EFFECT OF NUTRIENT MANAGEMENT AND FRUIT POSITION ON GROWTH AND SEED YIELD OF OKRA

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*This is to certify that thesis entitled, "**EFFECT OF NUTRIENT MANAGEMENT AND PRUIT POSITION ON GROWTH AND SEED YIELD OF OKRA**" submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SEED TECHNOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. RABIUL ISLAM**, Registration No. : 11-04536 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly been acknowledged.

Dated: December, 2017
Place: Dhaka, Bangladesh

(Associate Prof. Dr. Jasim Uddain)
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Dedicated To
My Beloved Parents

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SAU,Dhaka

EFFECT OF NUTRIENT MANAGEMENT AND FRUIT POSITION ON GROWTH AND SEED YIELD OF OKRA

By

Md. Rabiul Islam

ABSTRACT

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to September 2017 to study in effect of nutrient management and fruit position on growth and seed yield of okra. The experiment consisted of four different levels of NPKS as: F_0 = Control, F_1 = N_{60} P_{20} K_{40} $S_{10,}$ F_2 = N_{80} P_{30} K_{60} $S_{15,}$ and F_3 = N_{120} P_{40} K_{80} S_{20}, and Seed from fruits of different node position viz. P_1 =from fruits borne on 1-3 nodes, P_2 = from fruits borne on 4-8 nodes, P_3 = from all fruits. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Results showed that a significant variation among the treatments in respect majority of the observed parameters. Different nutrient level and seed from different fruit position had significant influence on growth, seed yield and quality components of okra. The maximum number of pods per plant (29.79), pod length (16.54 cm), individual pod weight (16.28g), number of seeds per pod (46.81) thousand seed weight (62.15g) was obtained from F_3P_1treatment combination (N_{120} P_{40} K_{80} S_{20} Kg/ha with seeds from fruits borne on 1-3 nodes) whereas the minimum number of pods per plant (23.36), pod length (13.2 cm), individual pod weight (11.23g), number of seeds per pod (37.95) thousand seed weight (42.65g) was obtained from F_0P_3treatment combination (control with from all fruits) It is apparent that F_3P_1 treatment combination gave the best performance for the growth and seed yield of okra.

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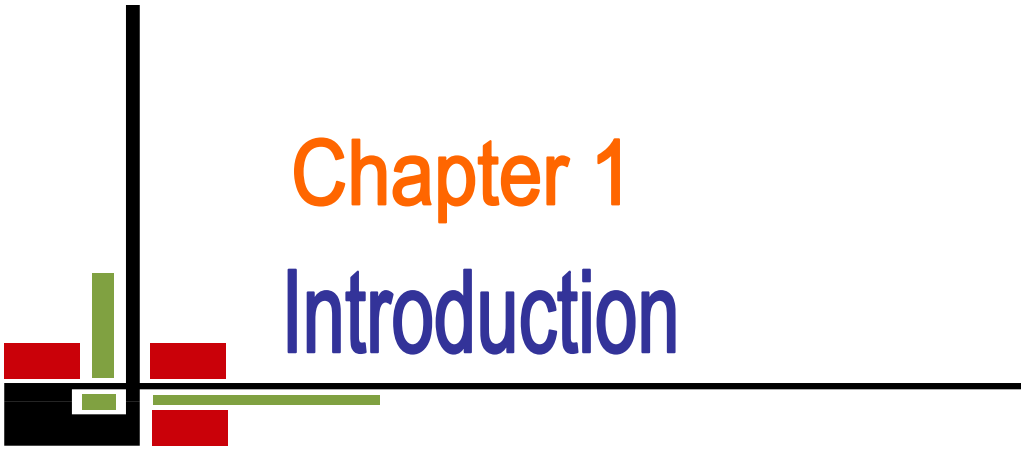
LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MoP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Per cent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)
RWC	=	Relative water content
NAA	=	Naphthalene acetic acid



Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) belongs to genus Hibiscus; section Abelmoschus under the family Malvaceae (Linnaeus, 1753). The wider use of Abelmoschus was subsequently accepted in the taxonomic and contemporary literature (Hochreutimer, 1924). This genus is distinguished from the genus Hibiscus by the characteristics of the calyx, spathulate, with five short teeth, connate to the corolla and caduceus after flowering (Kundu and Biswas 1973; Terell and Winters, 1974). Okra is mainly propagated by seeds and has duration of 90-100 days. It is generally an annual plant. Its stem is robust, erect and varying from 0.5 to 4.0 m in height. Leaves are alternate and usually palmately five lobed, whereas the flower is axillary and solitary. The flower structure combines hermaphrodism and self compatibility. The okra fruit contains numerous oval, smooth, striated and dark green to dark brown seeds.

In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during kharif season and around 70% in the rabi season (Anon., 1993). Therefore, as vegetable okra can get an importance in kharif season as well as summer season in our country context. There are variations of the per capita consumption of vegetables in SAARC countries, where it was in Pakistan (69 g), Srilanka (120 g), and India (135 g) and all are higher than that of Bangladesh. Although, many dietitians prescribed that the daily requirements of vegetables for

an adult person is approximately 285g (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and consumption of per capita vegetable in Bangladesh. As a result, malnutrition is very much evident in our country. Successful okra production may contribute partially in solving vegetable scarcity of summer season for the Bangladeshi people.

Use of proper doses of fertilizer is one of the most important way of quality green pod yield production of okra and nitrogen, phosphorus and potassic fertilizer have a great role in this respect. Ahmad and Tallock (1968) observed 75 percent yield increase due to phosphorus application at 56 kg/ha. Moreover, okra is a fruit vegetable. So, phosphorus fertilization can influence fruiting and development of fruits Phosphorus has been called “the key to life” because it is directly involved in most physiological processes.

Nitrogen is the key element to the vegetative growth of plants. It plays an important role to build up the protoplasm and protein which induce cell division and initiate meristematic activities when applied optimum quantity. Uwah *et al.* (2010) reported that nitrogen had significant effects on plant height, number of leaves and branches/plant, number of pods/plant, fresh pod weight and total fresh pod yield of okra. Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. It is also the most difficult element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Akanbi *et al*., 2010). An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Sajjan *et al*., 2002).

Phosphorus (P) is the second most important macronutrient for plant growth. Plants exhibit numerous physiological and metabolic adaptations in response to seasonal variations in phosphorus content. Activities of both acid and alkaline phosphatases increased manifold in winter to cope up with low phosphorus content. ATP content and ATPase activity were high in summer signifying an active metabolic period. Phosphorus deficiency is characterized by low ATP content and ATPase activity and which are in turn partly responsible for a drastic reduction in growth and yield and enhanced activities of acid and alkaline phosphatases which increase the availability of P in P-deficient seasons (Supatra and Mukherji, 2004). Akinrinde and Adigun (2005) reported that crop growth is continuously threatened by phosphorus (P) limitation on most tropical and temperate soils. Use of proper doses of fertilizer is one of the most important way of quality green pod yield production of okra and phosphorus fertilizer have a great effect in this respect (Yogesh and Arora, 2001). Most of the reports on the effect of phosphorus application on green pod yield in okra have been conflicting.

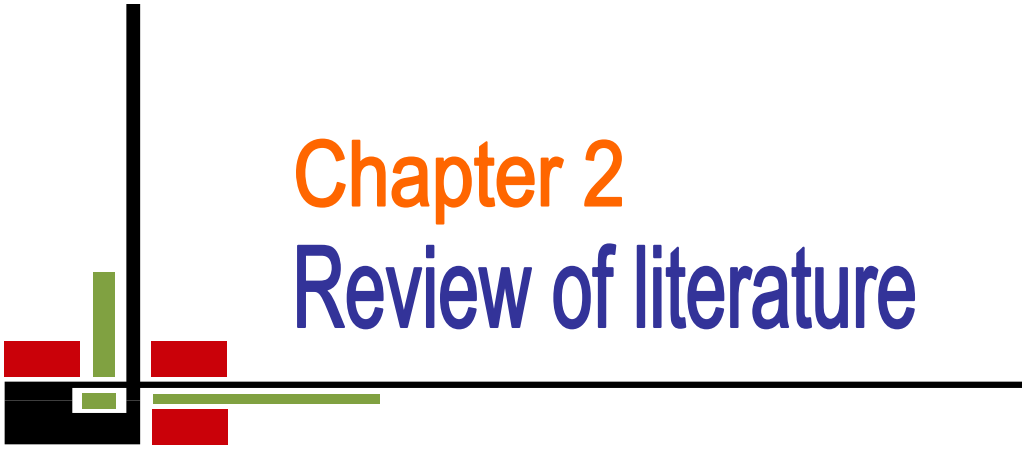
Potassium also has an important role in balancing physiological activities. Different levels of potassium influence the growth and yield of okra. Under the above circumstances, the present research was undertaken to study the effect of phosphorus and potassium on the growth and yield of okra.

Seed is very important input on which the ultimate yield of the crop depends. Hence, there is need to give utmost attention to this non-monetar input for improvement of yield. To obtain maximum seed yield with seed quality, the proper growth of the plant and its fruits are desired.

Okra is one of the most important vegetable crops grown for its green fruits for vegetable purpose. There is a greater demand of its seeds from growers. Various factors influence the seed yield in okra among which position of fruit and green fruit pickings are of great significance. Ability of seeds to produce more number of normal and vigorous seedlings depends on proper seed filling and maturation because of the competition for assimilates between fruits and within fruit distresses seed set and development (Bertin, 1995). Green fruit pickings promote fruit development and higher yield as it stimulates okra fruits to produce more number of fruits per plant. Quality of seed often determines the stability of yield in vegetable crops. Nucleus seeds which are of high quality should therefore be collected from fruits harvested at physiological maturity. In indeterminate flowering plants, the fruits may vary widely in seed maturity depending on the nodal positions of the seed pod. Traditionally, the whole plant of okra is harvested for seed purpose and the grower has to wait till the maturity of last fruit.

Hence, the present investigations on effect of nutrient management and fruit position on growth, seed yield and quality of okra were initiated with the following objectives:

1. To determine the optimum nutrient concentration on growth, seed yield and quality of Okra.
2. To find out the appropriate fruit position on seed yield and quality of okra.
3. To investigate the combined effect of nutrient and fruit position on seed yield and quality of okra.



Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Okra is one of the important vegetables grown throughout the tropical world. Different nutrient management and fruit position on growth, seed yield and quality of okra. Many research works have been done in different parts of the world to study the effect of nutrient management and fruit position on growth, seed yield and quality of okra. However, a little information is available in these regards on okra under Bangladesh condition, which is insufficient and sometimes conflicting. However, the available research findings relevant to the present study have been reviewed in this chapter.

2.1 Effect of fruit position on seed yield and quality of okra

Thomas *et al.* (1979) stated that the position at which a carrot or celery seed is produced on the plant can markedly affect its size, germination characteristics and size of the ensuing seedling.

Ho and Hewit (1986) reported that during rapid growth in tomato, the rate of maximum growth and of starch accumulation of proximal fruits are higher than those of distal fruits. However, when the assimilate supply is abundant, the proximal fruit could gain more weight than the distal ones.

The effects of fruit position on the mother plant and the number of fruits per cluster on the viability of seeds of two tropical tomato varieties known to be resistant to bacterial wilt were determined. Fruit cluster position on the mother plant did not influence fruit size, seed yield and percentage germination but

affected number of seeds per fruit, weight of thousand seeds and germination rate. Although the number of seeds increased from the lower fruit zone to the upper fruit zone, weight and yield of seeds, germination rate and percentage germination declined (Alpuerto and Philippine, 1987)

Cheplick and Sung (1998) reported that in the grasses, the basal seed (caryopsis) in a spikelet is larger and less dormant than the upper one. The annual dune grass *Triplasis purpurea* exhibits a position-dependent seed heteromorphism in seed number, mass and dormancy/germination characteristics.

Bhatt and Srinivasa Rao (1998) found a considerable difference in the germination percentage between the seeds collected from different pod positions on plants. The germination varied from 28 to 58 per cent in upper pods, 29 to 87 per cent in middle pods and 67 to 76 per cent inlower pods in different cultivars at 15ºC. At 25ºC seed germination varied from 83 to 95 per cent inupper, 95 to 98 per cent in middle and 95 to 96 per cent in lower pods. However, at 35ºC the upper pod seeds had 87-97 per cent, middle pod seeds 92-98 per cent and lower pod seeds 95-97 per cent germination in various cultivars of okra.

Yadav and Dhankhar (2001) reported that higher values of seeds per fruit (48.96), test weight (62.58 g), standard germination (86.57%) and seed yield (14.15 q/ha) were recorded in seed harvested from lower positions of plant, closely followed by middle position (45.81, 60.37g, 83.79% and 11.23q/ha, respectively) and significantly lower values were observed in seeds of upper position fruits. Better seed quality in terms of seedling length (28.13 cm), seedling dry weight (1.33 g) and vigour indices I and II (2453 and 115,

respectively) were recorded in seeds harvested from lower position fruits and their corresponding lowest values (19.64 cm, 1.13 g, 1369.51, 77.97, respectively)were recorded in seeds of upper position fruits in okra. studies were conducted on seed quality and productivity of okra in relation to nodal position of pod. Third and fourth nodes produced longer pods, with higher weight and more number of seeds per pod and hundred seed weight.

Prabhakar *et al.* (2003) in okra cv VRO-6 the pods from the lower 66% portion of the plant produced best quality seeds. Results of germination and seedling vigour tests indicated that seeds obtained from the middle 33% plant region showed maximum germination and vigour, closely followed by seeds collected from the lower 33% plant region. Seeds collected from the upper 33% portion are lighter seeds tended to decline the seed yield and quality. Although the best quality seeds were produced from lower and middle nodes, for practical bulk seed production, seeds can also be collected from upper nodes provided stringent density gravity separation and discarding infected seeds are practiced. (Rao *et al.*,2004)

Moravcova *et al*. (2005) concluded that in vegetables the position of a seed or fruit on a plant can affect its morphology, mass and dormancy/germination characteristics and these responses are described as ‘position dependent effects.

Ibrahim and Oladiran (2011) evaluated okra fruits that developed in positions 1, 3, 5 and 7 harvested at 14, 21, 28, 35, 42, 49, and 56 days after anthesis (DAA). Except for the initial increase in fruit weight between 14 and 21 DAA in position 7, no increase was generally recorded with delay in harvesting. However, fruits

of position 7 were significantly shorter and slimmer than those from other positions. There were significantly fewer seeds per fruit in position 7 than in the other positions at all the DAAs. Across DAAs, seed weight and survival ability were best in fruit positions 1, 3 and 5. Pod position had effects on test weight of seeds, germination rate (time to reach 50% germination, T50) and percentage germination. As regards test weight of seeds bottom fruits produced heavier seeds than middle and top fruits. Seeds from bottom and middle fruits germinated faster than those from top fruits. The seeds harvested from bottom fruits and middle fruits showed higher germination than those from top fruits in Spiderplant (*Cleome gynandra* L.) (Francis and Opondo, 2011).

Mohsen *et al*. (2012) reported that seed weight varied tremendously and the interactions of tiller order x seed position and genotype x seed position on the head were highly significant. Most seed position on the head of main tillers had heavier seed than their counterparts on second tillers, except the basal spikelet which had similar seed weight on both tillers in wheat.

Perkins *et al*. (1952) noticed continuous growth of okra plants with the picking of fruits once in every three to four days compared to fruits allowed to mature on the plant itself which severely checked growth.

Madhavarao (1953) reported the picking of tender fruits for consumption after leaving two trusses of fruits in okra for seed purpose produced significantly higher seed yield compared to the crop entirely left for seed purpose.

Premsekar (1964) opined that it is profitable to take up one picking of fresh pods in cluster bean for vegetable purpose, instead of leaving the entire crop for seed purpose.

Kolhe and Chavan (1967) reported higher number of dry pods in the treatment where no green fruits were harvested. There was no significant variation among the treatments (0, 1 and 2 pods picking) but a significant difference in seed yield was noticed between no picking and third or fourthfruit picking.

Grewal *et al.* (1972) reported that, in okra cv. PusaSawani, seed yield and number of pods per plant declined with increased number of pickings. However, two pickings of green fruits did not severely affect the seed yield and gave the maximum profit. Further, they observed the increase in number of seeds per fruit and total number of matured fruits. The decline in hundred seed weight was noticed with the increase in number of picking of fruits for vegetable purpose.

Wein *et al.* (1973) reported that, removal of green fruits on lower part of the branches manually for 11 days after first flowering produced more vegetative growth in beans.

Kulkarni (1978) observed the increased plant height and spread of plant canopy in french beans, when fresh fruits were removed twice for vegetable purpose before they were left for seed purpose. Similar results of increased plant height were observed by Velumani and Ramaswamy (1980) in okra, with increase in the number of fruits picking for vegetable purpose. Cent per cent increase in growth was observed in the treatment plot when 12 fruits were harvested for vegetable purpose. This increase in plant height was attributed to stimulation of

apical growth of plants. An increase in number of dry pods, seed yield and number of seeds per pods from cluster bean plants which were entirely left for seed purpose without picking of fresh pods for vegetable purpose as compared to those which were subjected to one or two picking for fresh pods.

Velumani and Ramaswamy (1980) studied the effect of picking of first formed fruits of okra cv. PusaSawani on plant height, total number of fruits and seed yield in comparison with harvesting of all fruits and reported that first formed two fruits can be harvested without any significant reduction.

2.2 Effect of different nutrient condition on growth and yield of okra

Candido *et al*. (2011) conducted an experiment with the objective of evaluating the influence of the nitrogen fertilizer in different ammonium/nitrate ratio on the vegetative development of the okra. The experimental design was in blocks randomized, arranged in factorial scheme with four repetitions, being the first factor of the scheme constituted by two nitrogen doses (50 and 100 mg kg-1), and the second for different $N\text{-}NH_4^+/N^-NO_3^-$ ratio, equivalent to 0/100; 25/75; 50/50; 75/25 and 100/0. At the beginning of the flowering the plants were collected and appraised as for the matter accumulation it dries of the aerial part, of the system root and total, leaf area, diameter of the stem, height and reason of leaf area. Significant effect of the interaction was observed between the doses and the appraised forms of nitrogen. The largest development of the plants was found when nitrogen was applied in the largest ratio of ammonium.

Pot and field experiments were conducted by Akanbi *et al*. (2010) at Institute of Agricultural Research and Training, Ibadan, Nigeria between 2002 and 2004 to determine okra response to organic and inorganic sources of nitrogen (N) fertilizer. In the pot experiment okra variety NHAe 47-4 was nourished with four N levels (0, 25, 50 and 75 kg N ha^{-1}) and five compost while in the field experiment the same variety of okra was fertilized with three N levels (0, 25 and 75 kg N ha^{-1}) and four compost rates. Application of 75 kgNha^{-1} gave the highest okra fruit yield.

Field experiments were conducted by Uwah *et al*. (2010) in 2007 and 2008 at Calabar in the south eastern rainforest zone of Nigeria to evaluate the response of okra [*Abelmoschus esculentus* (L.) Moench] due to the four rates of nitrogen (0, 40, 80 and 120 kg/ha) and three rates of lime. Nitrogen had significant effects on plant height, number of leaves and branches/plant, number of pods/plant, fresh pod weight and total fresh pod yield. 80 kg N/ha rate maximized all the growth and yield attributes.

A field-experiment was conducted by Jana *et al*. (2010) in early winter of 2006 and 2007 under sub-Himalayan teraiagroclimatic region of West Bengal to evaluate comparative effect of planting geometry and nitrogen levels on growth, yield and fruit quality in okra variety ArkaAnamika. The experiment was laid out in factorial randomized block design with four levels of nitrogen, viz., 50 kg, 100 kg, 150 kg and 200 kg ha^{-1} and four different spacings. Among different nitrogen level 150 kg N ha^{-1} recorded the highest number of fruits/plant (13.7), individual fruit weight (18.5 gm), fruit yield/plant (195.0 g) and fruit yield ha^{-1}

(12.2 t). The study amply revealed scope for growing okra crop profitably during early winter season of mild, cool-temperature by adopting nitrogen levels of 150 kg ha^{-1} with plant spacing of 45 cm × 30 cm in the terai agro-climatic region of West Bengal.

The influence of NPK 20-10-10 on the fresh pod yield and root growth of okra variety, V 35 grown in the lowland humid tropics was investigated by Awe *et al*. (2009) during the 2002 and 2003 cropping seasons. Four rates (0, 150, 300 and 450 kg/ha) of the fertilizer were applied to the crop. The findings suggest that the optimum NPK 20-10-10 level for okra variety, V 35 in the study area lies between 300-450 kg NPK 20-10-10/ha. Therefore, application rates above 450 kg NPK 20-10-10/ha for okra production in the study area were not economical.

A field experiment was conducted in by Singh *et al*. (2007) Meerut, Uttar Pradesh, India, to determine the effect of N (50, 100 and 150 kg/ha), Cu (500, 1000 and 2000 ppm) and Fe (500, 1000 and 2000 ppm) on the growth and yield of okra cv. PusaSawani. The maximum plant height, stem diameter, longest leaf length, longest leaf width, fresh pod weight and green pod yield, including the earliest number of days to emergence was obtained with 100 kg Nha^{-1}.

A field experiment was conducted by Khan *et al*. (2007) in 1999 in Medziphema, Nagaland, India, on a sandy loam soil having 5.3 pH, 4.5% organic carbon, 208.0 kg ha^{-1} available N, 12.3 kg P_2O_5 ha^{-1} and 189.6 kg K_2O ha^{-1} to study the response of okra to biofertilizers and N application in terms of growth, yield and leaf nutrient (N, P and K) status. The treatments consisted of five levels of N (0, 30, 60, 90 and 120 kg ha^{-1}) and four levels of biofertilizers.

The application of N and biofertilizers significantly increased the growth and yield. The optimum N requirement was found to be 60 kg/ha, along with Azotobacter in foothills of Nagaland.

Field experiments were conducted by Sunita *et al*. (2006) for two consecutive years (2000 and 2001) at the Feirsa Agricultural University, Ranchi, Jharkhand, India, to determine the effects of intercrop and NPK fertilizer application on the performance of okra (cv. ArkaAnamika). Treatments comprised: two intercrops (cowpea and French bean) and five fertilizer rates (0, 25, 50, 75 and 100%recommended dose of NPK). The results revealed that treatment with 100% recommended dose of fertilizers recorded higher okra equivalent yield (153.16 q/ha) and net returns (Rs. 30,709.91/ha) than the rest of the fertilizer rates. The best performance of okra in terms of yield, number of fruits per plant, fruit weight and plant height were observed with 100% recommended dose of fertilizer.

Two field experiments were carried out by Manga and Mohammed (2006) during the rainy seasons of 2002 and 2004 in Kano, Nigeria, to study the effects of plant population and nitrogen levels on the growth and yield of okra (cv. LD88-1).The treatments consisted of four plant populations and four nitrogen levels (0, 50, 90 and 120 kg/ha). Nitrogen application increased plant height, number of branches per plant, and number of fruits per plant, but did not significantly affect fruit weight. The high nitrogen content of the experimental fields may be the major reason why the yield response to nitrogen was not significant.

The effects of spacing and N rates (0, 75, 100, 125 and 150 kg ha^{-1}) on the growth seed yield of okra cv. Akola Bahar were determined by Soni *et al*. (2006) in a field experiment conducted in Maharashtra, India during the kharif season of 2004. The number of leaves per plant and number of branches increased with increasing rates of N up to 125 kg ha^{-1}, whereas leaf area, number of internodes, and seed yield per plant and per hectare increased with increasing rates of N.

An experiment was conducted by Ambare *et al*. (2005) at Akola during the kharifseason of 2002-03 to study the five levels of nitrogen viz., 0, 25, 50, 75 and 100 kg ha-1 and four varieties of okra on growth and fruit yield of okra. The results indicated that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the fruit.

Yadav *et al*. (2004) conducted an experiment during kharif 2001 at Jobner, India to study the effects of different levels of organic manures and N fertilizer (urea) on the growth and yield of okra cv. VarshaUpahar. The treatments consisted of 100% recommended dose of N, 75% N as urea + 25% N as Farm Yard Manure (FYM), Poultry Manure (PM) or Vermicompost (VC), 50% N as urea + 50% N as FYM, PM or VC, 25% N as urea + 75% N as FYM, PM or VC and 100% N as VC. The treatment involving 50% N as urea + 50% N as FYM, PM or VC recorded the highest yield (90.61 q/ha).

Gowda *et al*. (2002) conducted a study in the summer season in 1999 in Bangalore, Karnataka, India to investigate the effects of different fertilizer levels (N:P:K at 125: 75: 60, 150:100:75 and 175:125: 100 kg/ha) on okra cultivars ArkaAnamika, Varsha and Vishal. Dry matter accumulation andnutrient (N, P

and K) accumulation increased with increasing fertilizer levels. The highest fertilizer level resulted in the highest nutrient uptake. Varsha showed the highest nutrient uptake and accumulation in leaves and fruits at the highest level of fertilizer.

An experiment was conducted by Jalal-ud-Din *et al*. (2002) to observe effect of different doses of nitrogen on the growth and yield of okra under the agro-climatic conditions of Dera Ismail Khan in Pakistan. They used five different nitrogen doses viz. 50, 100, 150, 200 and 250 kg/ha along with a control (no nitrogen) treatment were kept in the study. All the parameters studied were significantly affected by different nitrogen levels. However, 150 Kg N/kg gave the best results. Minimum number of days for germination, flowering and fruit setting was also observed in the plots received nitrogen at the rate of 150 kg/ha. Maximum yield of pods (13.39 t/ha) was obtained from this level. Different parameters like plant height, pod length, pods per plant and weight of pods showed a favorablebehavior under 150 kg N/ha, but above this particular dose, decline in the data of all the observations were noted. The control plots revealed the poorest findings compared to other treatments.

Field studies were conducted by Sajjan *et al*. (2002) in Bagalkot, Karnataka, India, to elucidate the effect of sowing date, spacing and nitrogen rates (100, 125 and 150 kg/ha) on the yield attributes and seed yield of okra cv. ArkaAnamika. 150 kg N/ha recorded the highest yield attributes of branches per plant, fruits per plant, 100-seed weight, length and girth of fruits, processed seed recovery and processed yield (1139.7 kg/ha) in the kharif season.

A study was conducted by Omotoso and Shittu (2007) to determine the effect of NPK fertilizer application rates and method of application on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) at the Teaching and Research Farm, University of Ado-Ekiti. Okra seed variety LD88 were treated to three levels of NPK fertilizer rates (0, 150 and 300 kg NPK ha^{-1}) and two methods of fertilizer application. Treatments were arranged in a split-plot design with fertilizer application method as main plot factor and NPK rates as sub-plot factor. The treatments were replicated three times to give a total of eighteen experimental field plots.

The result indicated that the fertilizer NPK significantly increase growth parameters (plant height, leaf area, root length, number of leaves), yield and yield components with optimum yield of okra obtained at 150 NPK kg ha^{-1}. The influence of nitrogen (40, 80, 120, 160 and 200 kg/ha) and phosphorus (30, 60 and 90 kg ha^{-1}) on the performance and production economics of rainfed okra intercropped with tomato was studied by Mishra and Singh (2006) during kharif 1998 and 1999 in Uttaranchal, India. Application of increased doses of nitrogen recorded significantly higher plant height, yield and fruit size of the base crop (okra). The highest nitrogen rate showed 15.26, 7.29 and 1.33% higher mean okra equivalent yield over 40, 80 and 120 kg ha^{-1}, respectively. The higher mean net return (Rs. 48,853) and net profit (428%) were also recorded with 160 kg N ha^{-1}. Phosphorus application did not show any significant effect on individual plant performance, fruit size and unmarketable yield in okra. The maximum mean net return and net profit were also recorded with 60 kg phosphorus/ha.

A field experiment was conducted by Laxman *et al*. (2004) during the 2000-01 kharif seasons in Jobner, Rajasthan, India, to evaluate the effects of different levels of nitrogen (50, 100 and 150 kg ha^{-1}), phosphorus (30, 60 and 90 kg/ha), both by soil application, and gibberellic acid, applied through foliar spray, on the flowering, fruiting, yield attributes and yield of okra cv. PusaSawani. Most of the parameters were significantly influenced by the application of nitrogen, phosphorus. Increasing levels of nitrogen up to 150 kg/ha, phosphorus up to 90 kg/ha increased the percent fruit set, number of fruits per plant, length of fruit, diameter of fruit, number of pickings, duration of harvesting, mean fruit weight, yield and dry matter yield of fruit.

A study was undertaken by Shanke *et al*. (2003) during summer 1998 to assess the seed yield potential and other growth characters of okra cv. ParbhaniKranti under 5 levels of N (0, 50, 75, 100 and 125 kg/ha) and 4 levels of P (0, 25, 50 and 75 kg/ha) with agro-climatic conditions of Akola, Maharashtra, India.There was a linear increase in plant height with the application of N and P. The tallest plant (68.88 cm) was recorded under 125 kg N/ha and the shortest (54.90 cm) under no N. A similar trend was observed in respect of P application. The interaction effect between N and P was found to be significant, indicating maximum plant height with higher N and P levels. The number of fruits per plant increased significantly with an increase in N level. The highest number of fruits (5.78) was observed with 125 kg N/ha. Full fruit length and weight were also found highest (15.61 and 19.6 cm, respectively) in this treatment. The effect of application of P was also observed significant for fruit length, fruit number

per plant and fruit weight, the highest values for these parameters being recorded at 75 kg P/ha. The maximum seed yield per plot (0.330 kg) was observed with the highest levels of N and P.

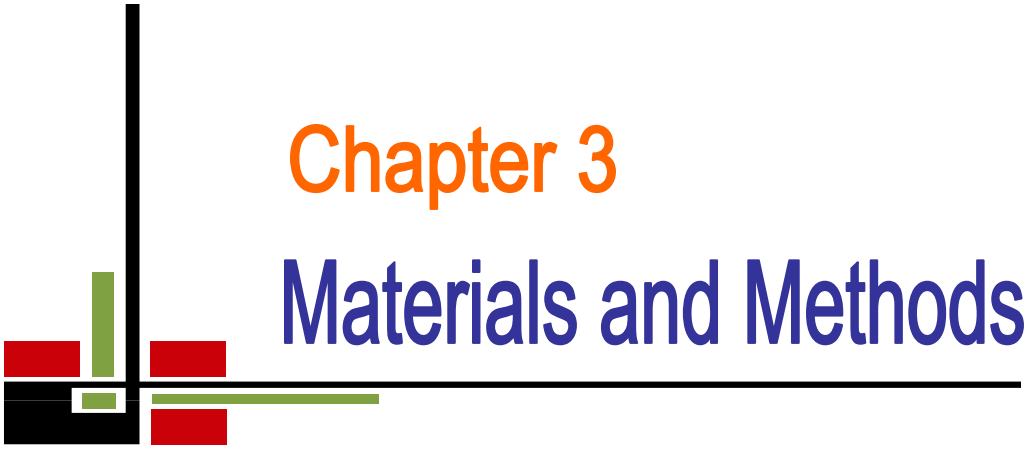
An experiment was conducted by Patton *et al*. (2002) to study effect of different levels of nitrogen and phosphorus on growth, flowering and yield of okra cv. ArkaAnamika grown under the foothills of Nagaland. Three doses N (50, 100, and 150 kg/ha) and P (0, 60, and 90 kg/ha) were used. P as single superphosphate was applied along with half of the N (urea) rate during sowing. The remaining N was applied at 30 days after sowing. N at 150 kg/ha and P at 90 kg/ha gave the greatest plant height (159.15 and 137.37 cm) and number of leaves per plant (24.98 and 23.57), the longest flowering duration (86.19 and 84.77 days), and the lowest number of days to flowering (40.93 and 41.48 days after sowing). N at 100 and 150 kg/ha resulted in the longest pods (15.81 and 16.72 cm) and the highest pod diameter (1.81 and 1.82), pod weight (19.74 and 20.19 g), pod number per plant (13.88 and 14.53), and pod yield per plant (274.14 and 293.75 g). P at 60 and 90 kg/ha recorded the greatest pod length (15.06 and 15.27 cm), pod diameter (1.75 and 1.77 cm), seed number per pod (50.00 and 49.87), pod weight (18.75 and 18.63 g), and pod yield (248.35 and 252.00 g). In general, the interaction between N and P rates was not significant.

Yogesh and Arora (2001) was conducted a field experiment in Nagina, Uttar Pradesh, India during the kharif season to study the effect of N (80, 100 and 120 kg ha^{-1}), P (60 and 80 kg ha^{-1}) and sowing date on okra (cv. ParbhaniKranti) seed yield. One-third of N and 100% of P were applied during sowing, the remaining

N was applied as a top dressing at 30 days after sowing and the flowering stage. They reported that seed yield increased with the increasing of N rate but was not significantly affected by P rate. The highest number of seed per pod (57.0) and seed yield per plot (2.94 kg) was obtained with the application of 120 kg N/ha and 80 kg P/ha.

The seed quality and yield of okra cv. ParbhaniKranti were studied by Chattopadhyay and Sahana (2000) during kharif seasons of 1998-99 in West Bengal, India. Five N rates (0, 60, 80, 100 and 120 kg/ha) were tested against 4 P rates (0, 40, 60 and 80 kg/ha). Urea (50% of the total N dose), single superphosphate and muriate of potash (50 kg K_2O) were applied basally. The remaining urea was applied 30 days after sowing. Most of the parameters improved significantly with increasing rates of N and P, the optimum N and P rates, being 100 and 60 kg/ha, respectively. Germination percentage and 100-seed weight were not significantly affected by N or P, while P had no significant effect on fruit length.

From above reviewed results it was found that nutrient management and fruit position and their interaction effect are indispensable for the production system of okra and play a vital role to increase the yield and yield attributes, providing other factors are not limiting. Physio-morphological, biological development and seed quality of okra plants depends on the judicious application of nutrient management and fruit position.



Chapter 3

Materials and Methods

CHAPTER 3

METERIELS AND METHODS

This chapter deals with the materials and methods that were used in carrying the experimen**t.**

3.1 Location of the experimental plot

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to September 2017. The site is 23^0 46' N and $90^0$24' E Latitude and at Altitude of 9m from the sea level.

3.2 Characteristics of soil

The soil of the experiment was carried out in a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam with a pH 6.7. Soil samples of the experimental plot was collected from a depth of a 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka. Details of the mechanical analysis of soil sample are shown in Appendix I. The experimental site was a medium high land. The morphological characters of soil of the experimental plots as indicated by UNDP (1998) are given below-
AEZ NO. 28 Soil Series- Tejgaon General Soil- Non- Calcareous, dark gray.

3.3 Climate and weather

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September) and scantly in the Rabi season (October to March). There was no rain fall during the month of December, January and February. The average maximum temperature during the period of experiment was 35.10°C and the average minimum temperature was 30.40°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity the period of the experiment were collected from Bangladesh Metrological Department, Agronomy, Dhaka

3.4 Planting materials used for experiment

The okra variety "BARI Dherosh-2'' was used in this study was resistant to yellow vein mosaic virus, a severe disease of okra. It was an open pollinated high yielding variety developed by the Vegetable Division of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI). The variety was released for commercial cultivation in 2015 Gazipur.

3.5 Treatments of the Experiment

Experiment consisted of two factors:

Factor A: Different nutrient level:

i. F_0 = Control

ii. $F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$

iii. $F_2 = N_{40}\ P_{30}\ K_{60}\ S_{15}$

iv. $F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

Factor B: Seed from different fruit position:

i. P_1 = Fruits borne on 1-3 nodes

ii. P_2 = Fruits borne on 4-8 nodes

iii. P_3 = All fruits from whole plant

3.6 Layout and design of experiment

The experiment consisting of 12 treatment combinations was laid out in RCBD with three replications. The whole field was divided into three blocks and each block consisted of 12 plots. Altogether there were 36 unit plots in the experiment. Each unit, bed was $4.8m^2$ (2.4m ×2m) in size. The replications were separated from one another by 1m. The distance between plots was 0.50m, plant to plant distance was 50cm and row to row distance was 60cm.

3.7 Cultivation of okra

3.7.1 Land preparation

The selected land for the experiment was first opened on 14 March 2017 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. Weeds and stubble's were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubble's and dead roots, the land was leveled and the experimental plot was partitioned in to the unit plots in accordance with the design, and the edge around each unit plot was raised to check run out of the nutrients. All types of manures were applied during final land preparation as basal dose.

3.7.2 Fertilizer application

Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP) and Gypsum were applied as per treatment in each randomized plots.

Full dose of TSP was applied to the soil at the final land preparation. Urea and MoP were applied as side dressing (ring method) in 3 equal installments at 15, 30 and 45 days after germination.

3.7.3 Sowing of seeds

Seed were sown on 16 April, 2017. In each plot, seeds were sown in rows and there were each plot. Three seeds were sown in each location. Then the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

3.7.4. Intercultural operations

The seedlings were kept always close observation. Necessary intercultural operations were done through the cropping season for obtain in proper growth and development of the plants.

3.7.4.1 Thinning

When the seedling got established, one healthy seedling in each location was kept and other seedlings were removed.

3.7.4.2 Gap filling

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock on the border line of the experiment.

3.7.4.3 Weeding

Four weedings were done manually at 15, 30, 45 and 60 DAS to keep the plots free from weeds.

3.7.4.4 Irrigation

Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.7.4.5 Drainage

Stagnant water effectively drained out at the time of heavy rains.

3.7.4.6 Plant protection measure

To control lady's finger shoot and fruit borer Diazinon 60 EC @ 3.5ml/L was sprayed at an interval of 15 days started soon after the appearance of infestation. After fruit setting, Nogos @ 0.02% was sprayed at an interval of 7 days for controlling Jassid.

3.8 Harvesting

The crops were harvested at different times. Green pods were harvested at four days interval when they attained edible stage. Green pod harvesting was started from 12, May and was continued up to 16 August, 2017. The crop was harvested from prefixed 1.0 m^2 areas. Before harvesting four plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.9 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.10 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.11 Parameters assessed

Ten plants were selected at random and harvested carefully from each plot and mean data on the following parameters were recorded:

- Plant height
- Number of leaves per plant
- Number of branches per plant
- Number of green pods per plant
- Green pod length
- Green pod diameter
- Individual green pod weight
- Green pod yield per hectare
- Number of seeds per pods
- Thousand seeds weight
- Seed yield per hectare

3.12 Collection of data

For data collection on the yield of green pod of okra, out of 4 plants in each unit plot 4 plants were selected at random.. The following yield and yield contributing characters were considered for data collection.

3.12.1 Plant height

Average plant height of selected plants from each plot was recorded at 20, 40 and 60 days after sowing (DAS). It was measured with the help of a meter scale from the ground level to the tip of the longest stem in centimeter**.**

3.12.2 Number of leaves per plant

Number of leaves of selected plants from each plot was recorded. Only the smallest young leaves at the growing point of the plant were excluded from counting. Calculating the average number of leaves, the average number was recorded.

3.12.3 Number of branches per plant

Average number of branches of selected plants from each plot at 20, 40 and 60 days after sowing (DAS) was recorded.

3.12.4 Number of green pods per plant

Mean number of green pods of selected plants from each plot as per treatment was recorded.

3.12.5 Pod length

Pods were collected from the selected plants of each plot as per treatment and length was measured with the help of a scale in centimeter (cm).

3.12.6 Pod diameter

Mean diameter of collected green pods from each plots as per treatment were measured in centimeter (cm) with the help of a slide calipers in middle position of fruit.

3.12.7 Weight of individual green pod

Weight of individual green pod collected from the selected plants was measured in gram (g) with the help of an electrical Balance.

3.12.8 Green pod yield per hectare

Green pod yield per hectare was calculated in metric ton by converting the mean green pods yield per harvesting area.

3.12.9 Number of seeds per pod

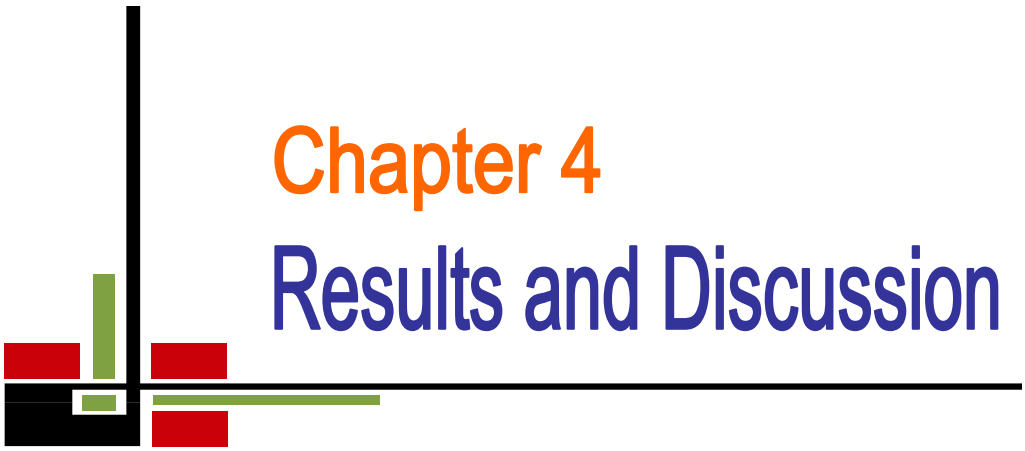
Number of seeds per pod was counted from 10 selected pod samples and then averaged.

3.12.10 1000 seed weight (g)

A composite sample was taken from the yield of ten plants. The 1000-seeds of each plot were counted and weighed with a digital electric balance. The 1000-seed weight was recorded in gram.

3.12 Statistical analysis

The calculated data on various parameters were statistically analyzed MSTATC package program. The mean for all the treatments were calculated and analyzed of variance for all the characters were performed by F-variance test. The significance of difference between the pairs of treatment mean was calculated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).



Chapter 4
Results and Discussion

CHAPTER 4

RESULT AND DISCUSSION

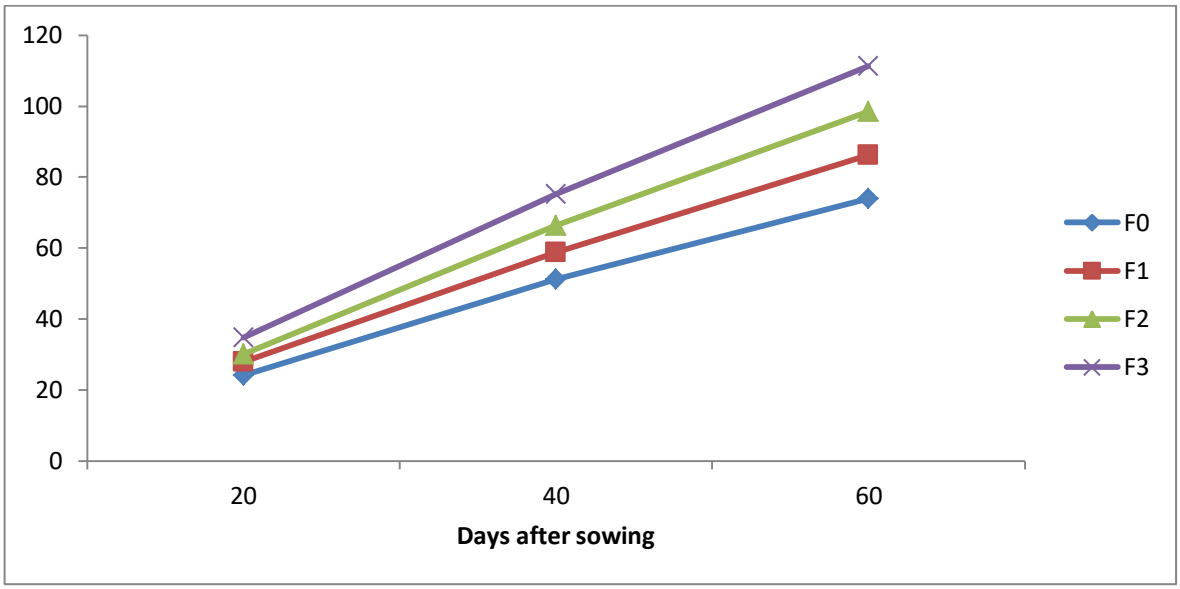
The experiment was conducted to observe the effect of nutrient management and fruit position on growth, seed yield and quality of okra. Data on different parameters were analyzed statistically and the results have been presented in the Table 1 to 10 and Fig. 1 to 2. The results of each parameter have been adequately discussed and possible interpretations have been given wherever necessary.

4.1 Plant height (cm)

Different nutrient level have significantly influence on plant height at 20, 40 and 60 DAS. At 20 DAS, the maximum plant height (34.72 cm) was obtained from F_3 ($N_{120}P_{40}K_{80}S_{20}$ kg ha^{-1}) treatment and the minimum plant height (24.03 cm) was obtained from the control treatment (Fig 1.). The maximum plant height (75.26 cm) was obtained from F_3 treatment at 40 DAS and the minimum plant height (51.16 cm) obtained from the control treatment. At 60 DAS, the maximum plant height (98.46 cm) was obtained from F_3 treatment and the minimum plant height (73.98 cm) obtained from the control treatment. It was revealed that with the increase of nitrogen plant height increased upto a certain level. Nitrogen ensured favorable level for the growth of okra plant with optimum vegetative growth and the ultimate results was maximum plant. Singh *et al*. (2007) found maximum plant height with 100 kg N/ha. Bhai and Singh (1998) reported that P application significantly increased the plant height.

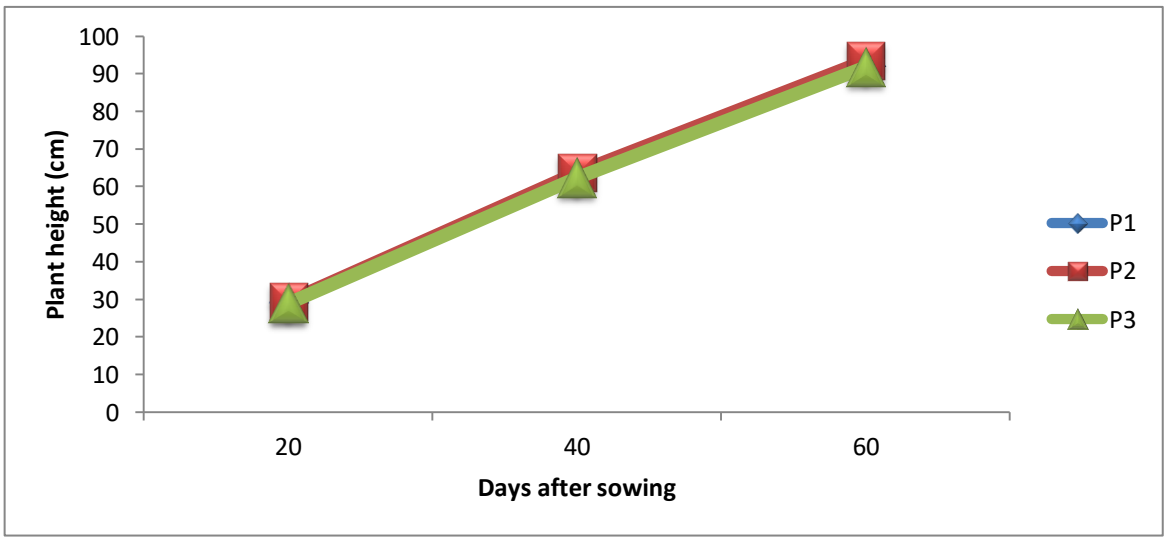
Seed from different fruit positions exhibited no significant influence on the plant height of okra. From the evidence Fig 2, the maximum plant height (29.33, cm) was obtained from P_2 (Fruits borne on 4-8 nodes) treatment at 20 DAS and the minimum plant height (28.97) was obtained from P_3 (all fruits from whole plant) treatment. At 40 DAS, the maximum plant height (63.72 cm) was obtained from P_2 (From fruits borne on 4-8 nodes) treatment and the minimum plant height (62.26 and) was obtained from P_3 (all fruits from whole plant) treatment. At 60 DAS, the maximum plant height (93.50 cm) was obtained from P_2 (From fruits borne on 4-8 nodes) treatment and the minimum plant height (91.71 cm) was obtained from P_3 (all fruits from whole plant) treatment.

Combined effect of different nutrient level and seed from different fruit position was significantly influenced on plant height at 20, 40 and 60 DAS. The maximum plant height (35.65 cm) was observed from F_3P_2 treatment combination which was statistically similar to F_3P_3 and $F_3P_1$and the minimum plant height (23.88 cm) was obtained from F_0P_3 which was statistically similar to F_0P_1 and F_0P_2 (Table 1). At 40 DAS, the maximum plant height (77.11) was recorded from F_3P_2, which was similar to F_3P_1 and the minimum plant height (51.09) was obtained from F_0P_3 which was statistically similar to F_0P_1 and F_0P_2. At 60 DAS, the maximum plant height (114.9 cm) was obtained from F_3P_2 and the minimum plant height (72.69 cm) was obtained from F_0P_3.



Where, F_0 = Control, F_1 = N_{60} P_{20} K_{40} S_{10}, F_2 = N_{80} P_{30} K_{60} S_{15}, F_3 = N_{120} P_{40} K_{80} S_{20}

Fig. 1. Effect of different nutrient level on plant height of okra at different days after sowing ($LSD_{(0.05)}$=1.83, 1.83 and 2.93 at 20, 40, 60 DAS, respectively)



Where, P_1 = Fruits borne on 1-3 nodes, P_2 = From fruits borne on 4-8 nodes, P_3 = all fruits from whole plant

Fig. 2. Effect of seed from different fruit position on plant height of okra at different days after sowing ($LSD_{(0.05)}$=0.57, 2.11 and 4.03 at 20, 40, 60 DAS, respectively)

Table 1. Combination effect of different nutrient level and seed from different fruit position on plant height of okra

Treatment	Plant height (cm) at 20 DAS		Plant height (cm) at 40 DAS		Plant height (cm) at 60 DAS	
F_0P_1	24.04	e	51.25	e	74.4	i
F_0P_2	24.16	e	51.13	e	74.86	i
F_0P_3	23.88	e	51.09	e	72.69	j
F_1P_1	26.71	de	58.31	d	85.93	h
F_1P_2	28.56	cd	60.18	d	87.57	g
F_1P_3	28.57	cd	57.66	d	85.16	h
F_2P_1	31.5	bc	66.29	c	98.65	e
F_2P_2	29.75	cd	66.47	c	96.67	f
F_2P_3	28.68	cd	66.08	c	100.1	d
F_3P_1	33.64	ab	74.62	ab	110.1	b
F_3P_2	35.65	a	77.11	a	114.9	a
F_3P_3	34.87	a	74.06	b	108.9	c
$LSD_{(0.05)}$	2.752		2.621		0.8831	
CV (%)	5.57		5.76		4.29	

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability

F_0 = Control

$F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$

$F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$

$F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

P_1 = From fruits borne on 1-3 nodes

P_2 = From fruits borne on 4-8 nodes

P_3 = From all fruits

4.2 Number of leaves per plant

Significant variation was observed on number of leaves per plant for different nutrient level of okra under the present trial. The maximum number of leaves per plant (23.42) was recorded from F_3 treatment which was statistically similar to F_2 treatment, whereas the minimum number (17.27) from F_0 treatment, which was statistically similar to F_1 treatment (Table 2). Soni *et al.* (2006) reported that number of leaves per plant increased with increasing rates of N up to 125 kg/ha. Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and at 90 kg/ha gave the highest number of leaves per plant (24.98 and 23.57).

Due to the effect of seed from different fruit position showed significant variation on number of leaves per plant of okra. The maximum number of leaves per plant (21.70) was performed by P_1 treatment, which was statistically similar with P_2 treatment. . On the other hand, the minimum number of leaves per plant (18.06) was recorded from P_3 treatment (Table 3).

Combined effect of different nutrient level and seed from different fruit position showed significant differences on number of leaves per plant of okra. The maximum number of leaves per plant (25.20) was found from F_3P_1 treatment which was statistically similar to F_3P_2 treatment and the minimum number (14.34) from F_0P_3 treatment.

Table 2. Effect of different nutrient level on number of leaves per plant, branches per plant and pods per plant of okra

Treatments	Number of leaves per plant	Number of branches per plant	Number of pods per plant
F_0	17.27 c	3.68 b	25.1 c
F_1	19.05 bc	3.91 b	26.17 b
F_2	20.72 ab	4.07 b	26.59 ab
F_3	23.42 a	4.93 a	26.87 a
$LSD_{(0.05)}$	3.089	0.581	0.6212
CV (%)	6.33	7.19	8.04

Where, F_0 = Control, $F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$, $F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$, $F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

Table 3. Effect of seed from different fruit position on number of leaves per plant, branches per plant and pods per plant of okra

Treatment	Number of leaves per plant	Number of branches per plant	Number of pods per plant
P_1	21.7 a	4.35	27.99 A
P_2	20.58 a	4.12	26.32 B
P_3	18.06 b	3.96	24.23 C
$LSD_{(0.05)}$	2.258	2.675	0.579
CV (%)	6.33	7.19	8.04

Where, P_1 = Fruits borne on 1-3 nodes, P_2 = Fruits borne on 4-8 nodes, P_3 = all fruits from whole plant

Table 4. Interaction effect of different nutrient level with seed from different fruit position on number of leaves per plant, branches per plant and pods per plant of okra

Treatment	Number of leaves per plant		Number of branches per plant		Number of pods per plant	
F_0P_1	19.15	def	3.69	bc	26.59	de
F_0P_2	18.32	ef	3.82	bc	25.36	fg
F_0P_3	14.34	g	3.52	c	23.36	h
F_1P_1	20.38	cde	4.01	bc	27.15	cd
F_1P_2	19.98	cde	3.79	bc	26.42	de
F_1P_3	16.79	f	3.92	bc	24.94	g
F_2P_1	22.05	bc	4.24	abc	28.44	b
F_2P_2	20.77	bcde	3.98	bc	26.04	ef
F_2P_3	19.34	cdef	3.98	bc	25.28	fg
F_3P_1	25.2	a	5.47	a	29.79	a
F_3P_2	23.26	ab	4.89	ab	27.46	c
F_3P_3	21.8	bcd	4.43	abc	23.37	h
$LSD_{(0.05)}$	2.449		1.146		0.7332	
CV (%)	6.33		7.19		8.04	

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability

F_0 = Control
$F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$
$F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$
$F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

P_1 = Fruits borne on 1-3 nodes
P_2 = Fruits borne on 4-8 nodes
P_3 = all fruits from whole plant

4.3 Number of branches per plant

There was a significant influence on number of branches per plant on this respect dose of different nutrient level. The F_3 treatment gave the highest number of branches per plant (4.93) and the minimum number of branches per plant (3.68) was obtained from F_0 (control) treatment, which was statistically similar with F_1 and F_2 treatment (Table 2). Soni *et al*. (2006) reported that number of branches increased with increasing rates of N up to 120 kg/ha. Akinrinde and Adigun (2005) reported that okra plants were more efficient in their use of P.

Insignificant variation was found in respect of number of branches per plant due to seed from different fruit position (Table.3). The highest number of branches per plant (4.35) obtained from P_1 (Fruits borne on 1-3 nodes) and the minimum (3.96) from P_3 (all fruits from whole plant) treatment.

Combined effect between different nutrient level and seed from different fruit position was found significant on number of branches per plant of okra. The F_3P_1 treatment gave the maximum number of branches per plant (5.47)) and the minimum number of branches per plant (3.52) was obtained from F_0P_3 treatment (Table 4).

4.4 Number of pods plant^{-1}

Number of pods per plant varied significant due to different nutrient level. The highest number of pods per plant (26.87) was found when the application of fertilizer dose of N_{120} P_{40} K_{80} S_{20} kg ha^{-1} (F_3) and control treatment (25.1) gave the minimum number of pods per plant. It may be due more sunlight absorbed and more produced food of the plants. The number of pods per plant gradually increased with the increasing of nitrogen rate (Table 2). Jana *et al.* (2010) reported that 150 kg N ha^{-1}produced the highest number of fruits plant^{-1} (13.7). Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased the number of pods per plant.

Different Seed from different fruit position showed significant variation on the pods per plant. The maximum pod per plant (27.99) was recorded from P_1 treatment. Whereas, the minimum pods (24.23) was obtained from P_3 treatment (Table 3).

The combined effect of different nutrient level and seed from different fruit position on number of pod per plant was significant. The highest number of pods per plant (29.79) was obtained from F_3P_1 treatment and the minimum number of pods per plant (23.36) was recorded from F_0P_3 treatment, which was statistically similar with F_3P_3 treatment (Table 4).

4.5 Pod length (cm)

Different nutrient level in the length of pod was found significant. The highest length of pod (15.51 cm) was observed on F_3 treatment and the minimum pod length (13.32 cm) was found on control treatment (Table 5). Jalal-ud-Din *et al*. (2002) observed that pod length showed a favorable behavior under 150 kg N/ha, but above this particular dose it declined. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased length of pod

Different Seed from different fruit position showed no significant variation on the pod length. The maximum pod length (14.79 cm) was recorded from P_1 treatment. Whereas, the minimum pods length (13.95 cm) was obtained from P_3 treatment (Table 6).

The combined effect of different nutrient level and seed from different fruit position on pod length was significant. The highest pod length (16.54 cm) was obtained from F_3P_1 treatment and the minimum pod length (13.2 cm) was recorded from F_0P_3 treatment, which was statistically similar with F_0P_1 treatment (Table 7).

Table 5. Effect of different nutrient level on pod length, pod diameter and individual pod weight of okra

Treatment	Pod length (cm)	Pod diameter (cm)	Individual pod weight (g)
F_0	13.32 b	1.61 b	12.05 c
F_1	14.35 ab	1.65 b	13.75 b
F_2	14.48 ab	1.72 ab	14.19 ab
F_3	15.51 a	1.78 a	15.34 a
$LSD_{(0.05)}$	2.069	0.116	1.153
CV (%)	6.69	5.89	6.69

Where, F_0 = Control, $F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$, $F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$, $F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

Table 6. Effect of seed from different fruit position on pod length, pod diameter and individual pod weight of okra

Treatment	Pod length (cm)	Pod diameter (cm^2)	Individual pod weight (g)
P_1	14.79 a	1.714 a	14.33 a
P_2	14.51 a	1.7 a	14.16 a
P_3	13.95 a	1.663 a	13 b
$LSD_{(0.05)}$	2.567	0.1924	1.094
CV (%)	6.69	5.89	6.69

Where, P_1 = Fruits borne on 1-3 nodes, P_2 = From fruits borne on 4-8 nodes, P_3 = all fruits from whole plant

Table 7. Interaction effect of different nutrient level and seed from different fruit position on pod length, pod diameter and individual pod weight of okra

Treatment	Pod length (cm)		Pod diameter (cm)		Individual pod weight (g)	
F_0P_1	13.23	c	1.65	ab	12.21	ef
F_0P_2	13.53	bc	1.64	ab	12.70	def
F_0P_3	13.2	c	1.55	b	11.23	f
F_1P_1	14.42	bc	1.68	ab	1.20	bcd
F_1P_2	14.47	bc	1.66	ab	14.18	bcd
F_1P_3	14.15	bc	1.62	ab	12.86	cdef
F_2P_1	14.98	abc	1.74	ab	14.63	bc
F_2P_2	14.71	bc	1.72	ab	14.39	bcd
F_2P_3	13.77	bc	1.71	ab	13.56	cde
F_3P_1	16.54	a	1.80	a	16.28	a
F_3P_2	15.31	ab	1.78	a	15.39	ab
F_3P_3	14.69	bc	1.77	a	14.35	bcd
$LSD_{(0.05)}$	1.633		0.1693		1.566	
CV (%)	6.69		5.89		6.69	

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability

F_0 = Control
$F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$
$F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$
$F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

P_1 = From fruits borne on 1-3 nodes
P_2 = From fruits borne on 4-8 nodes
P_3 = From all fruits

4.6 Pod diameter

A significant effect was to be found on pod diameter. The maximum pod diameter showed in F_3 (1.78 cm) and the minimum pod diameter (1.61 cm) from control treatment, respectively (Table 5). Ambare *et al*.(2005) reported that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the pod. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased diameter of pod.

The main effect of seed from different fruit position on pod diameter was not found to be statistically significant. However the maximum pod diameter (1.71 cm) was recorded from P_1treatment and the minimum pod diameter (1.66 cm) was recorded from P_3 treatment (Table 6).

Combination between different nutrient level and seed from different fruit position has significant effect on pod diameter. The F_3P_1 showed maximum pod diameter (1.79 cm) which was statistically similar with F_3P_2 and F_3P_3 and the minimum pod diameter (1.55 cm) was observed from F_0P_3 treatment (Table 7).

4.7 Individual pod weight (g)

Significant difference in the weight of individual pod was found among different nutrient level and ranged from 12.05g to 15.34 g. The highest weight of individual pod (15.34 g) was found at F_3 treatment. On the contrary, the minimum weight of individual pod (12.05 g) was found control treatment. Gradual increase in weight of

individual pod was found with the increasing of nutrient (Table 5). Jana *et al.* (2010) reported that 150 kg N ha^{-1} produced the highest individual fruit weight (18.5 gm). Laxman *et al.* (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased mean fruit weight.

Significant variation was due to the effect of seed from different fruit position on individual pod weight. The maximum pod weight (14.33g) was obtained from P_1 treatment, which was statistically similar with P_2 and the minimum pod weight (13.00 g) was obtained from P_3 treatment (Table 6).

Individual pod weight varied significant due to the interaction effect of different nutrient level and seed from different fruit position. The maximum pod weight (16.28g) was obtained from the treatment combinations of F_3P_1 and the minimum pod weight (11.23g) was obtained from F_0P_3 treatment (Table 7).

4.8 Number of seeds per pod

Number of seeds per pod is one of the most important yield contributing characters in okra. The different nutrient level showed significant variation in the number of seeds per pod (Table 8). The maximum number of seeds per pod (43.76) was produced by F_3 treatment and F_0 produced the minimum number of seeds per pod (40.92).

There was a significant difference among the seed from different fruit position in the number of seeds per pod (Table 9). The maximum number of seeds per pod

(44.22) was produced in P_1 treatment, which was statistically similar with P_2 and the minimum number of seeds per pod (38.90) was produced in P_3 treatment.

A significant variation was observed from the treatment combinations of different nutrient level and seed from different fruit position in number of seeds per pod. The maximum number of seeds per pod (46.81) was found in F_3P_1, whereas the minimum number of seeds per pod (37.95) was found in F_0P_3 treatment combination, which was statistically similar with F_1P_3 and F_2P_3 (Table 10).

4.9 Thousand seeds weight (g)

Different nutrient level did influence significantly on the thousand seed weight (Table 8). The maximum thousand seed weight (57.19 g) was produced by F_3 treatment and F_0 produced the minimum thousand seed weight (52.59 g).

The weight of thousand seed was significantly influenced by seed from different fruit position (Table 9). The highest thousand seed weight (60.94 g) was obtained from P_1 treatment, which was statistically similar with P_2 treatment. The minimum thousand seed weight (46.5 g) was obtained from P_3 treatment.

Thousand seed weight was significantly influenced by different nutrient level and seed from different fruit position (Table 7). The highest thousand seed weight (62.15 g) was found in F_3P_1 treatment combination, which was statistically similar with F_1P_1 and F_2P_1 whereas the minimum thousand seed weight (42.65 g) was found in F_0P_3 treatment (Table 10).

Table 8. Effect of different nutrient level on seed yield and yield contributing character of okra

Treatments	Number of seeds per pod	Thousand seed weight (g)	yield of seed (g/plot)
F_0	40.92 b	52.59 c	167.00 d
F_1	41.86 ab	54.34 bc	177.80 c
F_2	41.53 ab	56.20 ab	189.00 b
F_3	43.76 a	57.19 a	208.20 a
$LSD_{(0.05)}$	2.649	2.738	3.37
CV (%)	6.32	4.49	5.68

Where, F_0 = Control, $F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$, $F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$, $F_3 = N_{120}\ P_{40}\ K_{80}\ S_{20}$

Table 9. Effect of seed from different fruit position on seed yield and yield contributing character of okra

Treatment	Number of seeds per pod	Thousand seed weight (g)	Yield of seed (g/plot)
P_1	44.22 a	60.94 a	191.40 a
P_2	42.95 a	57.80 a	185.40 b
P_3	38.90 b	46.50 b	179.70 c
LSD(0.05)	3.943	3.531	4.94
CV (%)	6.32	4.49	5.68

Where, P_1 = Fruits borne on 1-3 nodes, P_2 = From fruits borne on 4-8 nodes, P_3 = all fruits from whole plant

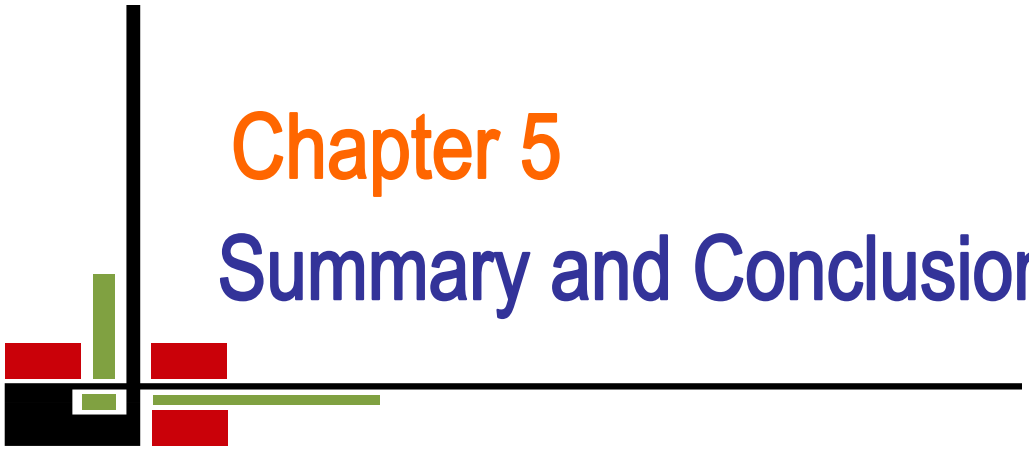
Table 10. Combination effect of different nutrient level with collection of seed from different fruit position on seed yield and yield contributing character of okra

Treatments	Number of seeds per pod	Thousand seed weight (g)	Yield of seed (g/plot)
F_0P_1	42.66 bc	58.62 b	165.00 i
F_0P_2	42.17 bc	56.52 c	174.60 g
F_0P_3	37.95 d	42.65 f	161.60 i
F_1P_1	43.86 b	61.69 a	179.40 f
F_1P_2	43.26 b	55.52 c	184.20 ef
F_1P_3	38.47 d	45.83 e	169.80 h
F_2P_1	43.56 b	61.32 a	189.00 e
F_2P_2	42.18 bc	60.29 ab	193.80 d
F_2P_3	38.87 d	46.99 e	184.20 f
F_3P_1	46.81 a	62.15 a	208.20 b
F_3P_2	44.19 b	58.89 b	213.00 a
F_3P_3	40.30 cd	50.53 d	203.40 c
$LSD_{(0.05)}$	2.55	1.94	4.69
CV (%)	6.32	4.49	5.68

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability

F_0 = Control
$F_1 = N_{60}\ P_{20}\ K_{40}\ S_{10}$
$F_2 = N_{80}\ P_{30}\ K_{60}\ S_{15}$
$F_3 = N_{120}\ P_{80}\ K_{80}\ S_{20}$

P_1 = Fruits borne on 1-3 nodes
P_2 = Fruits borne on 4-8 nodes
P_3 = All fruits from whole plant



Chapter 5

Summary and Conclusion

Chapter V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to September 2017 to study the effect of nutrient management and seeds of different fruit position on growth, seed yield and quality of okra. In this experiment, the treatment consisted of four different nutrient level viz. F_0 = Control, F_1 = N_{60} P_{20} K_{40} $S_{10,}$ F_2 = N_{40} P_{30} K_{60} $S_{15,}$ and F_3 = N_{120} P_{40} K_{80} S_{20}, and seed from different fruit position viz. P_1 =Fruits borne on 1-3 nodes, P_2 = Fruits borne on 4-8 nodes, P_3 = All fruits from whole plant. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The collected data was statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect of majority of the observed parameters.

Different nutrient level have significantly influence on plant height at 20, 40 and 60 DAS. The tallest plant height (34.72, 75.26 and 98.46 cm at 20, 40 and 60 DAS, respectively) was obtained from F_3 ($N_{120}P_{40}K_{80}S_{20}$ kg ha^{-1}) treatment. Significant variation was observed on number of leaves per plant for different nutrient level of okra under the present trial. The maximum number of leaves per plant (23.42) was recorded from F_3 treatment. There were a significant influenced on number of branches per plant on this respect dose of Different

nutrient level. The F_3 treatment gave the highest number of branches per plant (4.93). Number of pods per plant varied highly significant due to different nutrient level. The highest number of pods per plant (26.87) was found when the application of fertilizer dose was N_{120} P_{40} K_{80} S_{20} kg ha^{-1} (F_3). A significant effect was to be found on pod diameter. The maximum pod diameter showed (1.78 cm) at F_3 treatment.. The highest weight of individual pod (15.34 g) was found at F_3 treatment. Different nutrient level influenced the yield of pods per hectare was significant. The different nutrient level showed significant variation in the number of seeds per pod. The maximum number of seeds per pod (43.76) was produced by F_3 treatment. Different nutrient level did influence significantly on the thousand seed weight. The maximum thousand seed weight (57.19 g) was produced by F_3. The different nutrient level had significant effect on the yield of seed per hectare.

Plant height was recorded at 20, 40, and 60 DAS. Different seed from different fruit position exhibited no significantly influence on the plant height of okra. From the evidence Fig 2, the tallest plant height (29.33, 63.72 and 93.50 cm at 20, 40 and 60 DAS, respectively) was obtained from P_2 (Fruits borne on 4-8 nodes) treatment. The maximum number of leaves per plant (21.70) was performed by P_1 treatment.

The highest number of branches per plant (4.35) obtained from P_1 (Fruits borne on 1-3 nodes). Different seed from different fruit position showed significant variation on the pods per plant. The maximum pod yield per plant (27.99) was

recorded from P_1 treatment. Different seed from different fruit position showed no significant variation on the pod length. The maximum pod length (14.79 cm) was recorded from P_1 treatment. The main effect of seed from different fruit position on pod diameter was not found to be statistically significant. However the maximum pod diameter (1.71 cm) was recorded from P_1treatment. Significant variation was due to the effect of seed from different fruit position on individual pod weight. The maximum pod weight (14.33g) was obtained from P_1 treatment. seed from different fruit position showed a significant variation on the pod yield per hectare. The maximum number of seeds per pod (44.22) was produced in P_1 treatment. The highest thousand seed weight (60.94 g) was obtained from P_1 treatment. The total seed yield of okra varied significantly due to the seed from different fruit position.

Different nutrient level and seed from different fruit position combined have significant influence on plant height at 20, 40 and 60 DAS. The F_3P_2 (N_{120} P_{40} K_{80} S_{20} Kg/ha with fruits borne on 4-8 nodes) shows the tallest plant height (35.65, 77.11 and 114.9 cm at 20, 40 and 60 DAS, respectively). The maximum number of leaves per plant (25.20) found from F_3P_1 (treatment). The F_3P_1 treatment gave the highest number of branches per plant (5.47). The highest number of pod per plant (29.79) was obtained from F_3P_1 treatment. The highest pod length (16.54 cm) was obtained from F_3P_1 treatment. The F_3P_1 showed maximum pod diameter (1.79 cm). The maximum pod weight (16.28g) was obtained from the treatment combinations of F_3P_1. The maximum number of

seeds per pod (46.81) was found in F_3P_1. The highest thousand seed weight (62.15g) was found in F_3P_1 treatment combination.

From the above findings it is found that seeds from fruits born on 1-3 node gave the best performance. Again, application of N_{120} P_{40} K_{80} S_{20} Kg/ha showed the best performance regarding most of the yield and yield contributing parameters. In case of combined effect, N_{120} P_{40} K_{80} S_{20} Kg/ha and fruits borne on 1-3 nodes gave the best result considering fruit yield, seed yield and yield contributing parameters. The highest seed yield 443.83 kg ha^{-1} was obtained from N_{120} P_{40} K_{80} S_{20} Kg/ha and fruits borne on 1-3 nodes of BARI Dherosh-2. So, based on the present study it may be concluded that best yield of okra could be obtained by using seeds from fruits on 1-3 nodes and applying fertilizers at 120-40-80-20 kg/ha of NPKS.

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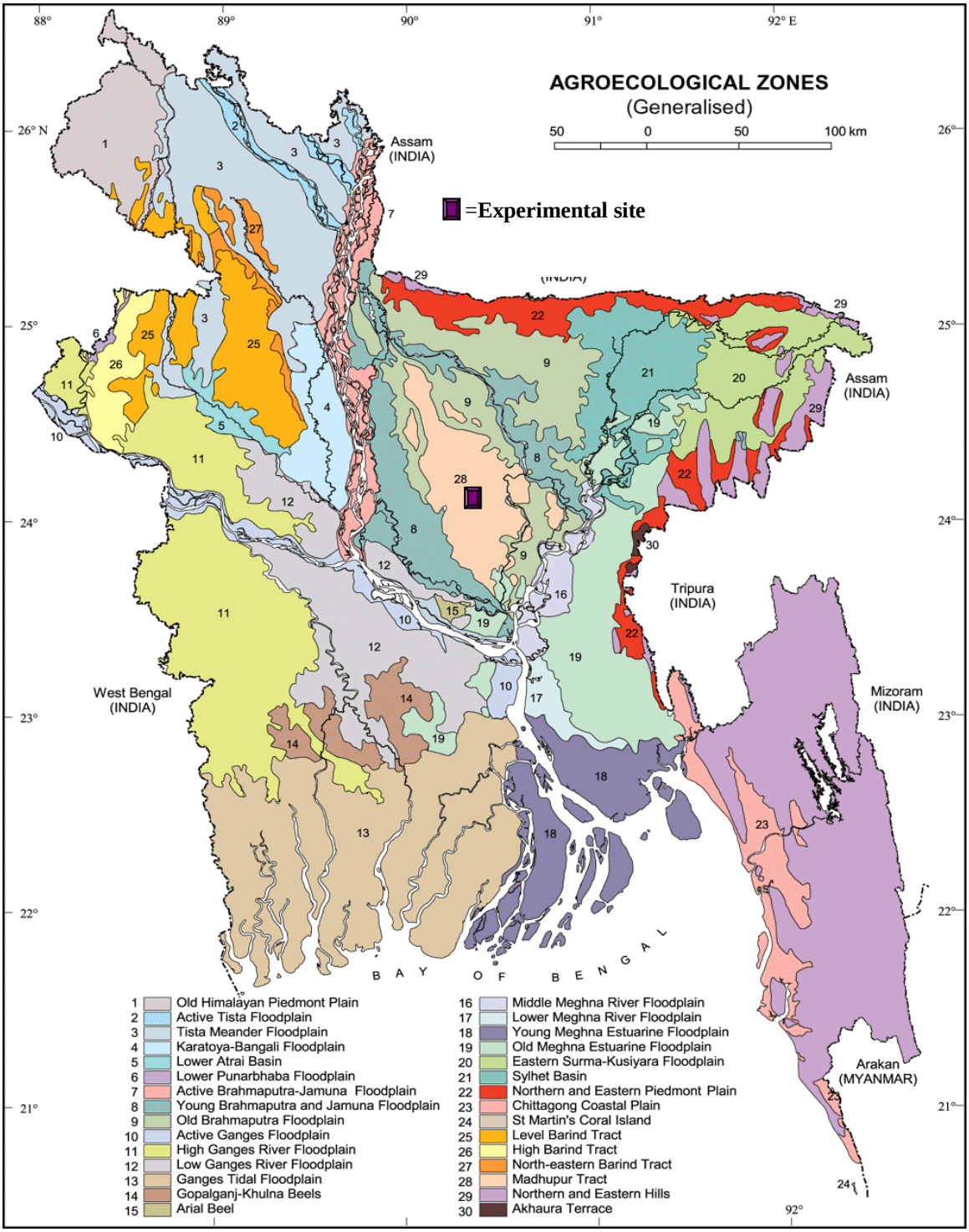
Appendices

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka