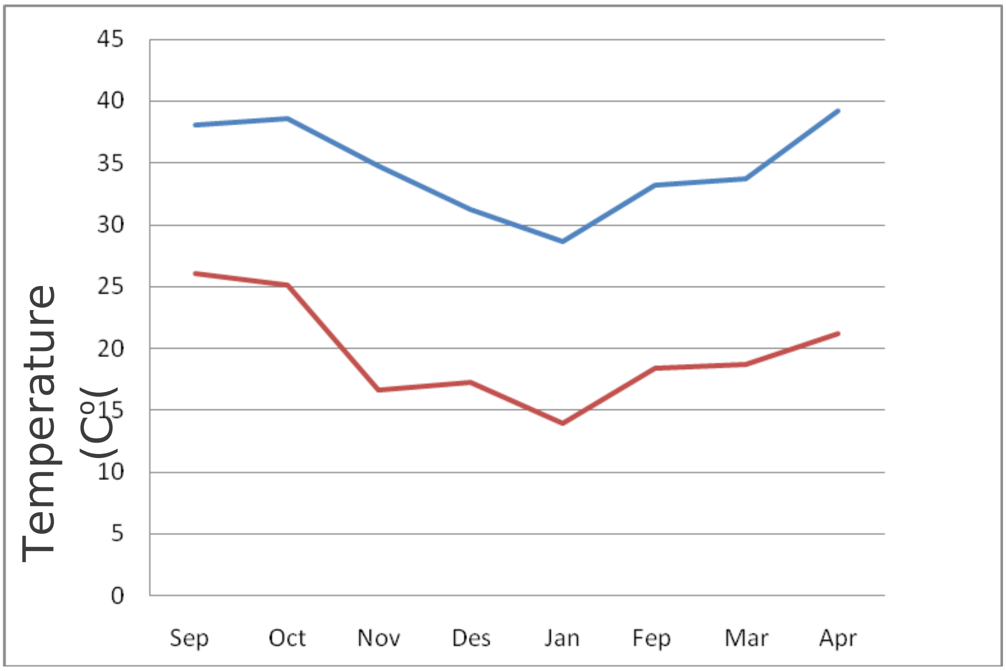

Fig. 1. Average daily maximum and minimum air temperatures during the experimental period from September 2011 to April 2012.

Table1. Effect of sowing date on number of days from seed sowing to seedling emergence of okra.

Sowing date	No. of days to emergence.
Sept.	3.8ab*
Oct.	2.6a
Nov.	5.1b
Jan.	8.0 c

***Mean value(s) having same superscript(s) within columns are not significantly different ($P \leq 0.05$ level)by Duncan's multiple range test.**

Table 2. Effect of sowing date and nitrogen level on plant dry weight (g) twelve weeks from sowing of okra.

					Nitrogenlevel
(kg/ha)	Sept.	Oct.	Nov.	Jan	mean
70	7.92a*	6.57ab	5.00abc	1.32c	5.20a
140	9.07a	8.77a	5.15abc	2.10bc	6,27a
210	9.65a	7.37a	5.63abc	2.37bc	6.25a
mean	8.88a	7.57a	5.21bc	1.93c	

***Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's multiple range test.**

Table3. Effect of sowing date and nitrogen level on number of days from sowing to the first flower opening of okra.

Nitrogen level (kg/ha)	Sept.	Oct.	Nov.	Jan.	mean
70	62.50a*	47.17b	46.33b	40.17c	49.04b
140	63,83a	45.00bc	47.17b	39.17c	48.79b
210	64.17a	43.33bc	47.50b	39.00c	48.50b
mean	63.50a	45.16b	47.00b	39.44c	

*** Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's range test**

Table 4. Effect of sowing date and nitrogen level on number of flowers per okra plant.

Nitrogen level (Kg/ha)	Sep.	Oct.	Nov.	Jan	mean
70	7.17c*	7.83bc	10.50abc	7.50c	8.20bc
140	8.83bc	8.33bc	8.50bc	7.50c	8.29bc
210	8.83bc	13.17a	11.67ab	9.00bc	10.66ab
mean	8.13bc	9.76ab	10.23ab	8.00bc	

*** Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's range test.**

Pollen grains were spherical in shape. They were in groups. They were yellowish in colour. With regard to pollen grain diameter, nitrogen levels had no effect at all (Table 5). The diameters were almost similar at the three levels of nitrogen. On the other hand, the effect of sowing date was remarkable. The pollen grains of the plants of the first sowing date were the largest. Then they decreased in diameter being the smallest at the last sowing (Table 5). The first two dates were not statistically different and likewize was the last two dates. However, the first two were statistically different from the last two. There is on interaction between the sowing date and the nitrogen levels.

The number of fruits per plant was affected by nitrogen level. There are no significant differences among the levels except the highest level at the second sowing date (Table 6). Also there are significant differences between the first three sowing dates except the second at the highest nitrogen level. However, the first three sowing date differ significantly from the last one. There is no interaction between the two factors.

It seems that nitrogen level had no effect on percent fruit set, although there is no regular trend (Table 7) .The plants of the last sowing date exhibited considerable flower abscission. There was significant difference between this sowing and others. There was a high level of coefficient of variation .

Table 5. Effect of sowing date and nitrogen level on pollen grain diameter (micron).of okra.

Nitrogen level Kg/ha	Sep.	Oct.	Nov.	Jan.	mean
70	150.00ab*	148.30ab	133.30bc	116.70cd	137.07bc
140	151.70a	145.00ab	123.30cd	116.70cd	133.92bc
210	150.00ab	145.00ab	122.50cd	114.20d	130.42bc
mean	150.57a	146.15ab	127.36c	115.86d	

***Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's multiple range test.**

Table 6. Effect of sowing date and nitrogen level on number of fruits per okra plant.

Nitrogen Level (Kg/ha)	Sept.	Oct.	Nov.	Jan.	mean
70	6.33bc*	6.00bc	4.83bc	2.83c	5.00bc
140	5.50bc	6.83b	5.33bc	2.83c	5.12bc
210	6.83b	10.33a	7.00b	3.17c	6.80bc
mean	6.22bc	7.72b	5.72bc	2.94c	

*** Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's multiple range test.**

Table7. Effect of sowing date and nitrogen level on percent fruit set of okra.

Nitrogen Level (Kg/ha)	Sept.	Oct.	Nov.	Jan	mean
70	90.00a*	77.60ab	46.40cd	35.68d	62.42bc
140	59.02bc	80.00ab	68.10b	36.72d	60.96bc
210	79.57ab	46.40cd	63.75bc	34.02d	56.00 cb
mean	76.19ab	68.00b	59.28bc	35.40d	

***Mean value(s) having same superscript(s) within columns and rows are not significantly different (P≤0.05 level) by Duncan's multiple range test.**

Chapter five

Discussion

Generally, nitrogen application had no significant effect on both vegetative and reproductive growth of okra in this study. Probably this was due to leaching of nitrogen from the pots and/or the high soil alkalinity (Khalil and Hamid, 1964). In addition, there are contradicting reports, with regard to the response of okra to nitrogen fertilization. Some reports showed positive effects (Chauhan and Gupta , 1967, Siambi and Padda, 1970 and Omer, 1981) whereas, others showed no effects (Ferran and Bowden, 1963 and Mahmoud,1969).

With respect to the effects of sowing date, apparently it was the level of temperature that brought about the differences in the vegetative and/ or the reproductive growth rather than any other environmental factor. It is clear that the decrease in soil temperature at the seed bed level, which is usually very close to air temperature, was behind the decrease in seedling emergence as the temperature decreased gradually from September to January (Fig. 1 and Table 1). The delay in seedling emergence would lead to fungal attack and consequently poor stand.

The levels of temperature during September and October were not low enough to have deleterious effects on dry weight of okra, whereas it seems to be too low during the later months. The optimum temperature for growth of okra is about 20/30ºC (Thamburaj, 1972; Marsh,1992; and Oscar and Doland, 1976). Perhaps this was the case with the length of time from sowing to flowering, although this was affected by the decrease in seedling emergence.

The reproductive growth was also affected by low temperature. However, it seems that the reduction in the yield was not due to reduction in number of flowers. It is rather due to the increase in flower abscission. This, probably, due to low pollen viability. The decrease in the size of pollen grains with decrease in temperature would reflect the decrease in pollen viability, since the small pollen grains are probably inviable (Srivastava and Sachnan,1973). Low pollen viability due to low temperature was reported with other plant species (Warrag,1991).It seems that more research is needed to verily this point.

Chapter six

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Appendix

Maximum and minimum air temperatures during the experimental .period from September 2011 to April 2012

Month	Temperature(°C)	
	maximum	minimum
September 2011	38.15	25.97
“ October	38.62	25.2
“ November	34.7	16.57
“ December	31.17	17.15
January 2012	28.6	13.97
“ February	33.2	18.42
“ March	33.72	18.7
“ April	39.17	21.22