APPLICATION OF VARIOUS DOSES OF NITROGEN ON THE PERFORMANCE OF OKRA IN ROOFTOP GARDEN

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APPLICATION OF VARIOUS DOSES OF NITROGEN ON THE PERFORMANCE OF OKRA IN ROOFTOP GARDEN

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CERTIFICATE

This is to certify that the thesis entitled **“APPLICATION OF VARIOUS DOSES OF NITROGEN ON THE PERFORMANCE OF OKRA IN ROOFTOP GARDEN”** submitted to the Department of Agroforestry and Environmental Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE** in **AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **MD. MAHBUBUL ALAM**, Registration No. **13-05378** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

JUNE, 2020

Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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APPLICATION OF VARIOUS DOSES OF NITROGEN ON THE PERFORMANCE OF OKRA IN ROOFTOP GARDEN

ABSTRACT

The present study was carried out at the roof of second floor of Academic Building, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from June to September 2019 to investigate the performance of okra with different doses of nitrogen (N) in rooftop garden. Four levels of N *viz*. N_0 = Control (No N), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1} and N_3 = 180 kg N ha^{-1}. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Data on different growth, yield contributing parameters and yield were recorded and analyzed statistically. The recorded data on different growth yield and yield contributing parameters were significantly influenced by different N doses. Regarding growth parameters, the highest plant height (123.20 cm), leaf length (30.17 cm) and stem base diameter (3.25) were recorded from the treatment N_3 whereas control treatment gave the lowest values. Again, the highest leaf breadth (37.49 cm), number of leaves plant^{-1} (62.07), number of branches plant^{-1} (9.87), number of nodes plant^{-1} (24.20), number of internodes plant^{-1} (23.87), fruit petiole length (5.76 cm), fruit length (13.20 cm) and fruit diameter (2.11 cm), number of fruits plant^{-1} (24.10), single fruit weight (16.59 g), yield plot^{-1} (3.80 kg) and yield ha^{-1} (13.89 t) were found in N_2 treatment. The lowest single fruit weight (15.14 g), number of fruits plant^{-1} (16.30), yield plot^{-1} (2.53 kg) and yield ha^{-1} (9.21 t) were recorded in control treatment. Regarding quality parameters of soil moisture and light, the highest soil moisture (22.13%) and soil temperature (16.20°C) were found from the treatment N_3 but the highest light intensity (32.54 klux) was found from N_2 whereas the lowest soil moisture (20.55%), soil temperature (15.82°C) and light intensity (30.46 klux) were recorded from the control treatment. From the above result, it can be concluded that application of 150 kg N ha^{-1} may ensure higher yield of okra in rooftop garden.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop consumed worldwide. It is a member of the malvaeceae family. It is widely cultivated in the tropics and subtropics for its immature edible green fruits and consumed as a vegetable, raw, cooked or fried (George, 1999). It is a common ingredient of soups and sauces. The fruits can be conserved by drying or pickling. The leaves are sometimes used as a substitute for spinach. The tender fruits, leaves and succulent shoots are consumed, either in fresh or dried form (Arapitsas, 2008).

The fruit is a greenish capsule, slightly curved, six-chambered pods of fibrous texture, containing numerous seeds (Lengsfeld *et al*., 2004). The thick slimy juice of the fruit makes it a relish and a thickener of stews and contains vitamin C and some minerals such as phosphorus, calcium and potassium and has larger concentration of thiamine, riboflavin and niacin than many vegetables (Ranganna, 1979). It is a source of carbohydrate, dietary fibre, fat and protein (Asawalam *et al*., 2007). Okra seeds serve as a good substitute for coffee and contain a considerable amount of good quality oil. Its consumption among other fruit vegetables was found beneficial in moderating blood pressure, fibrinogen concentration and plasma viscosity in Nigerian hypertensives (Adebawoo *et al*., 2007).

It is one of the important nutritious vegetable crops grown round the year in Bangladesh. Its every 100 g green pod contains protein 1.8 g, carbohydrate 6.4 g, fibre 1.2 g, vitamin C 18 mg and Ca 90 mg (Rashid, 1999). Okra as a summer season vegetable can play a vital role to ameliorate the lower availability of vegetable in rainy season to a certain extent.

In Bangladesh the total production of okra was about 272 thousand tons, produced from 7683 hectares of land in the year 2018 with average yield about 3.38 t ha^{-1} which is very low (BBS, 2019) which is lower compared to that of other neighboring country like India (6.12 t ha^{-1}) and other developing countries (7.12 t ha^{-1}) of the world (Yamaguchi, 1998). So, there is scope to increase yield and total production of okra in Bangladesh.

Rooftop garden plays an important role in the mental well-being of the gardeners as well as in amelioration of the physical environment. The production of fresh fruits and vegetables on the rooftop garden can increase nutritional status of household members of the urban citizens and it will make a positive contribution to the environment. Urban agriculture can supply city-dwellers with a supply of sparkling produce, accelerated food plan and essential family budgetary savings. Vegetated surfaces furnish essential sound insulations homes and are frequently employed for their noise discount doable in city settings. Rooftop gardens guide the social life, as an area to be satisfied outside surroundings with household and friends. It additionally develops a experience of self identification and independence, the place one can in particular acquire self and emotion legislation viewing special flower detached seasons (Rashid *et al*., 2010) and affords restorative ride from stressful daily things to do in city excessive upward shove residential building.

Nitrogen is important for vegetative growth of plants. Nitrogen had significant effects on plant height, number of leaves and branches $plant^{-1}$, number of fruits $plant^{-1}$, fresh fruit weight and total fresh fruit yield of okra (Uwah *et al*., 2010). It is difficult element to manage in fertilization system such that 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). Excessive application of nitrogen can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder in crop plant (Obreza and Vavrina, 1993).

Considering above mentioned facts current study was undertaken to determine the optimum levels of nitrogen on the growth and yield of okra with the following objectives

1. To determine the morphological characteristics of okra by applying various doses of nitrogen; and
2. To find out the optimum dose of nitrogen for growth and maximum yield of okra in rooftop garden.

CHAPTER II

REVIEW OF LITERATURE

Okra is specially valued for its tender and delicious edible pods and is an important summer vegetable crop in Bangladesh. Management of fertilizer especially nitrogen is the important factor that greatly affects the growth, development and yield of okra. So it is important to assess the effect of nitrogen for the best growth and yield of okra. However, limited research reports on the performance of okra in response to nitrogen have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect reviewed under the following headings:

2.1 Urban agriculture through rooftop gardening

Rooftop gardening can be a positive approach in ensuring meals furnish and enjoyable dietary desires of the inhabitants (Helen Keller International and Institute of Public Health Nutrition 1985). Rooftop gardening, though is being practiced in the town in many structure for years in the past, there have been infrequently any concerted effort on section of the Government, neighborhood groups and as properly the ordinary residents to combine it to city agriculture. Proper appreciation of the troubles and potentialities related with the adoption of insurance policies will contribute, to a fantastic extent, to elevated meals furnish in the city.

Hodgon *et al*. (2011) reported that urban agriculture is much more than private gardens and community gardens, and many communities are beginning to see the promise of other forms of urban agriculture.

Moustier (2007) provides an extensive summary of the importance of urban agriculture in 14 African and Asian cities. Among the results they found that 90 % of all vegetables consumed in Dar es Salaam (Jacob *et al.*, 2000) and 60 % of vegetables consumed in Dakar originate from urban agriculture.

McDonough (2005) engages with the overall construction of urban landscapes, inclusive of rooftop gardens, the various types, techniques and loading capacities associated to them. This proved useful when realizing the numerous constraints attached to rooftop gardens. Furthermore the introduction of sustainable techniques can help reduce problems arising from global warming and opportunity costs when constructing buildings in different habitats and climates.

2.2 Benefits of garden in roof

Orsini *et al*. (2014) carried out a study of addressing the quantification of the potential of rooftop vegetable production in the city of Bologna (Italy) as related to its citizen's needs. The potential benefits to urban biodiversity and ecosystem service provision were estimated. RTGs could provide more than 12,000 t $year^{-1}$ vegetables to Bologna, satisfying 77 % of the inhabitants' requirements.

Fioretti *et al*. (2010) has discovered that thermal reduction ratio (TRR) is positively related to the coverage ratio (CR) of plants and the total leaf thickness (TLT) of plants on the rooftop. The area of shadow increases with CR and reduce the transmission of solar radiation. Higher TLT will provide greater thermal resistance and increase the thermal reduction effect.

Wong *et al*. (2009) also conducted another study on the thermal performance of extensive rooftop greenery systems in Singapore. That study concluded that the green roof tends to experience lower surface temperature than the original exposed roof surface. In areas well covered by vegetation, over 60 percent of heat gain was stopped by the implementation of green roof system.

Islam (2004) has published an article named “Roof gardening as a strategy of urban agriculture for food security’: the case of Dhaka city, Bangladesh.” He has reported that urban agriculture in the cities of developing countries are growing rapidly which also means the number of low-income consumers is increasing. Because of food insecurity in these cities is increasing. Urban agriculture (UA) contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers.

2.3 Urban ecology and sustainable development through rooftop

Rashid and Ahmed (2010) carried a study on thermal performance of rooftop garden in a six storied building established in 2003. She found that the temperature of this building is 3°C lower than other surrounding buildings and this Green application can reduce the indoor air temperature 6.8°C from outdoor during the hottest summer Period.

Wheeler and Beatley (2004) mentioned that it’s offer additional analysis of urban ecology addressing it through an eco– city dimension and taking into account the role of nature and greening of the city. The Eco city vision links ecological sustainability with social justice and the pursuit of sustainable livelihoods.

Shaw *et al*. (2004) addressed that People generally want wildlife in urban areas and suburban areas, even if they are unsure about some of the potential conflicts. “Having nature around us in urban environments is an indication that nature still prospers in the places where we dwell. It is a sign that our habitat still retains some of its ecological integrity”.

Bennett (2003) reported that Roof Top Gardens, while being aesthetically appealing, can contribute to biodiversity in the urban environment, achieve more sustainable conditions, including those necessary for the production of food and improve the overall quality of urban life.

RTGs ought to grant greater than 12,000 t year^{-1} veggies to Bologna (Itali), fulfilling seventy seven p.c of the city inhabitants‟ necessities (Orsini et. al., 2014). Beyond the advantages related with meals manufacturing and the herbal environment, neighborhood gardening is claimed to enhance human well-being (Okvat and Zautra, 2011).

Together with the urbanization process, there has been a style in the quest for the inexperienced experience: at some point of history, each gardening and extra passive types of contact with nature (e.g. taking a stroll in a garden) have been identified as having intellectual fitness advantages (Davis 1998). Although restricted scientific reviews are reachable to date on the therapeutic position of neighborhood gardening, the gardening-related advantages in decreasing psychological problems e.g. in opposition to dementia (Simons *et al*. 2006), enabling stress restoration (Kingsley *et al*. 2009), or fostering cardiac rehabilitation (Wichrowski *et al*. 2005) are nicely known.

2.4 Effect of nitrogen on growth and yield of okra

Medeiros *et al*. (2018) conducted an experiment to evaluate the different doses of nitrogen on growth and yield of okra (BARI Dherosh-1). Experiment consisted four levels of nitrogen *viz*. N_0 : 0, N_1 : 110, N_2 : 120 and N_3 : 130 kg N ha^{-1} using Randomized Complete Block Design with three replications. Maximum plant height (86.2 cm), number of leaves (43.8 plant^{-1}), leaf length (28.8 cm), petiole length (23.1 cm), stem diameter (2.3 cm), internode length (14.3 cm), number of branches (4.0 plant^{-1}), fruit length (16.8 cm), fruit diameter (1.9 cm), number of flower buds (29.4 plant^{-1}), weight of individual fruit (11.6 g), fresh weight of leaves (298.4 g plant^{-1}), dry matter content of leaves (12.0%) and yield (7.1 kg plot^{-1} and 16.4 t ha^{-1}) were found from N_2 whereas minimum fro m N_0 .

Uddin *et al*. (2014) carried out a study entitled "Impact of nitrogen and spacing on the growth and yield of okra". The applications of nitrogen at 100 kg ha^{-1} recorded higher yield attributes of the number of nods per plant, leaves per plant, internodes length, plant height, pod length, number of pods per plant, fruit yield per plant and total green pod yield per hectare. Nitrogen application upto125 kg ha^{-1} significantly decreased the days to 50% flowering. The pod weight, pod length, number of nodes per plant, number of pods per plant, fruit yield per plant and total green pod yield per hectare increased higher with the optimum plant to plant spacing of 15 cm. The data revealed that the interaction between nitrogen level and plant density was present in case of plant growth and yield contributing characters of okra. Although the highest level interaction of 100 kg N ha^{-1} with plant to plant spacing 15 cm produced the high number of nods per plant, pod weight, pod length, number of pods per plant, pod yield per plant and total green pod yield per hectare and the days to 50% flowering decreased was recorded with 125 kg N ha^{-1} and plant to plant spacing 20 cm.

Candido *et al.* (2011) carried out 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. Being the first factor of the scheme constituted by two nitrogen doses (50 and 100 mg kg^{-1}), and the second for different N-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.

Akanbi *et al.* (2010) carried out pot and field experiments 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 kg N ha^{-1} gave the highest okra fruit yield.

Uwah *et al.* (2010) conducted a field experiment to evaluate the response of okra *[Abelmoschus esculentus* (L.) Moench] due to the four rates of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and three rates of lime. Nitrogen had significant effects on plant height, number of leaves and branches $plant^{-1}$, number of pods $plant^{-1}$, fresh pod weight and total fresh pod yield. 80 kg N ha^{-1} rate maximized all the growth and yield attributes.

Jana *et al.* (2010) evaluated a field-experiment to study comparative effect of planting geometry and nitrogen levels on growth, yield and fruit quality in okra variety Arka Anamika. 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 $plant^{-1}$ (13.7), individual fruit weight (18.5 gm), fruit yield $plant^{-1}$ (195.0 g) and fruit yield ha^{-1} (12.2 t).

Firoz (2009) conducted an experiment with six nitrogen Rates (N_1 = 0, N_2 = 40, N_3 = 80, N_4 = 120, N_5 = 160, and N_6 = 200 kg ha^{-1}) and irrigation by using wastewater. The water was added to the treatment with 100% (160 kg ha^{-1}) using nitrogen fertilization recommendation and irrigation water supply. The effects of treatments on the growth and production variables of okra plants were evaluated.

Singh *et al.* (2007) carried out a field experiment to determine the effect of N (50, 100 and 150 kg ha^{-1}), Cu (500, 1000 and 2000 ppm) and Fe (500, 1000 and 2000 ppm) on the growth and yield of okra cv. Pusa Sawani. 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 N ha^{-1}.

Khan *et al.* (2007) performed a field experiment 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^{-1}, along with Azotobacter in foothills of Nagaland.

Sunita *et al.* (2006) carried out field experiments to determine the effects of intercrop and NPK fertilizer application on the performance of okra (cv. Arka Anamika). 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^{-1}) and net returns (Rs. 30,709.91 ha^{-1}) 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.

Manga and Mohammed (2006) performed two field experiments during the rainy seasons of 2002 and 2004 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^{-1}). 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.

Soni *et al.* (2006) performed a field experiment to study 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. 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.

Ambare *et al*. (2005) carried out an experiment during the kharif season 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) performed an experiment during kharif 2001 to study the effects of different levels of organic manures and N fertilizer (urea) on the growth and yield of okra cv. Varsha Upahar. The treats 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^{-1}).

Gowda *et al.* (2002) carried out a study to study the effects of different fertilizer levels (N:P:K at 125: 75: 60, 150:100:75 and 175:125: 100 kg ha^{-1}) on okra cultivars Arka Anamika, Varsha and Vishal. Dry matter accumulation and nutrient (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.

Jalal-ud-Din *et al.* (2002) conducted an experiment to study the effect of different doses of nitrogen on the growth and yield of okra. They used five different nitrogen doses viz. 50, 100, 150, 200 and 250 kg ha^{-1} 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^{-1} 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^{-1}. Maximum yield of pods (13.39 t ha^{-1}) was obtained from this level. Different parameters like plant height, pod length, pods per plant and weight of pods showed a favorable behavior under 150 kg N ha^{-1}, 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.

Sajjan *et al.* (2002) carried out a field experiment to elucidate the effect of sowing date, spacing and nitrogen rates (100, 125 and 150 kg ha^{-1}) on the yield attributes and seed yield of okra cv. Arka Anamika. 150 kg N ha^{-1} 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^{-1}) in the *kharif* season.

Ogbaji (2002) conducted an experiment to study the effects of nitrogen as ammonium sulfate at 0, 30, 60 and 90 kg N ha^{-1} and potassium, as muriate of potash at 0, 30 and 60 kg K ha^{-1} on okra for three consecutive years (1996-98). Nitrogen application significantly enhanced okra leaf number per plant and plant height. Application of 90 kg N ha^{-1} produced fresh pod yield increase of 94% in 1996, 101% in 1997 and 102% in 1998 compared with the control plots.

Verma and Batra (2001) carried out a field experiment to study the response of spring okra to irrigation and nitrogen. Treatments consisted of three levels of irrigation and three levels of nitrogen, N_1 (100 kg), N_2 (150 kg) and N_3 (200 kg).

The maximum number of fruits per plant, fruit weight and plot yield were recorded from the 200 kg N ha^{-1} treatment, which was on a par with the 150 kg N ha^{-1} treatment. Increased nitrogen fertilization resulted in better leaf nutrient status, although 150 kg N ha^{-1} was the optimum treatment.

Rani *et al.* (1999) was carried out a field experiment in Bapatla, Andra Pradesh, India, in response to 4 fertilizer levels (0-0-0, 50-25-25,100-50-50 and 150-75-75 kg N, P_2O_5 and K_2O ha^{-1} respectively). Results showed that leaf area, leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects. Among the cultivars, Pusa Sawani showed the maximum leaf area, LAI and LAD. However, Arka Anamika showed significantly superior performance with respect to plant height, number of leaves, number of nodes and yield per plant. The highest fertilizer level resulted in maximum leaf area, LAI and LAD, which gradually increased up to 60 days after sowing (DAS). Dry matter increased between stages and was influenced significantly by cultivars, fertilizer levels and their combinations. Crop growth regulator (CGR) and relative growth rates were influenced by cultivars and fertilizers. Pusa Sawani supplied with the highest fertilizer level recorded the maximum CGR 60 DAS. Net assimilation rate (NAR) declined 60 DAS. Harvest index (HI) was also influenced by cultivars fertilizer levels and their interactions. Arka Anamika, with a moderate vegetable growth and high NAR, bad the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK ha^{-1}.

Rain and Lal (1999) were performed a field experiment and studied the growth and development of okra cultivars (Parbhani Kranti, Arka Anamika and Pusa Sawani) in response to 4 fertilizer levels (0-0-0, 50-25-25, 100-50-50 and 150-75-75 kg N, P_2O_5 and K_2O respectively). Results showed that leaf area, leaf area index and leaf area duration were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects.

Ganeshe *et al.* (1998) studied on the effects of soil or seed inoculation of Azospirillum and Azotobacter with or without inorganic N application (0, 20, and 40 kg ha^{-1}) on the growth, yield, and quality of okra cv. Parbhani Kranti. Nitrogen was applied through urea in two splits during sowing and 45 days after sowing. The tallest plants (66.40 cm) and the highest leaf number (15.53 per plant) and fruit yield (56.78 q ha^{-1}) were obtained with the recommended N rate (40 kg N ha^{-1}). 40 kg N ha^{-1} gave the highest net return (Rs 16293 ha^{-1}) and cost : benefit ratio (2.37).

Kurup *et al.* (1997) reported that N rate up to 100 kg could increase the setting percentage, length and diameter of fruits, fruit number and weight per plant and the total pod yield of okra cv. Kiron.

Somkuwar *et al.* (1997) conducted an experiment to determine the effect of 3 levels of nitrogen (25, 50 and 75 kg ha^{-1}) on the growth of okra varieties Punjab 7, Parbhani Kranti and Sel 2-2. The results showed that fruit yield per plant and yield per ha were increased with an increase in nitrogen concentration. Parbhani Kranti produced the highest fruit yield (171.11 kg) per plant and yield per ha (7770 kg) at 75 kg N ha^{-1}.

Birbal *et al.* (1995) carried out an experiment to study the effect of spacing and nitrogen on fruit yield of okra *(Abelmoschus esculentus* L. Moench.) cv. Varsha Uphar. Seeds of okra cv. Varsha Uphar were sown on a sandy loam soil with N applied at 0, 50, 100 or 150 kg ha^{-1}. Application of N at 100 and 150 kg ha^{-1} resulted in taller plants and more branches plant^{-1} than that at 0 and 50 kg ha^{-1}. Number of days to 50% flowering for N at 100 and 150 kg ha^{-1} delayed by 4.5 and 6.0 days, respectively, compared with no N. Number of fruits plant^{-1}, individual fruit weight and yield plant^{-1} were highest with N at 100 kg ha^{-1}.

Singh (1995) carried out an experiment to study effect of various doses of nitrogen on seed yield and quality of okra *(Abelmoschus esculentus* L. Moench). The plots of okra received 6 levels of nitrogen i.e., 0, 30, 60, 90, 120 or 150 kg ha^{-1}, with half applied before sowing and the rest applied 30 days after sowing. Plant height increased with increasing rate of N. Application of N at 90-150 kg ha^{-1} gave the highest number of pods $plant^{-1}$ (12.7-14.0), pod length (16.7-17.6 cm), seed yield (17.5-19.0 q ha^{-1}) and 1000-seed weight (67.2-68.7 g). Seed germination rate was not affected by fertilizer application.

Emebiri *et al.* (1992) carried out a trials with 0 (control), 100, 200 or 300 kg N ha^{-1} in split applications 2 and 6 weeks after sowing. N was applied as calcium ammonium nitrate. All vegetative and reproductive characteristics studied increased significantly with N application. At 4 days after anthesis, individual fruit weight was 50, 71 and 48% higher with 100, 200 and 300 kg N ha^{-1}, respectively, than in the control plots. Fruit growth rates between 4 and 10 days after anthesis were 11.97, 14.03 and 13.37 g day^{-1} at the 3 N rates, respectively, compared with 8.83 g day^{-1} in controls; fruit growth rate was highest in Pink Spineless at all N rates. The number of flowers formed $plant^{-1}$ was highest with 100 kg N ha^{-1}, but N application also increased the rate of flower abortion. Nevertheless, the average number of fruits set $plant^{-1}$ increased from 4.78 without N to 4.91-5.93 with applied N.

Arora *et al.* (1991) compared the growth and yield of a new okra cultivar, Punjab Padmini, with that of cv. Pusa Sawni grown under variable N (0, 30, 60 and 90 kg ha^{-1}) fertilizer application. They stated that plant height, numbers of pods pod size and total green pod yield were significantly improved by the application of 90 kg N ha^{-1}. A significant increase of marketable yield for both cultivars was obtained with an increase in N application from 0 to 90 kg ha^{-1} (100.9 to 156.0 q ha^{-1}).

Khan and Jaiswal (1988) found significant effect on seed yield per hectare due to spacing, nitrogenous fertilizer and fruit pickings. They obtained the highest seed yield (833-902 kg ha^{-1}) at close spacing with the highest amount of nitrogen (150 kg ha^{-1}) and edible pods picked twice.

Mishra and Pandey (1987) conducted trails with okra cv. Pusa Sawani, with N and K_2O were each applied at 0, 40, 80 and120 kg ha^{-1}. N at 80 kg ha^{-1} significantly increased the number of fruits $plant^{-1}$, 1000 seed weight and the seed yield of okra. Application of N above 80 kg ha^{-1} adversely affected seed yield. Interaction effect was significant with 80 kg ha^{-1} N and 40 kg K_2O ha^{-1} giving the highest seed yield and it was 15.47 q ha^{-1}.

Mani and Ramanathan (1980) carried out an experiment to study the effect of nitrogen and potassium on the yield of okra. There were 5 levels of N (0, 20, 40, 60 and 80 kg ha^{-1}) and 5 levels of K_2O (0, 15, 30, 45 and 60 kg ha^{-1}). Nitrogen fertilization significantly increased yield. The highest N level (80 kg ha^{-1}) increased yield by 149.2% over the control and combined application of 80 kg N ha^{-1} with either 30 kg or 60 kg K_2O ha^{-1} produced maximum yields (17.2 t ha^{-1} and 17.5 t ha^{-1} respectively).

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during the period from June to September 2019. The materials and methods that were used for conducting the experiment have been presented in this chapter.

3.1 Location of the experimental site

The experiment was conducted at the roof of second floor of Academic Building, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The duration of the experiment was June to September 2019. The site is 90.2°N and 23.5°E Latitude and at an altitude of 8.25 m from the sea level. Location of the experimental site is presented in Figure 1.

3.2 Climatic condition of the experimental site

Experimental location is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological data during the period of the experiment were collected from the Bangladesh Meteorological Department, Agargoan, Dhaka (Appendix I).

3.3 Soil characteristics of the experimental site

The soil of the experimental site was collected from outside of Dhaka city which was sandy clay. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resource Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and were presented in Appendix II.

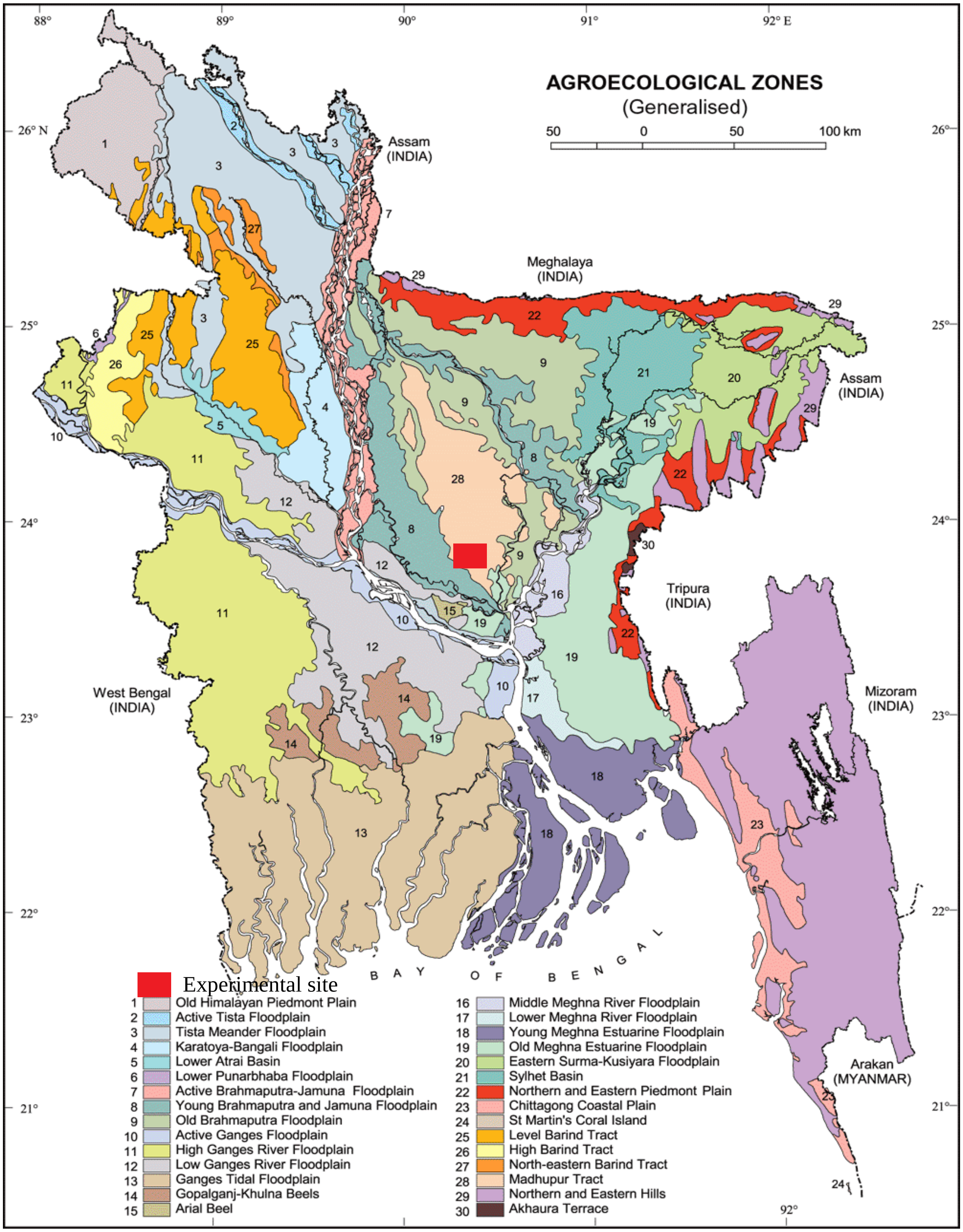

Figure 1. Experimental site

3.4 Planting materials

The test crop used in the experiment was BARI Dherosh-2.

3.5 Collection of seeds

The seeds of okra variety were collected from Bangladesh Agricultural Research Institute (BARI).

3.6 Treatment of the experiment

The experiment consisted of single factor. Four levels of nitrogen (N) was considered as treatments which is as follows:

1. N_0 = Control (No N)
2. N_1 = 120 kg N ha^{-1}
3. N_2 = 150 kg N ha^{-1}
4. N_3 = 180 kg N ha^{-1}

3.7 Land preparation

The preparation of land was started at 3 June 2019. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the experimental plot. The layout of the experiment was done in accordance with the design adopted. Finally, individual plots were prepared by using spade before organic manure application. To facilitate water supply in the prepared bed on the rooftop, GI pipe was established with the help of a structure constructed by bricks, sand and cement and pipe was connected with tap water.

3.8 Application of manure and fertilizers

Urea, triple super phosphate (TSP), muriate of potash (MP) and borax were used as source of nitrogen, phosphorus, potassium and boron, respectively. Well decomposed cowdung was also applied to the field before final ploughing. Total amount of TSP and 50% of urea were applied as basal doses during final land preparation. The remaining 50% urea was applied as top dressing at flowering and fruiting start stage. The doses and application method of fertilizers were given below:

Manure and fertilizers	**Doses/ha**
Cowdung	10 t ha^{-1}
Nitrogen (as urea)	As per treatment
TSP	120 kg ha^{-1}
MoP	150 kg ha^{-1}

3.9 Design and layout of the experiment

The experiment was laid out in Completely Randomized Design (CRD) having single factors with three replications. Each replication (block) is an area of 11.9 m × 1 m. Each block was consists of 4 plots where 4 treatments were allotted. There were 12 unit plots in the experiment. The size of each plot was (2.75 m × 1 m), which accommodated 10 plants at a spacing of (50 cm × 55 cm). The distance between two blocks and two plots were kept 0.5 m and 0.5 m respectively. The design and layout of the experiment is shown in Figure 2 and a sample structure of the roof top garden is presented in Plate 1.

3.10 Seed sowing

The okra seeds were sown in the experimental plot at 9 June in 2019. Seeds were treated with Bavistin @ 2ml/L of water before sowing the seeds to control the seed borne diseases. The seeds were sown in rows having a depth of 2-3 cm with maintaining distance from 50 cm and 55 cm from plant to plant and row to row, respectively.

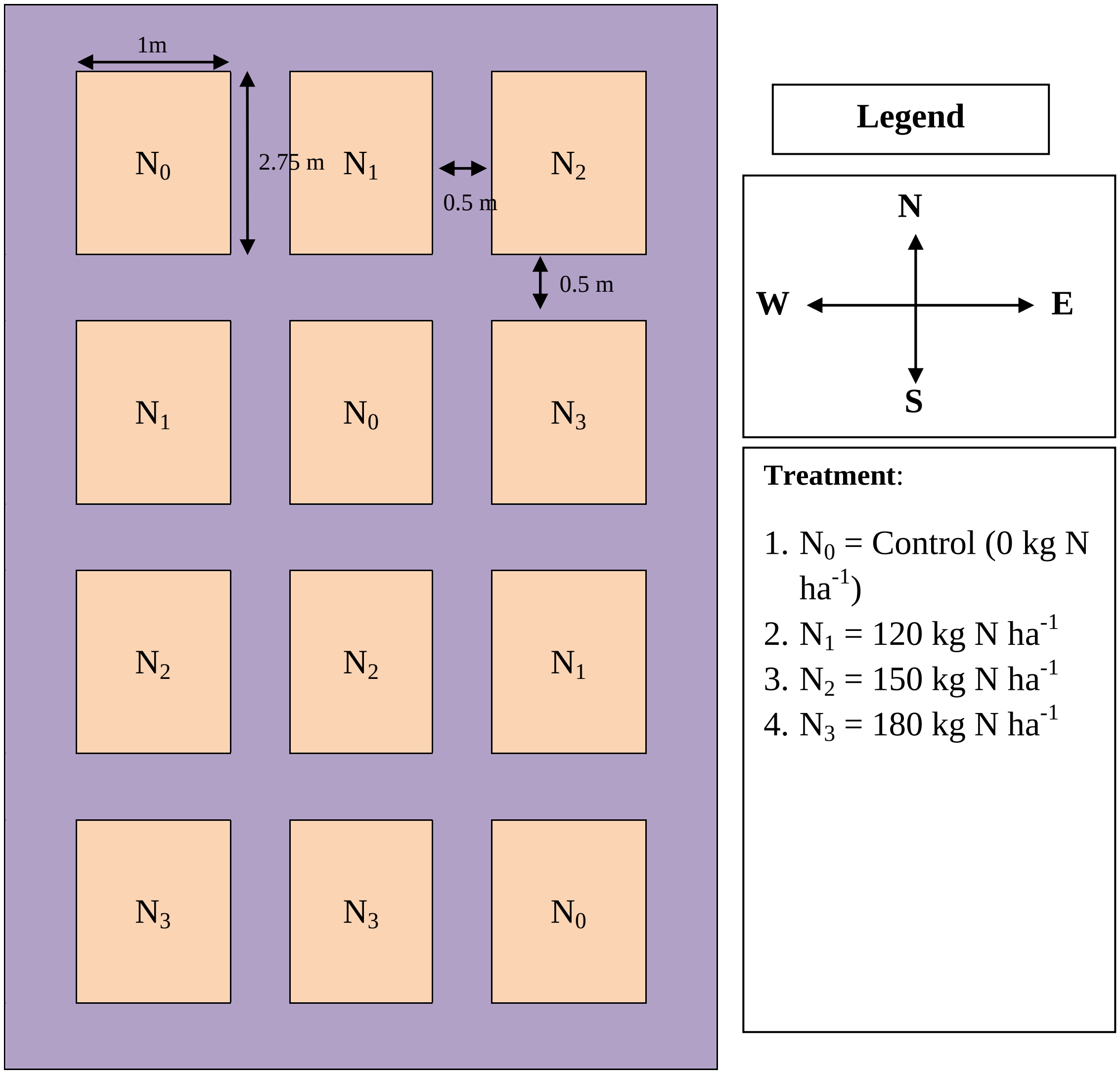

Figure 2. Layout of the experimental plot

Plate 1. Sample structure of the rooftop garden

3.11 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the okra seedlings.

3.11.1 Gap filling

The seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after germination and such seedling were replaced by new seedlings. Replacement was done with healthy seedling in the afternoon having a boll of earth which was also planted on the same date by the side of the unit plot. The seedlings were given watering for 7 days starting from germination for their proper establishment.

3.11.2 Weeding

The weeding was done by nirani with roots at 15, 30 and 45 days after sowing to keep the plots free from weeds.

3.11.3 Irrigation

Light watering was given by a watering cane at every morning and afternoon and it was continued for a week for rapid and well establishment of the germinated seedlings.

3.11.4 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedlings in the field. Cut worms were controlled both mechanically and spraying Bavistin 50WP, Furadan 5G, Ripcord 10EC as and when neccary. Some discolored and yellowish diseased leaves were also collected from the plant and removed from the field.

3.12 Harvesting

Fruits were harvested at 5 days interval based on eating quality at soft and green condition. Harvesting was started from 9 August, 2019 and was continued up to September 2019.

3.13 Data collection

The following parameters were collected during the present study

3.13.1 Growth parameters

1. Plant height (cm)
2. Leaf length (cm)
3. Leaf breadth (cm)

4. Number of leaves plant^{-1}
5. Number of branches plant^{-1}
6. Number of nodes plant^{-1}
7. Number of internodes plant^{-1}
8. Stem base diameter

3.13.2 Yield contributing parameters

1. Fruit petiol length (cm)
2. Fruit length (cm)
3. Fruit diameter (cm)

3.13.3 Yield parameters

1. Number of fruits plant^{-1}
2. Single fruit weight (g)
3. Yield plot^{-1} (kg)
4. Yield ha^{-1} (t)

3.13.4 Soil and light quality parameters

1. Soil moisture (%)
2. Soil temperature (°C)
3. Light intensity (klux)

3.14 Procedure of recording data

3.14.1 Growth parameters

Plant height (cm)

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem of five plants and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after sowing

(DAT) up to 60 days to observe the growth rate of plants.

Length of leaf (cm)

Length of leaf was measured from sample plants in centimeter from one side to another side of leaf of the longest five leaves and mean value was calculated. Length of leaves was also recorded at 20 days interval starting from 20 days after sowing (DAT) up to 60 days to observe the growth rate of plants.

Leaf breadth (cm)

Breadth of leaf was measured from sample plants in centimeter from the one side to another side as width of five leaves and mean value was calculated. Breadth of leaves was also recorded at 20 days interval starting from 20 days after sowing (DAT) up to 60 days to observe the growth rate of plants.

Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 60 DAS at 20 days interval.

Diameter of stem (cm)

Stem diameter was measured from sample plants with a digital calipers-515 (DC-515) from the three different parts of five plants and mean value was calculated. Stem diameter was recorded at 20 days interval starting from 20 days after sowing (DAS) up to 60 days to observe the growth rate of plants.

3.14.2 Yield contributing parameters

Fruit petiole length (cm)

Length of petiole was measured from the longest petiole of 5 sample plants in centimeter and mean value was calculated. Length of petiole was also recorded at 20 days interval starting from 20 days after sowing (DAS) up to 40 days to observe the growth rate of the plants.

Fruit length (cm)

The length of fruit was measured with a meter scale from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

Fruit diameter (cm)

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

3.14.3 Yield parameters

Number of fruits per plant

The number of fruits per plant was counted from the sample plants for the whole growing period and the average number of fruits produced per plant was recorded and expressed in fruits per plant.

Single fruit weight (g)

The weight of single fruit was measured with a digital weighing machine from 10 selected marketable fruits from each selected plots and there average was taken and expressed in gram.

Yield per plot (kg)

Yield of okra per plot was recorded as the whole fruit per plot by a digital weighing machine for the whole growing period and was expressed in kilogram.

Yield per hectare (t)

Yield per hectare of okra fruits was estimated by converting the weight of plot yield into hectare and was expressed in ton.

Soil moisture (%)

Soil moisture was measured by moisture meter and was expressed in percentage.

Soil temperature (°C)

Soil temperature was measured using thermometer and was expressed in degree centigrade ((°C).

Light (Klux)

One unit of light measurement is called a lux which describes how much light falls on a certain area. Light intensity was measured by photometer and expressed in Klux.

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C software to find out the significance of the difference for nitrogen fertilizer on growth and yield of okra. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the means of treatment combinations was estimated by Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was considered to investigate the effect of different level of nitrogen (N) on the performance of okra in rooftop garden. The analysis variances for different characters have been present in Appendix III to XV). Data of the different parameters analyzed statically and the results have been presented through Table 1 to11 and Figures 3 to 9. The results of the present study have been presented and discussed in this chapter under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

At 20 DAT, plant height of okra among the treatments was insignificant but at 40 and 60 DAT, it was significantly varied due to different nitrogen doses (Table 1 and Appendix III). However, at 20 DAT, the highest plant height (22.95 cm) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest plant height (21.23 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Similarly, at 40 DAT, the highest plant height (71.75 cm) was found from the treatment N_3 (180 kg N ha^{-1}) which was statistically identical with N_1 (120 kg N ha^{-1}) and N_2 (150 kg N ha^{-1}) and N_1 (120 kg N ha^{-1}) whereas the lowest plant height (65.55 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Again, at 60 DAT, the highest plant height (123.20 cm) was found from the treatment N_3 (180 kg N ha^{-1}) which was statistically identical with N_2 (150 kg N ha^{-1}) whereas the lowest plant height (115.10 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest plant height (22.95, 71.75 and 123.20 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest plant height (21.23, 66.5 and 115.10 cm at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). It was revealed that with the increase of nitrogen plant height increased upto a certain level. Nitrogen ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was tallest plant. Singh *et al*. (2007) found maximum plant height with 100 kg N ha^{-1}. Similar result was also observed by Manga and Mohammed (2006).

Table 1. Plant height of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Plant height (cm)		
	20 DAT	40 DAT	60 DAT
N_0	21.23	66.55 b	115.10 c
N_1	21.87	70.83 a	116.20 bc
N_2	22.13	71.29 a	121.40 ab
N_3	22.95	71.75 a	123.02 a
$LSD_{0.05}$	4.164^{NS}	2.324	5.396
CV(%)	9.45	1.66	2.27

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.2 Leaf length (cm)

At 20 DAT, leaf length of okra among the treatments was non-significant but at 40 and 60 DAT, it was significantly varied due to different nitrogen doses (Table 2 and Appendix IV). However, at 20 DAT, the highest leaf length (13.10 cm) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest leaf length (12.29 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest leaf length (32.68 cm) was found from the treatment N_3 (180 kg N ha^{-1}) which was statistically similar withN_1 (120 kg N ha^{-1}) and N_2 (150 kg N ha^{-1}). The lowest leaf length (26.51 cm) at 40 DAT was recorded from the control treatment

N_0 (0 kg N ha^{-1}). At 60 DAT, the highest leaf length (30.17 cm) was found from the treatment N_3 (180 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_2 (150 kg N ha^{-1}) whereas the lowest leaf length (25.31 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest leaf length (13.10, 32.68 and 30.17 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest leaf length (12.29, 26.51 and 25.31 cm) at 20, 40 and 60 DAT, respectively was recorded from the control treatment N_0 (0 kg N ha^{-1}). Medeiros *et al*. (2018); Manga and Mohammed (2006) also found similar results which supported the present study. Singh *et al*. (2007) also recorded the longest leaf with 100 kg N ha^{-1}.

Table 2. Leaf length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Leaf length (cm)		
	20 DAT	40 DAT	60 DAT
N_0	12.29	26.51 b	25.31 b
N_1	12.75	29.07 ab	28.04 ab
N_2	13.07	30.26 ab	29.57 a
N_3	13.10	32.68 a	30.17 a
$LSD_{0.05}$	1.212^{NS}	4.460	3.684
CV(%)	4.74	7.53	6.52

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.3 Leaf breadth (cm)

Leaf breadth of okra varied significantly due to different nitrogen doses at different growth stages of crop duration (Table 3 and Appendix V). At 20 DAT, the highest leaf breadth (15.54 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1})

whereas the lowest leaf breadth (14.14 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Again, at 40 DAT, the highest leaf breadth (38.53 cm) was found from the treatment N_2 (150 kg N ha^{-1}) wwhich was statistically similar withN_1 (120 kg N ha^{-1}). The lowest leaf breadth (33.81 cm) at 40 DAT was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}). At 60 DAT, the highest leaf breadth (37.49 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically identical with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}) whereas the lowest leaf breadth (32.07 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest leaf breadth (15.54, 38.53 and 37.49 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest leaf breadth (14.14, 33.81 and 32.07 cm at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

Table 3. Leaf breadth of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Leaf breadth (cm)		
	20 DAT	40 DAT	60 DAT
N_0	14.14 b	33.81 b	32.07 b
N_1	15.21 ab	36.08 ab	36.02 a
N_2	15.54 a	38.53 a	37.49 a
N_3	15.53 a	34.37 b	36.97 a
$LSD_{0.05}$	1.307	3.149	2.555
CV(%)	4.33	4.42	3.59

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.4 Number of leaves plant^{-1}

At 20 DAT, number of leaves plant^{-1} of okra among the treatments was non-significant but at 40 and 60 DAT, it was significantly varied due to different nitrogen doses (Table 4 and Appendix VI). However, at 20 DAT, the highest number of leaves plant^{-1} (10.40) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of leaves plant^{-1} (9.40) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest number of leaves plant^{-1} (56.80) was found from the treatment N_2 (150 kg N ha^{-1}) which was significantly different from other treatments whereas the lowest number of leaves plant^{-1} (47.60) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}). At 60 DAT, the highest number of leaves plant^{-1} (62.07) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_3 (180 kg N ha^{-1}) whereas the lowest number of leaves plant^{-1} (54.60) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest number of leaves plant^{-1} (10.40, 56.80 and 62.07 at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of leaves plant^{-1} (9.40, 47.60 and54.60 at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Soni *et al*. (2006) reported that number of leaves per plant increased with increasing rates of N up to 125 kg ha^{-1}. Medeiros *et al*. (2018) also observed similar result and found highest number of leaves plant^{-1} from 120 kg N ha^{-1}.

Table 4. Number of leaves $plant^{-1}$ of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Number of leaves $plant^{-1}$		
	20 DAT	40 DAT	60 DAT
N_0	9.40	47.60 c	54.60 c
N_1	9.53	47.87 bc	58.27 b
N_2	10.40	56.80 a	62.07 a
N_3	9.53	51.87 b	59.80 ab
$LSD_{0.05}$	1.265^{NS}	4.052	3.340
CV(%)	6.52	3.97	2.85

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.5 Number of branches $plant^{-1}$

Significant variation was recorded at different growth stages of okra due to different nitrogen doses (Table 5 and Appendix VII). At 40 DAT, the highest number of branches $plant^{-1}$ (7.60) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically identical with N_1 (120 kg N ha^{-1}) whereas the lowest number of branches $plant^{-1}$ (5.80) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}). At 60 DAT, the highest number of branches $plant^{-1}$ (9.87) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of branches $plant^{-1}$ (8.60) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}).

As a result in brief, the highest number of branches $plant^{-1}$ (7.60 and 9.87 at 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of branches $plant^{-1}$ (5.80 and 8.60 at 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Soni *et al*. (2006) reported that number of branches increased with increasing rates of N up to

125 kg ha^{-1}. Medeiros *et al*. (2018) also found similar result with the present study and found highest number of branches $plant^{-1}$ from 120 kg N ha^{-1}.

Table 5. Number of branches $plant^{-1}$ of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Number of branches $plant^{-1}$	
	40 DAT	60 DAT
N_0	5.80 b	8.60 b
N_1	7.07 a	8.73 b
N_2	7.60 a	9.87 a
N_3	6.20 b	8.67 b
$LSD_{0.05}$	0.855	0.991
CV(%)	6.42	5.53

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.6 Number of nodes $plant^{-1}$

Number of nodes $plant^{-1}$ of okra varied significantly due to different nitrogen doses at 20 DAT but at 40 and 60 DAT non-significant differences was recorded (Table 6 and Appendix VIII). At 20 DAT, the highest number of nodes $plant^{-1}$ (5.13) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}) whereas the lowest number of nodes $plant^{-1}$ (4.27) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest number of nodes $plant^{-1}$ (11.27) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of nodes $plant^{-1}$ (9.47) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 60 DAT, the highest number of nodes $plant^{-1}$ (24.20) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of nodes $plant^{-1}$ (23.47) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest number of nodes plant^{-1} (5.13, 11.27 and24.20 at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of nodes plant^{-1} (4.27, 9.47 and 23.47 at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

Table 6. Number of nodes plant^{-1} of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Number of nodes plant^{-1}		
	20 DAT	40 DAT	60 DAT
N_0	4.27 b	9.47	23.47
N_1	4.87 ab	9.53	23.53
N_2	5.13 a	11.27	24.20
N_3	5.07 a	10.47	23.67
$LSD_{0.05}$	0.647	1.82^{NS}	3.196^{NS}
CV(%)	6.70	8.95	6.74

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.7 Number of internodes plant^{-1}

Number of internodes plant^{-1} was influenced significantly due to different nitrogen doses at different growth stages of crop duration except at 60 DAT (Table 7 and Appendix IX). At 20 DAT, the highest number of internodes plant^{-1} (4.13) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}) whereas the lowest number of internodes plant^{-1} (3.27) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest number of internodes plant^{-1} (10.27) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) whereas the lowest number of internodes plant^{-1} (8.47) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically similar with N_3 (180 kg N ha^{-1}). At 60 DAT, the highest number of internodes plant^{-1} (23.87) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of internodes $plant^{-1}$ (22.33) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest number of internodes $plant^{-1}$ (4.13, 10.27 and 23.87 at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of internodes $plant^{-1}$ (3.27, 8.47 and 22.33 at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). The result obtained from the present study was similar with the present findings Medeiros *et al*. (2018) which supported the present study.

Table 7. Number of internodes $plant^{-1}$ of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Number of internodes $plant^{-1}$		
	20 DAT	40 DAT	60 DAT
N_0	3.27 b	8.47 c	22.33
N_1	4.07 a	9.47 ab	23.80
N_2	4.13 a	10.27 a	23.87
N_3	3.87 ab	8.53 bc	22.53
$LSD_{0.05}$	0.641	0.958	2.357^{NS}
CV(%)	8.39	5.22	5.10

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.1.8 Stem base diameter

At 20 and 40 DAT, stem base diameter of okra among the treatments was non-significant but at 60 DAT, it was significantly varied due to different nitrogen doses (Table 8 and Appendix X). However, at 20 DAT, the highest stem base diameter (0.78) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest stem base diameter (0.68) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest stem base diameter (0.91) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest stem base diameter (0.86) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 60 DAT, the highest stem base diameter (3.25) was found from the treatment N_3 (180 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_2 (150 kg N ha^{-1}) whereas the lowest stem base diameter (2.88) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest stem base diameter (0.78, 0.91 and 3.25 at 20, 40 and 60 DAT, respectively) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest stem base diameter (0.68, 0.86 and 2.88 at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Medeiros *et al*. (2018) and Candido *et al.* (2011) also found similar result which supported the present study. Singh *et al*. (2007) recorded maximum stem diameter with the application of 100 kg N ha^{-1}.

Table 8. Stem base diameter of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Stem base diameter		
	20 DAT	40 DAT	60 DAT
N_0	0.68	0.86	2.88 b
N_1	0.65	0.87	3.06 ab
N_2	0.70	0.89	3.10 ab
N_3	0.78	0.91	3.25 a
$LSD_{0.05}$	0.22^{NS}	0.14^{NS}	0.245
CV(%)	2.97	7.86	4.03

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.2 Yield contributing parameters

4.2.1 Fruit petiole length (cm)

Significant variation was recorded for fruit petiole length among the treatment due to different nitrogen doses at different growth stages of crop duration except at 60 DAT (Table 9 and Appendix XI). At 20 DAT, the highest fruit petiole length (6.13 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}) whereas the lowest fruit petiole length (5.41 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest fruit petiole length (5.94 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}) whereas the lowest fruit petiole length (5.07 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 60 DAT, the highest fruit petiole length (5.76 cm) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit petiole length (5.08 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

Table 9. Fruit petiole length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Fruit petiole length (cm)		
	20 DAT	40 DAT	60 DAT
N_0	5.41 b	5.07 b	5.08
N_1	5.95 ab	5.70 ab	5.48
N_2	6.13 a	5.94 a	5.76
N_3	5.84 ab	5.61 ab	5.40
$LSD_{0.05}$	0.638	0.681	1.09^{NS}
CV(%)	5.47	6.09	10.09

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

As a result in brief, the highest fruit petiole length (6.13, 5.94 and 5.76 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit petiole length (5.41, 5.07 and 5.08 cm at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Uwah *et al*. (2010) and Medeiros *et al*. (2018) reported longest petiole with the application of 120 kg N ha^{-1}.

4.2.1 Fruit length (cm)

Non-significant variation was found at 60 DAT but at 20 and 40 DAT significant variation was recorded for fruit length among the treatment due to different nitrogen doses (Table 10 and Appendix XII). However, at 20 DAT, the highest fruit length (18.11 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was significantly different from other treatments whereas the lowest fruit length (14.12 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}). At 40 DAT, the highest fruit length (16.00 cm) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) whereas the lowest fruit length (12.99 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}). At 60 DAT, the highest fruit length (13.20 cm) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit length (10.73 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest fruit length (18.11, 16.00 and 13.20 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit length (14.12, 12.99 and 10.73 cm at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Jalal-ud-Din *et al*. (2002) observed that pod length showed a favorable behavior under 150 kg N ha^{-1}, but above this particular dose it declined.

Table 10. Fruit length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Fruit length (cm)		
	20 DAT	40 DAT	60 DAT
N_0	14.12 c	12.99 b	10.73
N_1	16.63 b	15.00 ab	11.05
N_2	18.11 a	16.00 a	13.20
N_3	15.02 c	13.02 b	11.04
$LSD_{0.05}$	1.348	2.890	3.214^{NS}
CV(%)	4.22	10.15	13.98

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.2.3 Fruit diameter (cm)

Fruit diameter of okra was not significantly influenced due to different nitrogen doses during crop duration (Table 11 and Appendix XIII). However, At 20 DAT, the highest fruit diameter (2.10 cm) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit diameter (1.89 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 40 DAT, the highest fruit diameter (2.09 cm) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit diameter (1.89 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}). At 60 DAT, the highest fruit diameter (2.11 cm) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit diameter (1.73 cm) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

As a result in brief, the highest fruit diameter (2.10, 2.09 and 2.11 cm at 20, 40 and 60 DAT, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit diameter (1.89, 1.85 and 1.73 cm at 20, 40 and 60 DAT, respectively) was recorded from the control treatment N_0 (0 kg N ha^{-1}). Ambare *et* *al*. (2005) reported that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the fruit.

Table 11. Fruit diameter of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Treatment	Fruit diameter (cm)		
	20 DAT	40 DAT	60 DAT
N_0	1.89	1.85	1.73
N_1	2.09	2.06	1.97
N_2	2.10	2.09	2.11
N_3	1.93	1.86	1.83
$LSD_{0.05}$	0.26^{NS}	0.47^{NS}	0.49^{NS}
CV(%)	6.52	12.00	12.80

In a column means having similar letters) arc statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by LSD test.

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.3 Yield parameters

4.3.1 Number of fruits $plant^{-1}$

Significant variation was found for number of fruits $plant^{-1}$ among the treatment due to different nitrogen doses (Figure 3 and Appendix XIV). Results indicated that the highest number of fruits $plant^{-1}$ (24.10) was found from the treatment N_2 (150 kg N ha^{-1}) which was significantly different from other treatments whereas the lowest number of fruits $plant^{-1}$ (16.30) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_1 (120 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}). Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest number of fruits per plant (13.7). Medeiros *et al*. (2018) also found similar result with the present study.

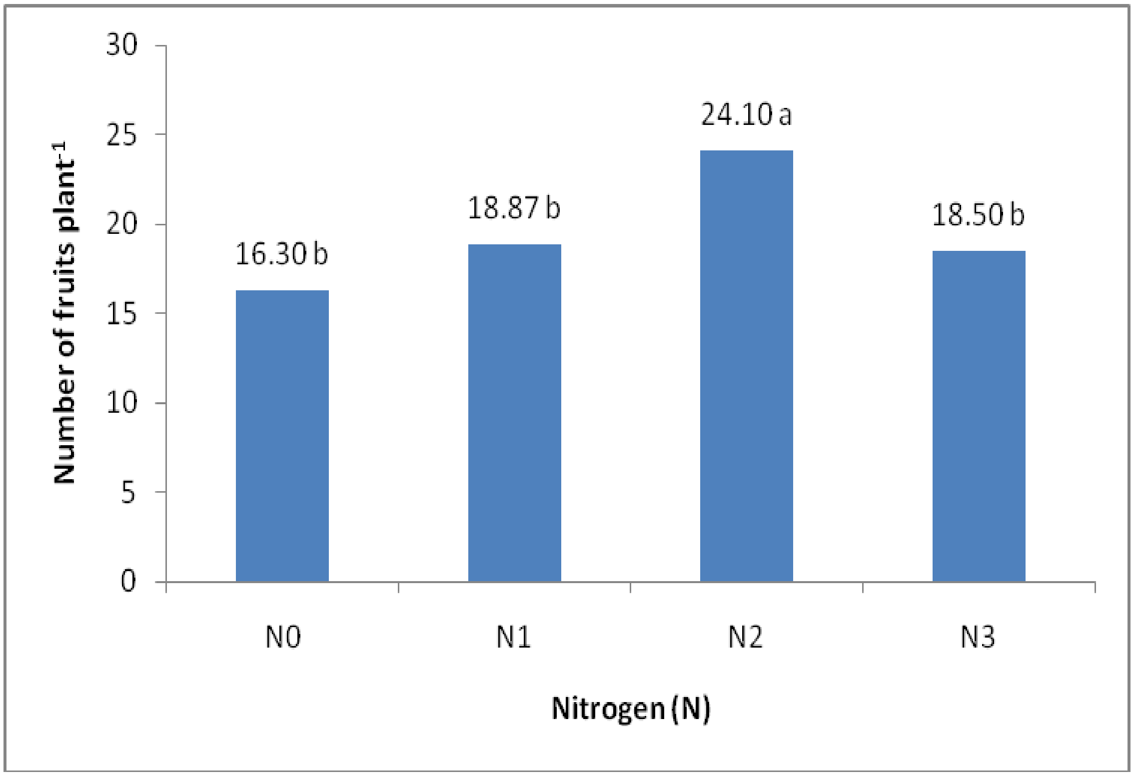

Figure 3. Number of fruits plant^{-1} of okra as influenced by different doses of nitrogen ($LSD_{0.05}$ = 3.386)

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.2.2 Single fruit weight (g)

Single fruit weight was significantly affected among the treatments due to different nitrogen doses (Figure 4 and Appendix XIV). Results revealed that the highest single fruit weight (16.59 g) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) whereas the lowest single fruit weight (15.14 g) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}).

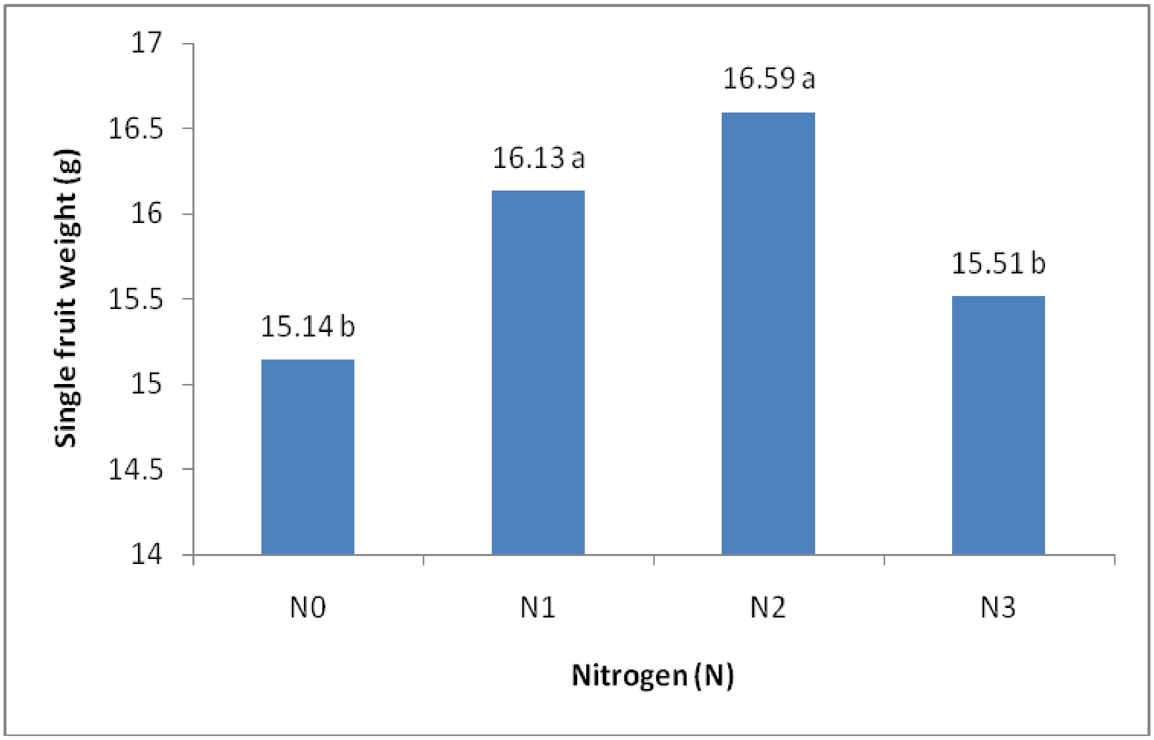

Figure 4. Single fruit weight of okra as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 0.583)

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.2.3 Yield $plot^{-1}$ (kg)

Significant variation was found for yield $plot^{-1}$ among the treatment due to different nitrogen doses (Figure 5 and Appendix XIV). Results indicated that the highest yield $plot^{-1}$ (3.80 kg) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) whereas the lowest yield $plot^{-1}$ (2.53 kg) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}).

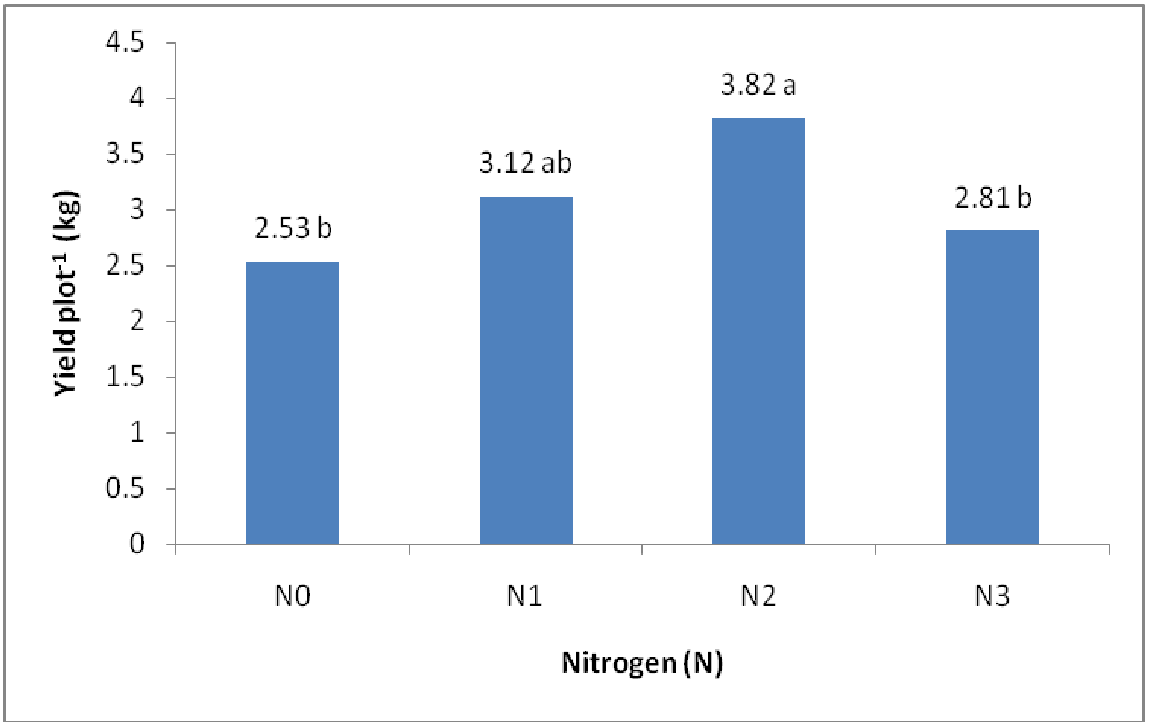

Figure 5. Yield plot^{-1} of okra as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 0.973)

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.2.4 Yield ha^{-1} (t)

Yield ha^{-1} was significantly affected among the treatments due to different nitrogen doses (Figure 6 and Appendix XIV). Results revealed that the highest yield ha^{-1} (13.89 t) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically similar with N_1 (120 kg N ha^{-1}) whereas the lowest yield ha^{-1} (9.21 t) was recorded from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_3 (180 kg N ha^{-1}). Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest fruit yield (12.2 t ha^{-1}). Similar result was also observed by Medeiros *et al*. (2018) who found okra yield (16.4 t ha^{-1}) from 120 kg N ha^{-1}.

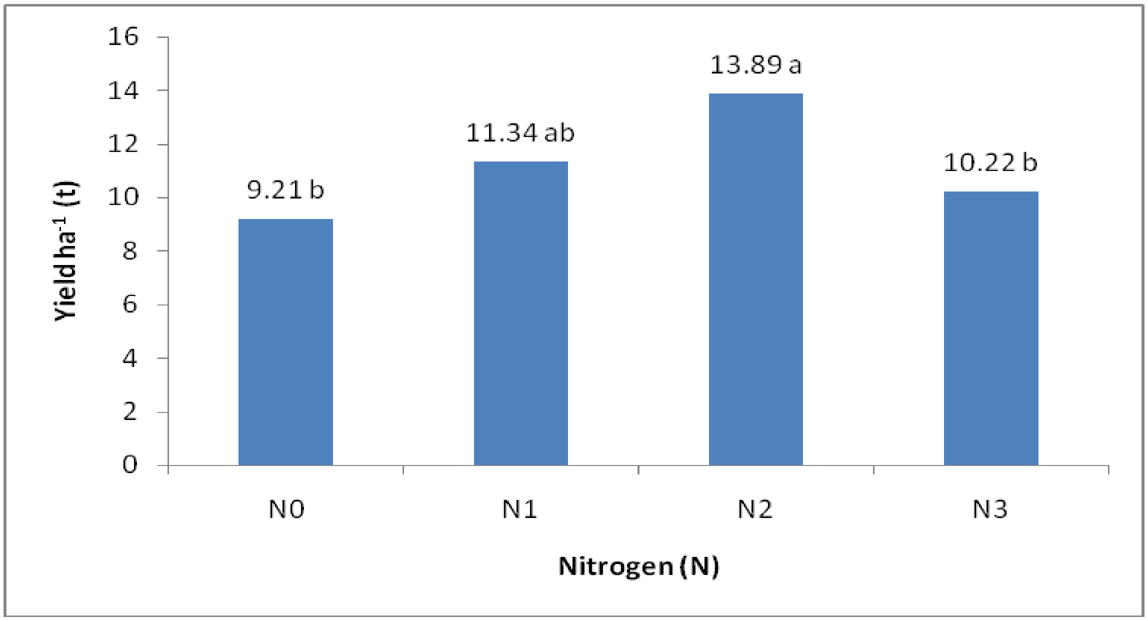

Figure 6. Yield ha^{-1} of okra as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 3.533)

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.4 Quality parameters of soil and light

4.4.1 Soil moisture (%)

Non-significant variation was recorded for soil moisture content influenced by different nitrogen doses (Figure 7 and Appendix XV). However, the highest soil moisture (22.13%) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest soil moisture (20.55%) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

4.4.2 Soil temperature (°C)

Non-significant variation was recorded for soil temperature influenced by different nitrogen doses (Figure 8 and Appendix XV). However, the highest soil temperature (16.20°C) was found from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest soil temperature (15.82°C) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

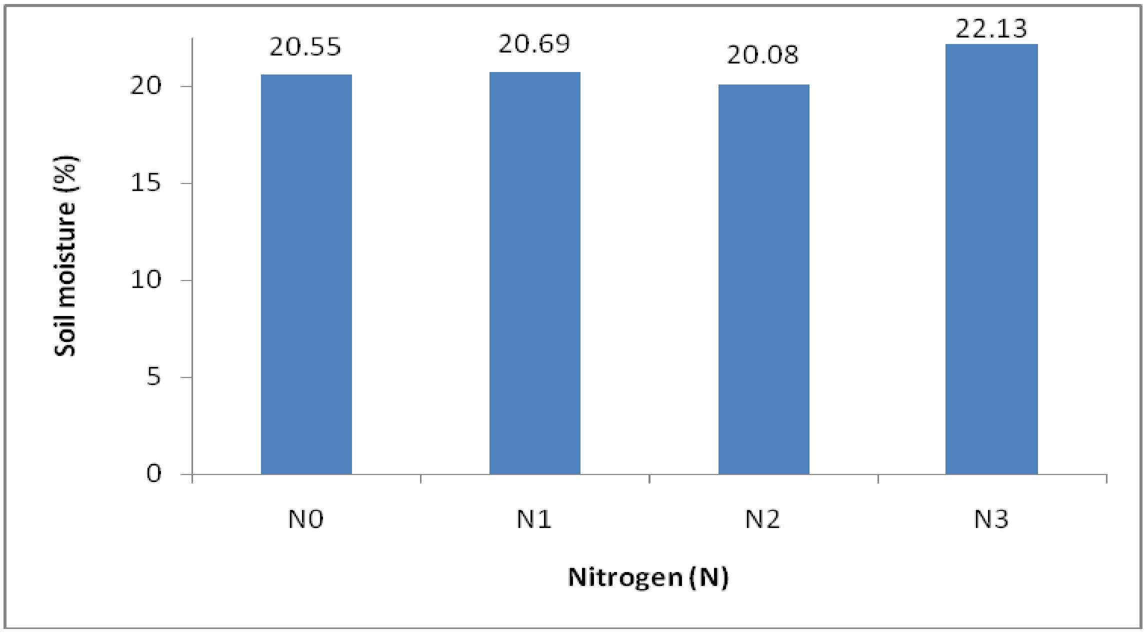

Figure 7. Soil moisture of the field as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 2.453^{NS})

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

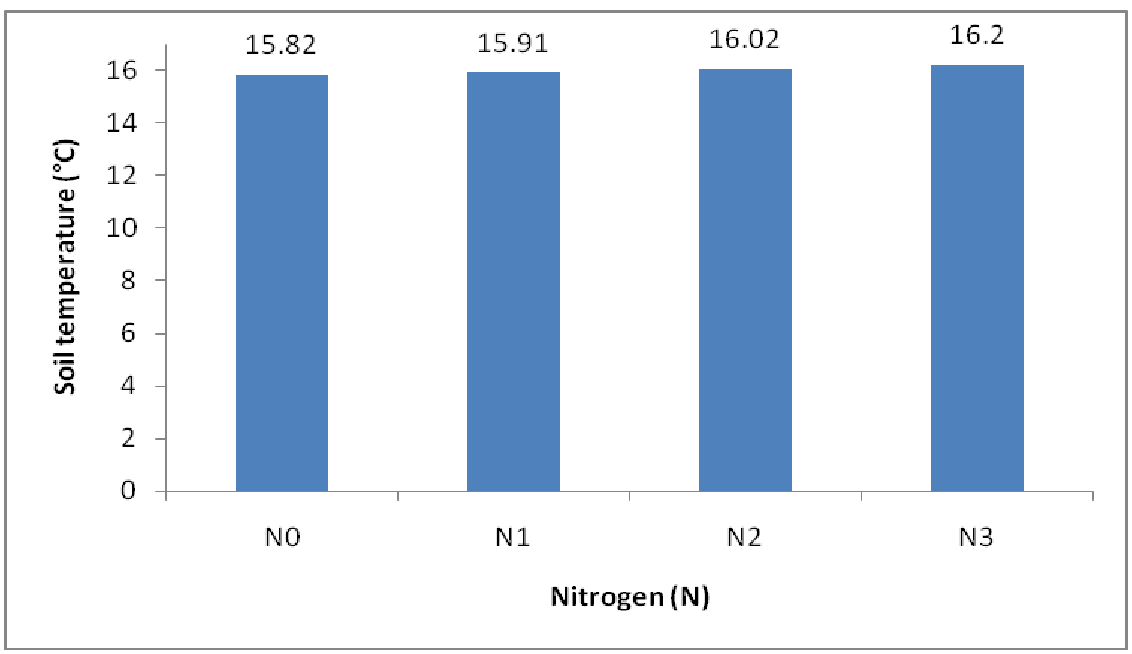

Figure 8. Soil temperature of the field as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 1.312^{NS})

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

4.4.3 Light intensity (klux)

Non-significant variation was recorded for light intensity influenced by different nitrogen doses (Figure 9 and Appendix XV). However, the highest light intensity (32.54 klux) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest light intensity (30.46 klux) was recorded from the control treatment N_0 (0 kg N ha^{-1}).

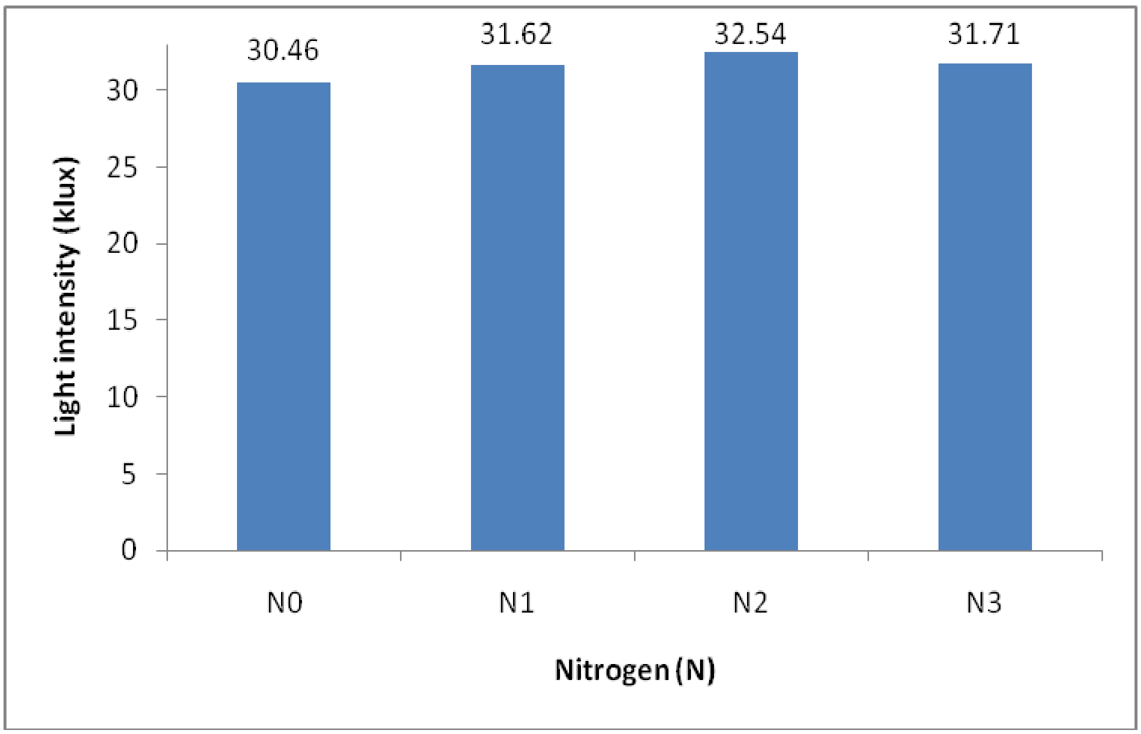

Figure 9. Light intensity of study area as influenced by different doses of nitrogen (N) ($LSD_{0.05}$ = 3.46^{NS})

N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY

The experiment was conducted at the roof of second floor of Academic Building, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June to September 2019 to investigate the performance of okra with different doses of N. One factor was used in the experiment, *viz.* four levels of nitrogen (N). The treatments were considered as N_0 = Control (0 kg N ha^{-1}), N_1 = 120 kg N ha^{-1}, N_2 = 150 kg N ha^{-1} and N_3 = 180 kg N ha^{-1}. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Data on different growth, yield contributing parameters and yield were recorded and analyzed statistically. The recorded data on different growth yield and yield contributing parameters were significantly influenced by different nitrogen doses.

Regarding growth parameters, the highest plant height (22.95, 71.75 and 123.20 cm at 20, 40 and 60 DAT, respectively), leaf length (13.10, 32.68 and30.17 cm at 20, 40 and 60 DAT, respectively) and stem base diameter (0.78, 0.91 and 3.25 cm at 20, 40 and 60 DAT, respectively) were recorded from the treatment N_3 (180 kg N ha^{-1}) whereas the lowest plant height (21.23, 66.5 and 115.10 cm at 20, 40 and 60 DAT, respectively), leaf length (12.2926.51 and 25.31 cm) at 20, 40 and 60 DAT, respectively was recorded from the control treatment N_0 (0 kg N ha^{-1}) and stem base diameter (0.68, 0.86 and 2.88 at 20, 40 and 60 DAT, respectively) were recorded from the control treatment N_0 (0 kg N ha^{-1}). Similarly, the highest leaf breadth (15.54, 38.53 and 37.49 cm at 20, 40 and 60 DAT, respectively), number of leaves plant^{-1} (10.40, 56.80 and 62.07 at 20, 40 and 60 DAT, respectively), number of branches plant^{-1} (7.60 and 9.87 at 40 and 60 DAT, respectively), number of nodes plant^{-1} (5.13, 11.27 and24.20 at 20, 40 and 60 DAT, respectively) and number of internodes plant^{-1} (4.13, 10.27 and 23.87 at 20, 40 and 60 DAT, respectively) were found from the treatment N_2 (150 kg N ha^{-1}). Conversely, the lowest leaf breadth (14.14, 33.81 and 32.07 cm at 20, 40 and 60 DAT, respectively), number of leaves plant^{-1} (9.40, 47.60 and54.60 at 20, 40 and 60 DAT, respectively), number of branches plant^{-1} (5.80 and 8.60 at 40 and 60 DAT, respectively), number of nodes plant^{-1} (4.27, 9.47 and 23.47 at 20, 40 and 60 DAT, respectively) and number of internodes plant^{-1} (3.27, 8.47 and 22.33 at 20, 40 and 60 DAT, respectively) were recorded from the control treatment N_0 (0 kg N ha^{-1}).

In terms of yield contributing parameters and yield of okra, the highest fruit petiole length (6.13, 5.94 and 5.76 cm at 20, 40 and 60 DAT, respectively), fruit length (18.11, 16.00 and 13.20 cm at 20, 40 and 60 DAT, respectively) and fruit diameter (2.10, 2.09 and 2.11 cm at 20, 40 and 60 DAT, respectively) were found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest fruit petiole length (5.41, 5.07 and 5.08 cm at 20, 40 and 60 DAT, respectively), fruit length (14.12, 12.99 and 10.73 cm at 20, 40 and 60 DAT, respectively) and fruit diameter (1.89, 1.85 and 1.73 cm at 20, 40 and 60 DAT, respectively) were recorded from the control treatment N_0 (0 kg N ha^{-1}). Again, the highest number of fruits plant^{-1} (24.10), single fruit weight (16.59 g), yield plot^{-1} (3.80 kg) and yield ha^{-1} (13.89 t) were found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest single fruit weight (15.14 g), number of fruits plant^{-1} (16.30), yield plot^{-1} (2.53 kg) and yield ha^{-1} (9.21 t) were recorded from the control treatment N_0 (0 kg N ha^{-1}).

The highest soil moisture (22.13%) and soil temperature (16.20°C) were found from the treatment N_3 (180 kg N ha^{-1}) but the highest light intensity (32.54 klux) was found from N_2 (150 kg N ha^{-1}). Similarly, the lowest soil moisture (20.55%), soil temperature (15.82°C) and light intensity (30.46 klux) were recorded from the control treatment N_0 (0 kg N ha^{-1}).

CONCLUSION

Considering the growth parameters, yield contributing parameters and yield, it is apparent that the treatment N_2 (150 kg N ha^{-1}) gave the best performance in most of cases. Results indicated that the highest plant height (123.20 cm), leaf length (30.17 cm) and stem base diameter (3.25 cm) were recorded from the treatment N_3 (180 kg N ha^{-1}) but the highest leaf breadth (37.49 cm), number of leaves $plant^{-1}$ (62.07), number of branches $plant^{-1}$ (9.87), number of nodes $plant^{-1}$ (24.20) and number of internodes $plant^{-1}$ (23.87) were found from the treatment N_2 (150 kg N ha^{-1}) whereas control treatment gave lowest results at all the cases. The treatment N_2 also showed highest number of fruits $plant^{-1}$ (24.10) and yield ha^{-1} (13.89 t). So, the treatment of N_2 (150 kg N ha^{-1}) was better than rest of the treatments and this treatment can be considered as the best compared to other treatments.

RECOMMENDATION

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Further study is needed in the rooftop garden for definite results of the present experiment.
2. Other doses of N and/or other plant nutrients can be included to conduct related experiment.
3. Scope to conduct similar experiment for other season in the rooftop

REFERENCES

Adebawoo, O.O., Salau, B.A., Adeyanju, M.M., Famodu, A.A. and Osilesi, O. (2007). Fruits and Vegetables moderates blood pressure, Fibrinogen concentration and plasma viscosity in Nigerian hypertensives. *African J. Food, Agric. Nutr. Dev*. **7**(6): 1-13.

Akanbi, W.B., Togun, A.O., Adediran, J.A. and Ilupeju, E.A.O. (2010). Growth, dry matter and fruit yields components of okra under organic and inorganic sources of nutrients. *American Eurasian J. Sust. Agric.,* **4**(1): 1-13.

Ambare, T.P., Gonge, V.S., Rewatkar, S.S., Anjali, M., Shelke, T.S. (2005). Influence of nitrogen levels and varieties on yield and quality of okra. *Crop Res. Hisar.,* **30**(1): 80-82.

Arapitsas, P. (2008). Identification and quantification of polyphenolics compounds from okra seeds. *Food Chem*. **110**: 1041-1045.

Arora, S.K., Narinder, K., Sharma, B.R. and Kumar, N. (1991). Effect of nitrogen and phosphorus and fertilizer on growth and yield components in okra *(Abelmoschus esculentus* L. Moench). *Haryana J. Hort. Sci.,* **13**(2): 8-11.

Asawalam, E.F., Emeasor, K.C. and Adieze, O. (2007). Influence of some soil amendments on insect pest infestation and damage to okra Abelmoschus esculentus (L.) Moench in Umudike, Abia State. *Res. J. Biol. Sci*. **2**(1): 108-111.

BBS (2019). Monthly statistical Bulletin of Bangladesh (October). Bangladesh Bureau of Statistics, Ministry of Planning. Government of People's Republic of Bangladesh, Dhaka.

Bennett, (2003). Linkages in the landscape: The role of corridors and connectivity in wildlife conservation. Gland: International Union for Conservation of Nature and Natural Resources.

Birbal, B., Nehra, K. and Malik, Y.S. (1995). Effect of spacing and nitrogen on fruit yield of okra *(Abelmoschus esculentus* L. Moench.) cv. Varsha Uphar. Dept. of Veg. *Crops. Indian J. Res.,* **25**(1-2): 47-51.

Candido, W.S., Oliveira, F.A., Silva, R.C.P., Medeiros, J.F. and Silva, O.M.P. (2011). Initial development of okra nitrogen fertilization in different ammonium/nitrate. *Agro Eco. Dev. Sust.*, **6**(1): 28-35.

Davis, S. (1998). Development of the profession of horticultural therapy. In S. P. Simson & M. C. Straus (Eds.), Horticulture as therapy: Principles and practice (pp. 3–18). New York: The Haworth Press.

Emebiri, L.C., Obiefuna, J.C., Abanij, M.S.C. and Ikpor, M.N. (1992). Growth, yield and yield component responses of three okra cultivars *[Abelmoschus esculentus* (L.) Moench] to nitrogen fertilization in the humid tropics. *Beitra. Trop. Land. Veteri.,* **30**(1): 47-58.

Fioretti, R., Palla, A., Lanza, L. G. and Principi, P. (2010). Green roof energy and water related performance in the Mediterranean climate. *Building Environ*., **45**(8): 1890-1904.

Firoz, Z. A. (2009). Impact of nitrogen and phosphorus on the growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] in hill slope condition. *Bangladesh J. Agril. Res*. **34**(4): 713-722.

Ganeshe, R.K., Pandey, R.P. and Rawat, A.K. (1998). Influence of biofertilizers and nitrogen on growth, yield, shelf life and economics of okra *(Abelmoschus esculentus* L. Moench). *JNKVVRes. J*., **32**(1-2): 33-37.

George, R.A.T. (1999). Vegetable seed population (2nd edition), CABI Publication, 328 pp.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst. A Willey Int. Sci., pp. 680.

Gowda, M.C.B., Krishnappa, K.S., Gowda, M.C. and Puttaraju, T.B. (2002). Effect of NPK levels on dry matter, nutrient accumulation and uptake of nutrients in okra. *South Indian Hort.,* **50**(4-6): 543-549.

Helen Keller International and Institute of Public Health Nutrition. (1985). Bangladesh Nutritional Blindness Study 1982-83, Dhaka.

Hodgon, K., Campbell, M. C. and Bailkey, M. (2011). Investing in Healthy, Sustainable Places through Urban Agriculture. Funders' Network for Smart Growth and Livable Communities, 1-15.

Islam, K.M. (2004). Rooftop Gardening as a Strategy of Urban Agriculture for Food Security: The Case of Dhaka City, Bangladesh. Retrieved from teiep.gr: (http://wwwlib.teiep.gr/images/stories/acta/Acta%20643/643_31.pdf).

Jalal-ud-Din, Ghaffoor, A., Waseem, K., Farooq, M.A. and Khan, S.N. (2002). Effect of different doses of nitrogen on the growth and yield of okra *(Abelmoschus esculentus* L. Moench) under the agro-climatic conditions of Dera Ismail Khan. Dept. of Hort. *Pakistan J. Soil Sci.,* **21**(4): 9-13.

Jana, J.C., Guha, S. and Chatterjee, R. (2010). Effect of planting geometry and nitrogen levels on crop growth, fruit yield and quality in okra grown during early winter in terai zone of West Bengal. *J. Hort. Sci.,* **5**(1): 30-33.

Khan, A.H., Singh, A.K. and Singh, V.B. (2007). Response of okra to biofertilizers and nitrogen fertilization in relation to growth, yield and leaf nutrient status in foothill condition of Nagaland. *Environ. Ecol.,* **25**(1): 109-112.

Khan, A.R. and Jaiswal, R.C. (1988). Effect of nitrogen, spacing and green fruit pickings on the seed production of okra *(Abelmoschus esculentus* L. Moench). *Veg. Sci.,* **15**(1): 8-14.

Kingsley, J., Townsend,M.,& Henderson-Wilson, C. (2009). Cultivating health and well-being: Members‟ perceptions of the health benefits of a Port Melbourne community garden. *Leisure Studies*, **28**: 207–219.

Kurup, P. and Gupta, A., Srinivas, K. and Shukla, V. (1997). Response of okra *(Abelmoschus esculentus* L. Moenchj to plant spacing and nitrogen, phosphorus fertilization. *Indian J. Hort., Sci.,* **38**(3-4):218-222.

Lengsfeld, C., Titgemeyer, F., Faller, G. and Hensel, A. (2004). Glycosylated compounds from okra inhibit adhesion of Helicobacter pylori to human gastric mucosa. *J. Agric. Food Chem*. **52** (6):1495-1503.

Manga, A.A. and Mohammed, S.G. (2006). Effect of plant population and nitrogen levels on growth and yield of okra *[Abelmoschus esculentus* (L.) Moench]. *Adv. Hort. Sci.,* **20**(2): 137-139.

Mani, S. and Ramanthan, K.M. (1980). Effect of nitrogen and potassium on the yield of behind fruit. *South Indian Hort.,* **28**(4): 136-138.

McDonough, W. (2005) Green Roofs, Ecological Design and Construction. Earth Pledge, Schiffer Publishing Ltd.

Medeiros, A.S., Queiroz, M.M.F. and Renato A. (2018). Yield of the Okra Submitted to Nitrogen Rates and Wastewater in Northeast Brazilian Semiarid Region. *J. Agric. Sci*., **10**(4): 409-416.

Mishra, H.P. and Pandey, R.G. (1987). Effect of N and K on the seed production of okra *(Abelmoschus esculentus* L. Mill *J* in calcarious soil. *Indian J. Agron.,* **32**(4): 425-427.

Moustier, P. (2007). Urban horticulture in Africa and Asia, an effi cient corner food supplier. *ISHS Acta Horticulturae*, **762**: 145–158.

Obreza, T.A. and Vavrina, C.S. (1993). Production of vegetable in relation to nitrogen Source, Rate and Leaf nutrient concentration in Soil Science and *Plant Analysis*. **24**: 13-14.

Ogbaji, M.I. (2002). Response of okra to nitrogen and potassium fertilizers in a Southern Guinea savannah agro-ecological location. *J. Sust. Agric. Envir.,* **4**(1): 17-22.

Okvat, H. A., and Zautra, A. J. (2011). Community gardening: A parsimonious path to individual, community, and environmental resilience. *American J. Community Psychol*., **47**: 374-387.

Orsini, F., Gasperi, D., Marchetti, L., Piovene, C., Draghetti, S., Ramazzotti, S. and Gianquinto, G. (2014). Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. *Food Security*, **6**(6): 781-792.

Orsini, F., Daniela, G., Livia, M., Chiara, P., Stefano, D. Solange, R. Giovanni, B. and Giorgio, G. (2014). Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. A Case Study. Food Sec. DOI 10.1007/s12571-014-0389-6.

Rain, K.M. and Lal, M.L. (1999). Effect of 4 (four) fertilizer level on the growth and development of okra cultivars (Parbani Kranti, Arka Anamika and Pusa Sawani). *Haryana J. Hort. Sci.,* **9**: 3-14.

Ranganna, S. (1979). Manual Book for Analysis of Fruit and Vegetable Products. 2 ndEdition. Central Food Technological Research Institute, Mysore, India, pp: 5-6, 10-12, 317.

Rashid and Ahmed M.H.B. (2009). The passive cooling effect of green roof in highrise residential building in Malaysia. Sustainable Architecture and Urban Development, CSAAR, 3-6 November.

Rashid R., M.H.B. Ahmed, M.S. Khan. (2010). Green Roof and Its Impact on Urban Environmental Sustainability: The Case in Bangladesh. *World J. Manag*. **2**(2):59 – 69.

Rashid, M.M. (1999). Sabji Biggan (Vegetables Science). 2nd edition, Rashid Publishing House, Dhaka.

Sajjan, A.S., Shekhargouda, M. and Badanur, V.P. (2002). Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. *Karnataka Indian J. Agril. Sci*., **15**(2): 267-274.

Sajjan, A.S., Shekhargouda, M. and Badanur, V.P. (2002). Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. *Karnataka Indian J. Agril. Sci.*, **15**(2): 267-274.

Shaw, WW. Harris, L.K. and VanDruff, L. (2004) Proceedings of the 4th International Symposium on Urban Wildlife Conservation. May 1-5, 1999.

Simons, L. A., Simons, J., McCallum, J., & Friedlander, Y. (2006). Lifestyle factors and risk of dementia: Dubbo study of the elderly. *The Medical J. Australia*. **184**: 68-70.

Singh, I.P. (1995). Effect of various nitrogen on seed yield and quality of okra (*Abelmoschus esculentus L.). Annl. Agril. Res*., **16**(2): 227-229.

Singh, K.V., Singh, M.K. and Singh, B. (2007). Response of macro and micro-nutrients on growth and yield of okra *[Abelmoschus esculentus* (L.) Moench] cv. Pusa Sawani. *Prog. Agric.,* **7**(1/2): 63-65.

Somkuwar, R.G., Mahakal, K.G. and Kale, B.P. (1997). Effect of different levels of nitrogen on growth and yield of okra varieties. *PKV Res. J*., **21**(2): 202-204.

Soni, N., Bharad, S.G., Gonge, V.S., Nandre, D.R. and Ghawade, S.M. (2006). Effect of spacing and nitrogen levels on growth and seed yield of okra. *Internl. J. Agril. Sci.,* **2**(2): 444-446.

Sunita, K., Prasad, K.K., Chowdhary, B.M. and Singh, S.K. (2006). Effect of intercrop and NPK fertilization of performance of okra *(Abelmoschus esculentus* L. Moench). *J. Res. Birsa Agric. Univ.,* **18**(2): 251-255.

Uddin, M.J., Hossain, M.I., Islam, S., Mehraj, H. and Jamal-Uddin, A.F.M. (2014). Growth and yield of okra as influenced by different levels of nitrogen. *Int. J. Business, Social and Scientific Res*. **2**(2): 104-108.

Uwah, D.F., Nwagwu, F.A. and Iwo, G.A. (2010). Response of okra (Abelmoschus esculentus (L.) Moench) to different rates of nitrogen and lime on an acid soil. *Int. J. Agric. Sci*., **2**(2): 14- 20.

Uwah, D.F., Nwagwu, F.A. and Iwo, G.A. (2010). Response of okra *(Abelmoschus esculentus* (L.) Moench) to different rates of nitrogen and lime on an acid soil. *Internl. J. Agric. Sci.,* **2**(2): 14-20.

Verma, I.M. and Batra, B.R. (2001). Effect of irrigation and nitrogen on growth and yield in okra. Changing scenario in the production systems of horticultural crops. Proceedings of a National Seminar, Coimbatore, Tamil Nadu, India, 28-30 August 2001. *South Indian Hort.*, **49**(Special): 386-388.

Wheeler, S.M. and Beatley, T. (2004). The Sustainable Urban Development Reader. Routledge Taylor and Francis Group London and New York.

Wichrowski, M., Whiteson, J., Haas, F., Mola, A., and Rey, M. J. (2005). Effects of horticultural therapy on mood and heart rate in patients participating in an inpatient cardiopulmonary rehabilitation program. *J. Cardiopulmonary Rehabilitation*. **25**: 270–274.

Wong NH, Tan AYK, Tan PY, Wong NC (2009). Energy simulation of vertical greenery systems. *Energy and Buildings*. **41**:1401-8.

Yadav, P., Singh, P., Yadav, R.L. and Lal, R. (2004). Ameliorative potential of organic manures and nitrogen levels on okra cv. Varsha Upahar. *Haryana J. Hort. Sci.*, **33**(1/2): 124-126.

Yamaguchi, Y. (1998). Effect of nitrogen, phosphorus and potassium on bhindi (*Abelmoschus esculentus* L. Moench). *Progress Hort*., **10**(4): 21-30.

APPENDICES

Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from June to September 2019.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2019	June	27.40	23.44	25.42	71.28	190
2019	July	30.52	24.80	27.66	78.00	536
2019	August	31.00	25.60	28.30	80.00	348
2019	September	30.8	21.80	26.30	71.50	78.52

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Sample ID.	Soil sample code	pH	Organic matter	Total N	K	P
			%		meq/100 g soil	μ/g
7219	Plot 1	6.6	3.5	0.150	0.3	97.54
	$1B_1 D_1$	Nutral	Medium	Low	Standard	Very high
7220	Plot 1	6.8	1.8	0.090	0.19	93.89
	$1B_1 D_2$	Nutral	Medium	Very low	Medium	Very high
7221	Plot 1	6.9	2.4	0.120	0.23	97.4
	$2B_1 D_1$	Nutral	Medium	Low	Low	Very high
7222	Plot 1	6.6	2.6	0.130	0.18	102.9
	$2B_1 D_2$	Nutral	Medium	Low	Low	Very high
7223	Plot 1	6.5	3.4	0.170	0.2	113.64
	$3B_1 D_1$	Nutral	Medium	Low	Medium	Very high
7224	Plot 1	6.6	3.3	0.165	0.18	123.54
	$3B_1 D_2$	Nutral	Medium	Low	Low	Very high
7225	Plot 2	7.1	2.1	0.105	0.3	44.5
	$1B_1 D_1$	Nutral	Medium	Low	Standard	Very high
7226	Plot 2	7.2	1.9	0.095	0.2	33.5
	$1B_1 D_2$	Nutral	Medium	Low	Medium	High
7227	Plot 2	6.9	2.3	0.115	0.21	105.26
	$2B_1 D_1$	Nutral	Medium	Low	Medium	Very high
7228	Plot 2	7	2.4	0.120	0.21	39.31
	$2B_1 D_2$	Nutral	Medium	Low	Medium	Very high
7229	Plot 2	6.8	2.1	0.105	0.25	112.8
	$3B_1 D_1$	Nutral	Medium	Low	Medium	Very high
7230	Plot 2	6.8	2.3	0.115	0.21	107.29
	$3B_1 D_2$	Nutral	Medium	Low	Medium	Very high
7231	Plot 3	7	1.9	0.095	0.18	32.61
	$1B_1 D_1$	Nutral	Medium	Low	Low	High
7232	Plot 3	6.7	1.7	0.085	0.17	73.67
	$1B_1 D_2$	Nutral	Medium	Very low	Low	Very high
7233	Plot 3	6.7	2.1	0.105	0.28	101.84
	$2B_1 D_1$	Nutral	Medium	Low	Standard	Very high
7234	Plot 3	6.8	1.4	0.070	0.21	78.21
	$2B_1 D_2$	Nutral	Medium	Very low	Medium	Very high
7235	Plot 3	7.1	1.6	0.080	0.24	54.8
	$3B_1 D_1$	Mildacidic	Low	Very low	Medium	Very high
7236	Plot 3	6.5	1.8	0.090	0.21	84.74

Appendix III. Plant height of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of plant height (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	8.530	3.851	19.179
Factor A	3	1.523^{NS}	17.27*	46.723**
Error	6	4.344	1.353	7.294

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Leaf length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of leaf length (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	1.147	0.304	0.206
Factor A	3	0.424^{NS}	19.72*	14.07*
Error	6	0.368	4.984	3.400

NS = Non-significant * = Significant at 5% level

Appendix V. Leaf breadth of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of leaf breadth (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	0.573	0.099	5.789
Factor A	3	1.304*	13.509*	18.101**
Error	6	0.428	2.484	1.635

* = Significant at 5% level ** = Significant at 1% level

Appendix VI. Number of leaves plant^{-1} of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		20 DAT	40 DAT	60 DAT
Replication	2	0.823	1.603	4.923
Factor A	3	0.634^{NS}	55.764**	29.541**
Error	6	0.401	4.114	2.794

NS = Non-significant ** = Significant at 1% level

Appendix VII. Number of branches plant^{-1} of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}	
		40 DAT	60 DAT
Replication	2	1.263	1.463
Factor A	3	2.000**	1.089*
Error	6	0.183	0.246

* = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Number of nodes plant^{-1} of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of number of nodes plant^{-1}		
		20 DAT	40 DAT	60 DAT
Replication	2	0.141	2.643	0.443
Factor A	3	0.467*	2.190^{NS}	0.332^{NS}
Error	6	0.105	0.830	2.559

NS = Non-significant * = Significant at 5% level

Appendix IX. Number of internodes plant^{-1} of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of number of internodes plant^{-1}		
		20 DAT	40 DAT	60 DAT
Replication	2	0.143	1.243	5.343
Factor A	3	0.467*	2.190*	1.982^{NS}
Error	6	0.103	0.230	1.392

NS = Non-significant * = Significant at 5% level

Appendix X. Stem base diameter of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of stem base diameter		
		20 DAT	40 DAT	60 DAT
Replication	2	0.004	0.003	0.061
Factor A	3	0.010^{NS}	0.001^{NS}	0.070*
Error	6	0.000	0.005	0.015

NS = Non-significant * = Significant at 5% level

Appendix XI. Fruit petiole length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of fruit petiole length (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	0.233	0.215	0.189
Factor A	3	0.275*	0.405*	0.234^{NS}
Error	6	0.102	0.116	0.300

NS = Non-significant * = Significant at 5% level

Appendix XII. Fruit length of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of fruit length (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	3.465	0.092	1.027
Factor A	3	9.365**	6.729*	3.898^{NS}
Error	6	0.455	2.092	2.588

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XIII. Fruit diameter of okra at different days after transplanting (DAT) as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of fruit diameter (cm)		
		20 DAT	40 DAT	60 DAT
Replication	2	0.009	0.011	0.206
Factor A	3	0.037^{NS}	0.048^{NS}	0.081^{NS}
Error	6	0.017	0.056	0.060

NS = Non-significant

Appendix XIV. Yield parameters of okra as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Number of fruits plant^{-1}	Single fruit weight (g)	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
Replication	2	1.003	0.018	0.528	6.965
Factor A	3	32.79**	1.240**	0.920*	12.176*
Error	6	2.873	0.085	0.237	3.127

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XV. Soil and light quality parameters as influenced by different doses of nitrogen (N)

Sources of variation	Degrees of freedom	Mean square of soil and light quality parameters		
		Soil moisture (%)	Soil temperature (°C)	Light intensity (klux)
Replication	2	3.252	2.048	0.001
Factor A	3	2.362^{NS}	0.079^{NS}	2.187^{NS}
Error	6	1.507	0.431	0.000

NS = Non-significant