INTERACTIVE EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF CHILI (*Capsicum annuum* L.) IN ROOFTOP GARDEN

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CERTIFICATE

*This is to certify that the thesis entitled "**INTERACTIVE EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF CHILI (Capsicum annuum L.) IN ROOFTOP GARDEN**' 'submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agroforestry & Environmental Science**, embodies the result of a piece of bona fide research work carried out by **Md. Khalid Mahmud**, Registration number: **16-07574** 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 duly been acknowledged.

Dated: December, 2017
Place: Dhaka, Bangladesh

Prof. Dr. Md. Forhad Hossain
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

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INTERACTIVE EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF CHILI (*Capsicum annuum L.*) IN ROOFTOP GARDEN

ABSTRACT

Roof top garden is suitable for vegetables cultivation in our country. Chili is an important vegetable of robi season. Nitrogen (N) and phosphorus (P) play an important role in growth of chili. An adequate amount of N and P exerts significant effect on the growth and yields of this crop. This experiment was done to evaluate suitable dose of N and P for different growth and yield contributing parameters of chili in rooftop garden. The experiment was conducted at the roof of third floor of Biotechnology department of Sher-e-Bangla Agricultural University, Dhaka during October, 2016 to March, 2017. The two factorial experiments were laid out in Completely Randomized Design (CRD) with three replications. Three levels of nitrogen N_0: 0 kg N ha-^{1}, N_1: 100 kg N ha-^{1}, N_2: 130 kg N ha-^{1} and three levels of phosphorous P_0: 0 kg P_2O_5 ha-^{1}, P_1: 50 kg P_2O_5 ha-^{1}, P_2: 80 kg P_2O_5 ha-^{1} were used in this experiment. Growth and yield contributing parameters significantly influenced by different doses of nitrogen and phosphorus fertilizers. The dose of N_2 treatment gave the highest plant height (87.45 cm) and most of the growth parameters increased with increasing nitrogen levels up to N_2 treatment. The dose of P_2 treatment gave the highest plant height (79.45 cm) and most of the growth parameters increased with increasing phosphorus levels up to P_2 treatment. The treatment combination N_2 and P_2 gave the highest fruit diameter (4.26 cm), fruit length (11.913 cm), yield of fruits plant-^{1} (200 g), average fruit yield plot-^{1} (0.81 kg), individual fruit weight (0.84 g) and average fruit yield (6.79 ton/ha). Based on the present results, it can be suggested that the combined use of 130 kg N ha-^{1} with 80 kg P_2O_5 ha-^{1} increased plant growth and fruit yield of chili in rooftop garden. It is apparent that growth and yield of chili may be increased by using nitrogen and phosphorus fertilizer.

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LIST OF ABBRIVIATIONS

BARI	Bangladesh Agricultural Research Institute
^{0}C	Degree Centigrade
DAS	Days after sowing
DAT	Day after transplanting
et al.	and others *(at elli)*
Kg	Kilogram
Kg/ha	Kilogram/hectare
gm	gram (s)
LSD	Least Significant Difference
m	Meter
PH	Hydrogen ion conc.
CRD	Completely Randomized Design
TSP	Triple Super Phosphate
t/ha	ton/hectare
%	Percent
CV	Coefficient of Variation

CHAPTER I

INTRODUCTION

Nowadays in this urban planet, 54 percentage of the world's population are living in urban areas and the share is expected to increase to 66 percentages by 2050 (United Nations, 2014). Rapid urbanization and urban growth is placing massive demand on urban food supply systems. Moreover, many cities in the world are facing problems like rapid decrease in green space and increase in heat island effects. Urban agriculture or farming is promoted as a potential solution to these problems (Smit *et al*., 2001).

Farming on the rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014). In Dhaka, one of the world's fastest growing mega cities, open and cultivable land has been converting to built-up area indiscriminately and thus agricultural land has been decreased at an alarming rate (Islam and Ahmed, 2011). Implementing rooftop farming can be a possible solution to reduce the food supply problems, make urban living more self-sufficient and make fresh vegetables more accessible to urban individuals. It is estimated that 10,000 ha space of Dhaka city can be brought under rooftop farming and the residents of the city can taste fresh vegetables as well as over 10 percent of the demand can be fulfilled through rooftop farming (Wardard, 2014). A survey shows that most of the roofs of Dhaka city are suitable for gardening and do not require major improvement work, sometimes only need some modifications (Islam, 2004).

Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Rooftop garden is a part of urban agriculture. Besides the decorative benefit, roof plantings may provide food, temperature control, hydrological benefits, architectural enhancement, habitats or corridors for wildlife, recreational opportunities, and in large scale it may even have ecological benefits (Stewart *et al*., 2009). Roof top gardening is suitable for vegetables cultivation in our country. Chili (*Capsicum annuum L.*) is one of the most important vegetables which play an important role in balance diet of human beings. Chili is rich sources of vitamins and minerals. Due to practice of chili production on rooftop garden chili production will be increased which meet the demand of urban people and also reduce the costs of transport as well as encourage the verities of vegetables production in the urban area (Rhodes *et al.,* 2000).

The Solanaceous group of vegetables (tomato, eggplant, chili and bell peppers) generally takes up large amounts of nutrients that have specialized functions and should be supplied to plant at the right time with suitable quantity. When chilies are adequately supplied with the essential nutrients through fertilization it improves their yield, quality and enhance maturity (Carter *et al.,* 1981). Generally, a large amount of nitrogen is required for the growth of the leaf and stem of chili (Aman *et al.*, 2002). It plays a vital role as a constituent of protein, nucleic acid and chlorophyll. Nitrogen progressively increases the marketable yield but an adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Aminifard *et al.,* 2012).

After nitrogen (N), phosphorus (P) is the second most frequently limiting macronutrient for plant growth. An adequate supply of P is required for optimum growth and reproduction. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next (Singegol, 1997). Phosphorus promotes root growth and provides resistances to root diseases. Phosphorus induces earliness in flowering and fruiting including seed formation (Srinivasan *et al.,* 1999).

Green roofs are constructed with less than 20% organic matter combined with coarse, heat-expanded materials, such as slate or shale. This provides for high permeability and low cation exchange capacity (Emilsson *et al.*, 2007). Substrate organic matter breaks down over time (Hathaway *et al.,* 2008). This breakdown of organic matter can result in nutrient leaching which often decreases as the roof ages (Czemiel Berndtsson, 2010). In order to maintain rooftop productivity, these lost nutrients must replace. In this situation, nitrogen (N) and phosphorus (P) in chili production should be judicious. Rooftop farmers should also be especially careful of applying various doses of nitrogen and phosphorus fertilizers will be used and optimum dose that is beneficial for chili production in rooftop will be identified (Khurana *et al.,* 2006).

Objectives:

Considering the above mentioned facts this experiment was conducted to fulfil the following objectives:

1. To find out the optimum dose of nitrogen and phosphorus for growth and maximum yield of Chili in rooftop garden; and
2. To study the combined effect of nitrogen and phosphorus for obtaining desirable yield of chili in rooftop.

CHAPTER II

REVIEW OF LITERATURE

Several influences make up the concept of urban ecology therefore the literature review was divided into discrete categories. However, the linkages between these and the overlaps should not be overlooked. This literature review draws together a wide range of dimensions in a lattice, to provide a conceptual framework for the research. Literatures related of rooftop gardens and vegetable which were collected through reviewing of journals, thesis, internet browsing, reports, newspapers, periodicals and other form of publications are presented in this chapter under the following headings-

2.1 Urban agriculture and role of nature in cities

Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping and horticulture. Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of food and non-food products, reusing largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area (Mougeot, 2001).

Hough (1995) addresses the view of architecture from an urban design perspective embracing the natural processes that need to be incorporated into urban spaces and designs of cities. An example of this is the use of forgotten urban spaces such as the rooftops of buildings.

Thompson and Sorvig (2000) offer understandings of the need for a more holistic and sustainable landscape construction process. This alludes to the role of landscape and urban planning especially with regards to how sustainable landscape construction can be envisioned in a vertical form such as rooftop gardens.

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.

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.

2.2 The benefit of green roof

A rooftop garden is a garden on the roof of a building. Besides the decorative benefit, roof plantings may provide food, temperature control, hydrological benefits, architectural enhancement, habitats or corridors for wildlife, recreational opportunities, and in large scale it may even have ecological benefits.

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.

Niachou *et al.* (2001) which discovered the indoor temperature values in the building with green roof are lower during the day, supported this finding. They measured the roof temperatures in non-insulated building with and without green roof.

Wong *et al.* (2009) also conducted another study on the thermalperformance of exten sive rooftop greenery systems in Singapore. That studyconcluded that the green roof tends to experience lower surface temperature than theoriginal 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.

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.

2.3 Nature and its effects on human behaviour

The literature regarding the effects of rooftop garden on human beings is very broad. It engages with concepts of behaviour and human psychology. This theory is adapted further and suggests that children who have abundant exposure to nature tend to be more biophilic.

Razzaghmanesh and Beecham (2014) stated that when people deplete and degrade the natural environment, most particularly their meaningful and satisfying experience of it, they diminish their potential for emotional and intellectual capacity. He also suggests that as children get older they lose touch with nature. This is a result of various socially conditioned processes. For example they value television, computers and video games above trees, insects and birds.

Thomas (2003) stated that the mere presence of natural areas, trees and established landscapes can influence human psyche. People who drive, live and work in tree-lined streets are less prone to violent behaviour. Furthermore colour therapy specialists state that in the colour spectrum, green is the neutral colour, perceived as an analeptic for exhaustion and stress.

2.4 Urban ecology and sustainable development through rooftop

Rooftop greening can create healthy, functioning habitats on rooftops as opposed to being primarily lifeless places of bituminous surfaces. As mentioned above, the value of rooftop greening forms part of the understandings of eco- cities, urban agriculture and their connection to the theory of urban ecology. This was confirmed by the secondary sources assessed; and it became evident that the concepts of urban ecology, eco cities, sustainable development and urban design are inherently interrelated.

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”.

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.

Rashid and Ahmed (2010) experimented the 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.

Bennett (2003) reported that RTGs, 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.

2.5 Effect of fertilizer management on growth and yield of chili

Fertilizer application have various effects on the plant growth and yield. Many researchers noted that plants were significantly influenced by various doses of fertilizer application.

2.5.1 Effect of nitrogen

Kannan *et al.* (2006) stated that application of recommended nitrogen through different organic sources significantly influenced the growth and yield of tomato. Among the different organic sources, substitution of 100 per cent N through FYM recorded higher plant height, number of branches plant^{-1} and yield.

Sable *et al.* (2007) recorded that a higher number of branches and fruit yield with the combination of 50 per cent N through neem cake and 50 per cent N through vermicompost.

Ahmed *et al*. (2007) reported that an increase in nitrogen application resulted in maximum fruit length, fruit weight, vine length and yield.

Bahuguna *et al*. (2014) in their study reported that total P had a quadratic response to N fertilization with maximum concentrations at low N dosages of 6 and 12 g/m at the onset of flowering. High N concentrations caused a negative effect on P absorption and transport. Total P, inorganic, and organic concentrations responded linearly to K, with the highest values at the lowest K treatment. Potassium fertilization reduced P concentrations while the highest K treatment significantly increased yields.

Bajaj *et al.* (1979) found that the application of 0 P in combination of the highest dose of N resulted in increased pepper plant dry matter content as well as 0 N and highest

P rate. The combination of N and P fertilizers applied at any selected rates reduced plant dry matter content when compared to the 0 P high N, and 0 N high P treatments.

Kinet *et al*. (1985) found nitrogen influences flower development of several vegetable crops including pepper, tomato and cucumber. However, the effect of fertilizer upon flowering and fruit set of green pepper has produced contradictory results. Nitrogen is known to be the most important nutrient affecting fruit yield in pepper.

2.5.2 Effect of phosphorus

Heuvelink (2005) found that Phosphorus is essential to crops, in much smaller quantities than N. It is associated with early root development and architecture especially when P levels are low.

Lau and Stephenson (1994) found the positive role of Phosphorus in flower and seed production.

Wanknade and Morey (1982) studied the effect of phosphate and plant spacing on growth and yield of field grown chilies and found higher P rates increased plant height, dry matter, and yield.

2.6 Role of light intensity, soil moisture and soil temperature on chili production

Rashid and Ahmed (2009) showed that green roof reduces the ceiling surface temperature by a maximum of 3.0°C and on average 1.7°C, in comparison to bare roof. The average indoor air temperature is reduced by 2.4°C with roof during sunshine hours. The amount of solar heat energy entering into the indoors through green roof in comparison with the bare roof is decreased by more than 3 times. Daily average indoor air temperature is 33.0°C with bare roof. This is reduced by 3.0°C with green roof, thereby reducing the average indoor air temperature to 30.0°C.

Kuo *et al.* (1979) stated that high light intensity affects the internal temperature of the reproductive organ of tomato. High temperature is known to limit fruit-set of tomato due to simultaneously and/or sequentially impaired series of reproductive processes i.e. Pollen production and development, ovule development, pollination, germination of pollen grains, pollen tube growth, fertilization and fruit initiation.

Carter and Butler (2008) evaluated how storm water retention, building energy and temperature, and rooftop habitat are influenced by the use of green roofs using test plots in Georgia and Massachusetts. Green roofs were shown to recreate part of the predevelopment hydrology through increasing interception, storm water storage, evaporation, and transpiration on the rooftop and worked extremely well for small storm events. Temperature reductions were found on the green rooftop as compared to an asphalt surface.

CHAPTER III

MATERIALS AND METHODS

The materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Location of the experiment field

The experiment was conducted at the roof of third floor of Biotechnology department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar,Dhaka, Bangladesh. The duration of the experiment was October, 2016 to March, 2017. The site is 90.2^0N and 23.5^0E Latitude and at an altitude of 8.25 m from the sea level.

3.2 Climatic condition

The experimental area was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season and scanty in the Rabi season (October to March). There was little rainfall during the month of October, November, December and January. The average maximum temperature during the period of experiment was 29.35˚C and the average minimum temperature was 15.10˚C. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented in Appendix II.

3.3 Characteristics of soil

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 I.

3.4 Collection of plant materials

The 30 days old seedling of BARI Morish-3 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatment of the experiment

The experiment was conducting by the following experiments:

Treatment A: Three Level of Nitrogen

1) N_0 = 0 kg N ha^{-1} (Control)
2) N_1 = 100 kg N ha^{-1}
3) N_2 = 130 kg N ha^{-1}

Treatment B: Three level of Phosphorus

1) P_0 = 0 kg P_2O_5 ha^{-1} (control)
2) P_1 = 50 kg P_2O_5 ha^{-1}
3) P_2 = 80 kg P_2O_5 ha^{-1}

There were in total 9 (3×3) treatment combinations such as: N_0P_0, N_0P_1, N_0P_2, N_1P_0, N_1P_1, N_1P_2, N_2P_0, N_2P_1, N_2P_2

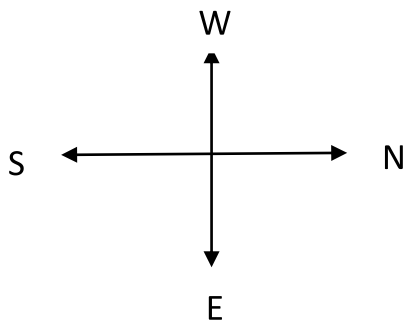
3.6 Design and layout of the experiment

The experiment was laid out in Completely Randomized Design (CRD) having single factors with three replications. An area of 9 m x 4 m was divided into three equal block.

Each block was consists of 9 plots where 3 treatments were allotted in three block. There were 27 unit plots in the experiment. The size of each plot was (1 m x 1 m), which accommodated 4 plants at a spacing of (0.3 m x 0.3 m). The distance between two blocks and two plots were kept 0. 5 m and 0.25 m respectively. The design and layout of the experiment was shown in figure 1.

N_1P_1	N_2P_1	N_2P_0
N_0P_2	N_1P_1	N_1P_2
N_1P_2	N_1P_0	N_0P_1
N_2P_0	N_0P_2	N_0P_2
N_2P_1	N_2P_0	N_2P_1
N_2P_2	N_0P_1	N_2P_2
N_0P_0	N_1P_2	N_0P_0
N_1P_0	N_2P_2	N_1P_1
N_0P_1	N_0P_0	N_1P_0

Legend



Replication: 3

Plot size: 1m x 1m

Plot to plot distance: 0.5 m

Block to block distance: 0.5m

Treatments were as follows:

Factor A: Three Level of Nitrogen

1) N_0= 0 kg N ha-^{1} (Control)
2) N_1 = 100 kg N ha-^{1}
3) N_2= 130 kg N ha-^{1}

Factor B: Three level of Phosphorus

1) P_0 = 0 kg P_2O_5 ha-^{1} (control)
2) P_1 =50 kg P_2O_5 ha-^{1}
3) P_2 =80 kg P_2O_5 ha-^{1}

Figure 1. Layout of the Experiment

3.7 Land preparation

The land was preparation was started at 21 November 2016. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the field. 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.

3.8 Application of manure and fertilizer

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 25 DAT, 50 DAT and 75 DAT during flowering and fruiting start stage. The doses and application method of fertilizers were given below:

Table 1: Manures and fertilizers application method on chili field

Name of manure and fertilizers	Doses/ha	Application (%)			
		Basal	25 DAT	50 DAT	75 DAT
Cowdung	10 ton	100	-	-	-
Urea (N_1)	110 kg	50	16.67	16.67	16.67
Urea (N_2)	130 kg	50	16.67	16.67	16.67
TSP (P_1)	50kg	100	-	-	-
TSP (P_2)	80 kg	100	-	-	-

3.9 Transplanting and after care

Healthy and 30 days old seedlings were transplanted on 21 November, 2016 in the afternoon and light irrigation was given around each seedling for their better establishment. Each unit plot accommodated 4 plants. The transplanted seedlings were protected from birds by providing shed using net. A number of seedlings were planted in the border of the experimental plots for gap filling.

3.10 Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows:

i) Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gap filling was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

ii) Weeding

Weeding were accomplished as and whenever necessary to keep the crop free from weeds for better soil aeration and to break the crust.

iii) Staking and Pruning

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were given a uniform moderate pruning.

iv) Irrigation

Light irrigation was provided immediately after transplanting the seedlings and it was continued till the seedlings established in the field. Thereafter irrigation was provided as per when needed.

3.11 Harvesting

The harvesting was not possible to be done on a particular date because fruit initiations as well as fruit maturation period in different plants were not similar probably due to use of different manures and genetic characters of varieties. Those were harvested over a period of time. The crop under investigation was harvested for the first time on 25 February, 2017 and the last harvesting was done on 25 March, 2017.

3.12 Data collection

Three plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.12.1 Plant height

Plant height was measured from sample plants in centimetre from the ground level to the tip of the longest stem of five plants and mean value was calculated. Plant height was measured with a meter scale from three plants at 30, 45, 60 and 75 days after transplanting of seedling.

3.12.2 Number of leaves per plant

The number of leaves per plant was measured with a meter scale from three selected plants at 30, 45, 60 and 75 days after transplanting of seedling. The average of primary branches from three plants were computed and expressed in average number of leaves per plant.

3.12.3 Leaf length (cm)

A meter scale was used to measure the length of leaves. Leaf length of four plants was measured in centimeter (cm) at harvest. It was measured from the base of the petiole to the tip of the leaf. Most of the leaves of each plant were measured separately and then average it. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.12.4 Leaf breadth (cm)

Leaf breadth of four randomly selected plants was measured in centimeter (cm) at harvest from the widest part of the lamina with a meter scale and average breadth was recorded in centimeter (cm). All the leaves of each plant were measured separately. Only the smallest young leaves at the growing point of the plant were excluded from measuring.

3.12.5 Number of Branches plant^{-1}

Number of Branches plant^{-1} was measured by was counted unit plot wise from four plants and then averaged.

3.12.6 Length of fruit

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

3.12.7 Diameter of fruit

Breath of fruit was measured at the middle portion of fruit from each plot with a digital callipers and average was taken and expressed in cm.

3.12.8 Individual fruit weight

The weight of individual fruit was measured with a digital weighing machine from each selected plots and average was taken and expressed in gm.

3.12.9 Yield of fruits per plant

An electric balance was used to measure the weight of fruits per plant. The total fruit yield of each plant measured separately during the harvest period and was expressed in gm.

3.12.10 Yield of fruits per plot

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately during the harvest period and was expressed in kilogram (kg).

3.12.11 Yield of fruits per hectare

Yield of fruits per hectare was measured by the following formula:

$$\text{Fruit yield (ton/ha)} = \frac{\text{Fruit yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.13 Light measurement

Light was measured by Lux meter on each vegetable crop rows. It was done to determine the availability of light and expressed as lux. Light intensities were measured above the canopy of chili crops at 8.30- 10.30 am and 3.30- 4.30 pm using Lux meter at three times per month.

3.14 Soil moisture measurement

Soil moisture was measured by Soil Moisture Meter on each vegetable crop rows. It was expressed as percentage (%). Soil moisture was measured at 10 cm depth of soil adjacent to main root of vegetable crop rows at 8.30- 10.30 am, 12.30-1.30 pm and 3.30- 4.30 pm in 3 times per month.

3.15 Soil temperature measurement

Soil temperature was measured by Soil Temperature Meter on each vegetable crop rows. It was expressed as degree centigrade ($^{\circ}$C). Soil temperature was measured at 10 cm deep soil adjacent to main root of vegetable crop rows at 8.30- 10.30 am, 12.30-1.30 pm and 3.30- 4.30 pm in 3 times per month.

3.16 Statistical analysis

The recorded data on different parameters were statistically analysed by using MSTAT-C software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments were accomplished by DMRT test. The significance of difference between pair of means was tested at 5% and 1% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

In this chapter, result of the experiment entitled "Interactive effect of nitrogen and phosphorus on growth and yield of chili (*Capsicum annuum L.*) in roof top garden conducted during October 2016 to March 2017, have been presented. Data recorded on various observations during the course of investigation are tabulated and statistically analysed to find out the effects of different treatments on growth and yield of chili. The results are furnished in this chapter in the form of tables and illustrated through the figures wherever necessary under appropriate headings.

4.1 Plant height of chili

Effect of various doses of nitrogen

Plant height is one of the important parameter, which is positively correlated with the yield of chili. The plant height varied due to the application of different level of nitrogen fertilizer. The plant height of chili was statistically significant with various levels (30, 45, 60 and 75 DAT) of nitrogen (Appendix III, Table 2). The result revealed that at 30 DAT the tallest plant was recorded from N_2 (44.80 cm) which was statistically different from N_1 (37.33 cm) whereas the shortest plant height was found from N_0 (23.09). At 45 DAT the highest plant height (59.91 cm) was observed from the N_2 treatment which was statistically different from N_1 (50.11 cm) whereas, the lowest (37.33 cm) was observed in N_0 treatment.

At 60 DAT the highest plant height (74.44 cm) was observed from the N_2 treatment which was statistically similar to N_1 (67.14 cm) whereas, the lowest (50.95 cm) was observed from N_0 treatment. At 75 DAT the highest plant height (87.45 cm) was observed from the N_2 treatment which was statistically similar with N_1 (82.31 cm) whereas, the lowest (55.78 cm) was observed from N_0 treatment. It was revealed that increased plant height up to a certain level then decreases due to increasing the nitrogen fertilizer. The result was similar with that of Lal and Pundrik (1971), Damke *et al.* (1990) and Nicola *et al. (1995).* They observed an improvement on plant height with increasing nitrogen application.

Effect of various doses of phosphorus

The plant height of chili was statistically significant with various levels (30, 45, 60 and 75 DAT) of phosphorus (Appendix III, Table 2). The result revealed that at 30 DAT the tallest plant was recorded from P_2 (37.24 cm) which was statistically similar with P_1 (35.59 cm) whereas the shortest plant height was found from P_0 (32.39 cm). At 45 DAT the highest plant height (52.66 cm) was observed from the P_2 treatment which was statistically similar to P_1 (49.65 cm) whereas, the lowest (45.69 cm) was observed in P_0 treatment.

At 60 DAT the highest plant height (67 cm) was observed from the P_1 treatment which was statistically similar to P_2 (64.26 cm) whereas, the lowest (61.26 cm) was observed from P_0 treatment. At 75 DAT the highest plant height (79.45 cm) was observed from the P_2 treatment which was statistically similar with P_1 (75.02 cm) whereas the lowest (71.08 cm) was observed from P_0 treatment. It was revealed that increased plant height up to a certain level then decreases due to increasing the phosphorus fertilizer. It revealed that with the increase of application of phosphorus, plant height showed increasing trend, but after a certain level plant height increases very slowly. Similar results were found by Murugan *et al.* (2001) they reported that plant height increased with the increasing levels of nitrogen and also same for phosphorus application. Roy *et al.* (2011) also agreed with this result.

Table 2. The effect of different levels of nitrogen and phosphorous on plant height of chili

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
Levels of Nitrogen				
N_0	23.091 c	37.977 c	50.953 b	55.784 b
N_1	37.329 b	50.113 b	67.140 a	82.309 a
N_2	44.798 a	59.906 a	74.439 a	87.454 a
Levels of Phosphorus				
P_0	32.393 b	45.686 b	61.263 b	71.077 b
P_1	35.589 ab	49.653 ab	64.269 a	75.021 ab
P_2	37.236 a	52.657 a	67.000 a	79.450 a
LSD (0.01)	6.040	5.857	7.477	7.589
CV%	7.22%	4.98%	4.89%	4.23%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Combined effect of different levels of nitrogen and phosphorus showed significant variation on plant height of chili at 30, 45, 60 and 75 DAT (Appendix III, Table 3). At 30 DAT the tallest plant (47.57 cm) was observed from N_2P_2 which was statistically different from N_2P_1 (44.903 cm) whereas the shortest plant was recorded from N_0P_0 (20.667 cm). At 45 DAT the tallest plant (64.02 cm) was observed from N_2P_2 whereas the shortest plant was recorded from N_0P_0 (34.55 cm).

At 60 DAT the tallest plant was observed from N_2P_2 (77.04 cm) which was statistically similar with N_2P_1 (73.73 cm) whereas the shortest plant was recorded from N_0P_0 (48.38 cm) which was statistically similar to N_0P_1 (50.41 cm), N_0P_2 (54.07cm. At 75 DAT the tallest plant was observed from N_2P_2 (92.90 cm) which was statistically similar to N_2P_1 (86.82 cm) and N_1P_2 (85.82 cm) whereas the shortest plant was recorded from

N_0P_0 (52.29 cm) which was statistically similar to N_0P_1 (55.44 cm), N_0P_2 (59.63 cm. Similar results were found by Chauhan *et al.* (2005) They stated that among the various N and P combinations, 120 kg N + 60 kg P ha^{-1} recorded the greatest plant height (64.83 cm). Sarma *et al.* (2004) were also found similar results.

The type of organic matter used will have a large influence on the amount of nutrients available, substrate biological activity and therefore also plant growth and performance (Nagase and Dunnett 2011). But the breakdown of organic matter can result in nutrient leaching which often decreases as the roof ages (Czemiel Berndtsson, 2010) which reduce the growth and development of chili plant at a higher extent. But in agricultural field condition, the nutrient loss was lower than roof top garden. That's why physical growth (plant height) of plant in roof top garden is lower than normal field condition.

Table 3. The combined effect of different levels of nitrogen and phosphorous on plant height of chili

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
N_0P_0	20.667 g	34.550 g	48.380 f	52.287 e
N_0P_1	24.830 f	38.453 f	50.410 ef	55.440 de
N_0P_2	23.777 fg	40.927 f	54.070 e	59.627 d
N_1P_0	34.597 e	46.437 e	62.863 d	78.303 c
N_1P_1	37.033 de	50.877 d	68.663 c	82.803 bc
N_1P_2	40.357 cd	53.027 cd	69.893 bc	85.820 b
N_2P_0	41.917 bc	56.070 c	72.547 abc	82.640 bc
N_2P_1	44.903 ab	59.630 b	73.733 ab	86.820 b
N_2P_2	47.573 a	64.017 a	77.037 a	92.903 a
LSD (0.01)	3.487	3.382	4.317	4.381
CV%	7.22%	4.98%	4.89%	4.23%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

4.2 Number of leaves plant^{-1} of chili

Effect of various doses of nitrogen

Nitrogen fertilizer doses showed significant effect on number of leaves per plant of chili at 30, 45, 60 and 75 DAT (Appendix III, Table 4). At 30 DAT the highest number of leaves per plant (67.00) was observed from the N_2 treatment which was statistically different from N_1 (54.67) whereas the lowest (42.11) was observed from N_0 treatment. At 45 DAT the highest number of leaves per plant (103.11) was observed from the N_2 treatment whereas the lowest (54.89) was observed from N_0 treatment.

At 60 DAT the highest number of leaves per plant was observed from the N_2 (144.000) treatment whereas the lowest was observed from N_0 (84.333) treatment. At 75 DAT the highest number of leaves per plant was observed from the N_2 (182.44) treatment which was statistically different from N_1 (167.22) whereas the lowest was observed from N_0 (84.33) treatment. As data shown, N fertilization increased leaf number which were in agreement with findings of Ayodele (2002) and Boroujerdnia and Ansari (2007).

Effect of various doses of phosphorus

Number of leaves per plant of chili varied significantly for different levels (30, 45, 65 and 80 DAT) of phosphorus (Appendix III, Table 4). At 30 DAT the highest number of leaves (58.44) was recorded in P_2 which was statistically different from P_1 (54.44) whereas the lowest number of leaves were recorded from P_0 (50.89). At 45 DAT the highest number of leaves (87.00) was recorded in P_2 which was statistically similar to P_1 (83.44) whereas the lowest number of leaves was recorded from P_0 (79.89). At 60 DAT the highest number of leaves was recorded in P_1 (129.00) whereas the lowest number of leaves was recorded from P_0 (86.00). At 75 DAT the highest number of leaves (164.78) was recorded in P_2 whereas the lowest number of leaves was recorded from P_0 (157.44). The results showed significant variation in number of leaves per plant with increasing phosphorus in P_1 treatment up to P_2 treatment.

Table 4. The effect of different levels of nitrogen and phosphorous on number of leaves plant-1 of chili

Treatment	Number of Leaves Plant-1			
	30 DAT	45 DAT	60 DAT	75 DAT
Levels of Nitrogen				
N_0	42.111 c	54.889 c	84.333 c	135.444 c
N_1	54.667 b	92.333 b	129.667 b	167.222 b
N_2	67.000 a	103.111 a	144.000 a	182.444 a
Levels of Phosphorus				
P_0	50.889 c	79.889 b	86.000 b	157.444 a
P_1	54.444 b	83.444 ab	129.000 ab	162.889 a
P_2	58.444 a	87.000 a	121.333 a	164.778 a
LSD (0.01)	3.273	4.811	5.172	9.307
CV%	2.51%	2.42%	1.75%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus

Significant variation observed on nitrogen and phosphorus on number of leaves were at 30, 45, 60 and 75 DAT (Appendix III, Table 5). At 30 DAT N_2P_2 showed the maximum (70.33) number of leaves which was statistically different with N_2P_1 (66.67), N_2P_0 (64.00), N_1P_2 (59.67) while N_0P_0 treatment showed the minimum (39.00) number of leaves which was statistically different with N_0P_1 (42.00) treatment. At 45

DAT N_2P_2 showed the maximum (106.33) number of leaves while N_0P_0 condition showed the minimum (51.33) number of leaves which was statistically similar to N_0P_1 (55.00). At 60 DAT the maximum (153.67) number of leaves observed in N_2P_2 while N_0P_0 treatment showed the minimum (86.89) number of leaves. At 75 DAT N_2P_2 showed the maximum (187.67) number of leaves while N_0P_0 treatment showed the minimum (131.00) number of leaves which was statistically similar to N_0P_1 (136.33) and N_0P_2 (136.33). The results showed significant variation in interaction of nitrogen and phosphorus treatments. These results agree with Manchanda and Singh, (1988). They concluded that number of leaf per plant increased with increase fertilizer dose of nitrogen and phosphorus.

Table 5. The combined effect of different levels of nitrogen and phosphorous on number of leaves plant-^{1} of chili

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
N_0P_0	39.000 i	51.333 i	86.889 i	131.000 e
N_0P_1	42.000 h	55.000 h	87.000 h	136.333 de
N_0P_2	45.333 g	58.333 g	90.333 g	139.000 d
N_1P_0	49.667 f	88.333 f	131.000 f	165.000 c
N_1P_1	54.667 e	92.333 e	135.333 e	169.000 c
N_1P_2	59.667 d	96.333 d	140.333 d	167.667 c
N_2P_0	64.000 c	100.000 c	143.667 c	176.333 b
N_2P_1	66.667 b	103.000 b	149.000 b	183.333 a
N_2P_2	70.333 a	106.333 a	153.667 a	187.667 a
LSD (0.01)	3.89	2.78	2.99	5.37
CV%	2.51%	2.42%	1.75%	2.41%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.3 Leaf length (cm) of chili

Effect of various doses of nitrogen

Leaf length of chili was statistically influenced by different levels of nitrogen (Appendix IV, Table 6). The highest length of leaf (11.54 cm) was observed from N_2 while the shortest length of leaf (9.66 cm) was found from N_0 or control treatment. The increase in leaf area brought by the N supply causing expansion of individual leaves has also been reported by (Taylor *et al.* 1993, Gastal and Lemaire, 2002) because nitrogen stimulated the cell division and cell expansion (Lemaire, 2001).

Effect of various doses of phosphorus

Length of leaf of chili varied significantly for different levels of phosphorus (Appendix IV, Table 6). The highest length of leaf (11.09 cm) was observed from P_2 which was statistically identical to P_1 (10.88 cm) whereas the shortest length of leaf was recorded from P_0 (9.89 cm) or control condition. The beneficial effect of phosphorus on the leaf length has been reported by (Rao and Subramanian 1990) in cowpea (Reddy *et al.* 1991) in groundnut.

Table 6. The effect of different levels of nitrogen and phosphorous on leaf length (cm) of chili

Treatment	Leaf Length (cm)
Levels of Nitrogen	
N_0	9.662 b
N_1	11.663 a
N_2	11.540 a
Levels of Phosphorus	
P_0	9.896 b
P_1	10.880 a
P_2	11.090 a
LSD (0.01)	1.232
CV%	4.72%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Significant influence was observed on leaf length of chili due to application of different doses of nitrogen and phosphorus (Appendix IV, Table 7). The highest leaf length (11.913 cm) was obtained from N_2P_2 which were similar to N_2P_1, N_2P_0, and N_1P_1. In contrast to the lowest leaf length (9.55 cm) was observed from N_0P_0 or control condition.

Table 7. The combined effect of different levels of nitrogen and phosphorous on leaf length (cm) of chili

Treatment	Leaf Length (cm)
N_0P_0	9.550 b
N_0P_1	9.750 b
$N0P_2$	9.687 b
N_1P_0	11.777 a
N_1P_1	11.543 a
N_1P_2	11.670 a
N_2P_0	11.360 a
N_2P_1	11.347 a
N_2P_2	11.913 a
LSD (0.01)	0.7115
CV%	4.72%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.4 Leaf breath (cm) of chili

Effect of various doses of nitrogen

Leaf breadth of chili was statistically influenced by different doses of nitrogen (Appendix IV, Table 8). The highest leaf breadth (3.87 cm) was observed from N_2 which was statistically identical to N_1 (3.52 cm) while the shortest leaf breadth (3.00 cm) was found from N_0 or control condition. A critical observation of the data indicated that leaf breadth increased with increasing levels of nitrogen up to 100 kg/ha and then a decreasing trend was observed with increase in nitrogen levels (Gupta and Sangar, 2000).

Effect of various doses of phosphorus

Breadth of leaf of chili varied significantly for different levels of phosphorous (Appendix IV, Table 8). The highest leaf breadth (3.56 cm) was observed from P_2 which was statistically identical to P_1 (3.39 cm) whereas the shortest breath of leaf was recorded from P_0 (3.26 cm) or control condition. The report was supported by Chauhan *et al.* (2005). They reported that a linear increase was observed on leaf breadth with the increasing application of phosphorus up to 180 kg/ha.

Table 8. The effect of different levels of nitrogen and phosphorous on leaf breadth (cm) of chili

Treatment	Leaf Breadth (cm)
Levels of Nitrogen	
N_0	3.000 b
N_1	3.522 a
N_2	3.871 a
Levels of Phosphorus	
P_0	3.260 a
P_1	3.394 a
P_2	3.562 a
LSD (0.01)	1.232
CV%	4.09%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Significant influence was observed on leaf breath of chili due to application different doses of nitrogen and phosphorus ((Appendix IV, Table 9). The longest leaf breath (4.26 cm) was obtained from N_2P_2 which was statistically different with N_2P_1 (3.76

cm) and N_2P_0 (3.59 cm). In contrast to the lowest leaf breath (2.95 cm) was observed from N_0P_0 or control condition.

Table 9. The combined effect of different levels of nitrogen and phosphorous leaf breadth (cm) of chili

Treatment	Leaf Breadth (cm)
N_0P_0	2.953 f
N_0P_1	3.143 ef
N_0P_2	2.973 f
N_1P_0	3.233 e
N_1P_1	3.280 de
N_1P_2	3.453 cd
N_2P_0	3.593 bc
N_2P_1	3.760 b
N_2P_2	4.260 a
LSD (0.01)	0.1898
CV%	4.09%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.5 Number of branches plant-^{1} of chili

Effect of various doses of nitrogen

Number of branches of chili varied significantly for different levels of nitrogen (Table 10). The maximum number of branches (15.00) was observed from N_2 and the minimum number of branches was recorded from N_0 (7.00) or control condition. Nitrogen has a significant effect on number of branches per plant as it activates vegetative growth. These results agree with the findings of Manchanda and Singh

(1988). They concluded that branches per plant increase with the increasing nitrogen rate.

Effect of various doses of phosphorus

Number of branches of chili was significantly influenced by different doses of phosphorous (Appendix IV, Table 10). The maximum number of branches was observed from P_2 (12.22) which was statistically similar to P_1 (11.11) while the minimum number of branches was found from P_0 (8.45) or control condition. Phosphorus had a significant effect on number of branches per plant and increase with the increasing of phosphorus rate. Similar result was found by Tumbare and Bhoite, (2002).

Table 10. The effect of different levels of nitrogen and phosphorous on number of branches Plant-^{1} of chili

Treatment	Number of Branches Plant-^{1}
Levels of Nitrogen	
N_0	7.000 c
N_1	11.222 b
N_2	15.000 a
Levels of Phosphorus	
P_0	8.45 b
P_1	11.111 a
P_2	12.222 a
LSD (0.01)	3.51
CV%	9.50%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Significant influence was observed on number of branches of chili due to application of different doses of nitrogen and phosphorus fertilizer (Appendix IV, Table 11). The maximum number of branches (16.33) was obtained from N_2P_2 which was statistically identical to N_2P_1 (14.67). In contrast to the minimum number of branches (6.00) was observed from N_0P_0 or control condition which was statistically identical to N_0P_1 (7.00). These results showed that higher dose of nitrogen and phosphorus was influential nutrients for number of branches per plant. Similar result was found by Tumbare and Bhoite, (2002). In roof top garden, excessive nutrient and water loosed through leasing reduced the number of branches of chili plant.

Table 11. The combined effect of different levels of nitrogen and phosphorous on number of branches plant-^{1} of chili

Treatment	Number of Branches Plant-^{1} (cm)
N_0P_0	6.000 g
N_0P_1	7.000 fg
N_0P_2	8.000 f
N_1P_0	9.000 f
N_1P_1	11.333 cd
N_1P_2	12.333 c
N_2P_0	10.667 e
N_2P_1	15.000 ab
N_2P_2	16.333 a
LSD (0.01)	1.448
CV%	9.50%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.6 Fruit length (cm) of chili

Effect of various doses of nitrogen

Significant variation was observed among the different treatments due to application of different doses of nitrogen in respect of average fruit length of chili (Appendix V, Table 12). Fruit length was recorded 3.972 cm, 4.326 cm, 4.827 cm in N_0, N_1 and N_2 treatments, respectively. Maximum (4.827 cm) fruit length was found in N_2 treatment which was statistically different to N_1 (4.326 cm) treatment whereas minimum fruit length was recorded from N_0 (3.972 cm) or control treatment. The results are to some extent in agreement with Lal and Pundrik (1971) who observed an improvement in fruit size with increasing amount of nitrogen application.

Effect of various doses of phosphorus

Significant variation was found among the different treatments due to different doses of phosphorus in respect of fruit length of chili (Appendix V, Table 12). Average fruit length was recorded 4.457 cm, 4.392 cm, and 3.776 cm in P_2, P_1 and P_0 treatments, respectively. However, maximum (4.457 cm) fruit length was found in P_2 treatment whereas minimum fruit length was recorded in P_0 (3.776 cm).

Table 12. The effect of different levels of nitrogen and phosphorous on fruit length (cm) of chili

Treatment	Fruit Length (cm)
Levels of Nitrogen	
N_0	3.972 c
N_1	4.326 b
N_2	4.827 a
Levels of Phosphorus	
P_0	3.776 b
P_1	4.392 a
P_2	4.457 a
LSD (0.01)	0.272
CV%	2.62%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Combined effect of nitrogen and phosphorus doses showed significant variation on fruit length of chili (Appendix 5, Table 13). Maximum (4.99 cm) fruit length was recorded in N_2P_2 treatment whereas minimum (3.893 cm) fruit length was recorded in N0P0 or control treatment. These results are similar to that of Lal and Pundrik (1971) and Ludilov and Ludilova (1977). Lal and Pundrik (1971) who obtained the highest yield due to an improvement in fruit size in response to 80 kg N and 90 kg P.

Table 13. The combined effect of different levels of nitrogen and phosphorous on fruit length (cm) of chili

Treatment	Fruit Length (cm)
N_0P_0	3.893 e
N_0P_1	4.057 e
N_0P_2	3.967 e
N_1P_0	4.223 d
N_1P_1	4.340 cd
N_1P_2	4.413 c
N_2P_0	4.710 b
N_2P_1	4.780 b
N_2P_2	4.990 a
LSD (0.01)	0.1570
CV%	2.62%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.7 Fruit diameter (cm) of chili

Effect of various doses of nitrogen

Significant variation was observed among the different treatments due to different doses of nitrogen in respect of average fruit diameter of chili (Appendix V, Table 14). Fruit diameter was recorded 0.81, 0.70 and 0.67 cm in N_2, N_1 and N_0 treatments, respectively. Maximum (0.81 cm) fruit diameter was found in N_2 treatment which was statistically different to N_1 (0.70 cm) treatment whereas minimum fruit diameter was recorded in N_0 (0.67 cm) or control treatment. Roy *et al.* (2011) documented the similar report on fruit diameter of chili. According to them length and diameter of fruits and nos. fruits per plant increased significantly with increasing nitrogen dose at N_2 treatment (110 kg N ha-^{1}).

Effect of various doses of phosphorus

Significant variation was found on fruit diameter due to the effect of different levels of phosphorus in chili (Appendix V, Table 14). Fruit diameter was recorded 0.69, 0.73 and 0.76 cm in P_0, P_1, and P_2 treatments respectively. Maximum (0.75 cm) fruit diameter was found in P_2 treatment which was statistically similar to P_1 (0.73 cm) whereas minimum fruit diameter was recorded in P_0 (0.69 cm) or control treatment.

Table 14. The effect of different levels of nitrogen and phosphorous on fruit diameter (cm) of chili

Treatment	Fruit Diameter (cm)
Levels of Nitrogen	
N_0	0.673 b
N_1	0.697 b
N_2	0.712 a
Levels of Phosphorus	
P_0	0.689 a
P_1	0.726 a
P_2	0.751 a
LSD (0.01)	0.07541
CV%	5.65%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined effect of nitrogen and phosphorus

Combined effect of nitrogen and phosphorus doses showed significant variation on fruit diameter of chili (Appendix V, Table 15). Maximum (0.84 cm) fruit diameter was recorded in N_2P_2 treatment whereas minimum (0.66 cm) fruit diameter was recorded in N_0P_0.

Table 15. The combined effect of different levels of nitrogen and phosphorous on fruit diameter (cm) of chili

Treatment	Fruit Diameter (cm)
N_0P_0	0.657 d
N_0P_1	0.663 d
N_0P_2	0.700 cd
N_1P_0	0.673 cd
N_1P_1	0.703 cd
N_1P_2	0.713 c
N_2P_0	0.787 b
N_2P_1	0.810 ab
N_2P_2	0.840 a
LSD (0.01)	0.04354
CV%	5.29%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.8 Individual fruit weight (gm) of chili

Effect of various doses of nitrogen

There was a significant variation in single fruit weight among different doses of nitrogen treatments (Appendix V, Table 16). Individual fruit weight was recorded 1.270 gm, 1.714 gm and 1.912 gm in N_0, N_1 and N_2 treatments, respectively. The highest individual fruit weight (1.912 gm) was found in N_2 treatment whereas the lowest individual fruit weight was found in N_0 (1.27 gm) or control treatment. The result showed increase in nitrogen levels increases the fruit weight. The results also similar with Akanbi *et al.* (2007) who also reported that increasing the rate of nitrogen fertilizers increases the average fruit weight and volume of pepper. This result is also in agreement with Ahmed *et al.* (2007).

Effect of various doses of phosphorus

There was a significant variation in single fruit weight among different doses of phosphorus treatments (Appendix V, Table 16). Individual fruit weight was recorded 1.384, 1.62 and 1.692 gm in P_0, P_1 and P_2 treatments, respectively. The highest individual fruit weight (1.692 gm) was found in P_2 treatment whereas the lowest single fruit weight was found in P_0 (1.384 gm) or control treatment.

Table 16. The effect of different levels of nitrogen and phosphorous on individual fruit weight (gm) of chili

Treatment	Individual Fruit Weight (gm)
Levels of Nitrogen	
N_0	1.270 c
N_1	1.714 b
N_2	1.912 a
Levels of Phosphorus	
P_0	1.384 b
P_1	1.620 a
P_2	1.692 a
LSD (0.01)	0.1306
CV%	3.28%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus

Combined effect of nitrogen and phosphorus doses showed significant variation on single fruit weight (Appendix V, Table 17). The highest single fruit weight (2.02) was found in N_2P_2 treatment whereas the lowest single fruit weight was found in N_0P_0 (1.24) or control treatment.

Table 17. The combined effect of different levels of nitrogen and phosphorous on individual fruit weight (gm) of chili

Treatment	Individual Fruit Weight (g)
N_0P_0	1.240 e
N_0P_1	1.267 e
N_0P_2	1.303 e
N_1P_0	1.670 d
N_1P_1	1.720 cd
N_1P_2	1.753 c
N_2P_0	1.843 b
N_2P_1	1.873 b
N_2P_2	2.020 a
LSD (0.01)	0.07541
CV%	3.28%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

4.9 Yield per plant (gm) of chili

Effect of various doses of nitrogen

There was a significant variation on number of fruits per plant among different treatments (Appendix V, Table 18). The highest number of fruits per plant was found in N_2 (195.33) treatment whereas the lowest number of fruits per plant was found in N_0 (114.22) or control treatment. It was revealed that at optimum level nitrogen fertilizer gave the highest yield plant-^{1}, further increase of nitrogen fertilization delayed flowering. Guohua *et al*. (2001) found that flowering was delayed with increase in nitrogen fertilization due to diversion of photosynthetic for vegetative growth of plant. Shrivastava (2003) also found similar results.

Effect of various doses of phosphorus

Significant variation was found among the different treatments due to different doses of phosphorus in respect of number of fruits per plant (Appendix V, Table 18). The highest number of fruits per plant was found in P_2 (164.78) treatment whereas the lowest number of fruits per plant was found in P_0 (136.89) or control treatment. Bahuguna *et al.* (2014) also found an increase in fruits increasing per plant with the increasing levels of phosphorus and the maximum number at P_2 levels in pea.

Table 18. The effect of different levels of nitrogen and phosphorous on yield per plant (gm) of chili

Treatment	Yield Plant-^{1} (gm)
Levels of Nitrogen	
N_0	114.222 c
N_1	172.667 b
N_2	195.333 a
Levels of Phosphorus	
P_0	136.889 b
P_1	160.556 ab
P_2	164.778 a
LSD (0.01)	0.1306
CV%	3.28%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Combined Effect of nitrogen and phosphorus

Combined effect of nitrogen and phosphorus doses showed significant variation on number of fruits per plant (Appendix V, Table 19). The highest number of fruits per plant (200.00) was found in N_2P_2 treatment whereas the lowest (111.00) number of fruit per plant was found in N_0P_0. The high yield will obtain due to high nitrogen and phosphorus rate. These results agree with the findings of Manchanda and Singh, (1988) and Nicola *et al.* (1995) who obtained the maximum fruits per plant at higher rate of nitrogen and phosphorus.

Table 19. The combined effect of different levels of nitrogen and phosphorous on yield plant-^{1} (gm) of chili

Treatment	Yield Plant-^{1} (gm)
N_0P_0	111.000 h
N_0P_1	114.333 g
N_0P_2	117.333 f
N_1P_0	168.000 e
N_1P_1	173.000 d
N_1P_2	177.000 c
N_2P_0	191.667 b
N_2P_1	194.333 b
N_2P_2	200.000 a
LSD (0.01)	2.878
CV%	2.41%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.10 Fruit yield plot^{-1} (kg) of chili

Effect of various doses of nitrogen

Yield of green fresh fruit of chili was recorded 0.458, 0.698 and 0.786 kg/plot in N_0, N_1 and N_2 treatments, respectively (Appendix V, Table 20). Maximum (0.786 kg/plot) yield was obtained in N_2 treatment and minimum (0.458 kg/plot) was found in N_0 treatment or control treatment. Nitrogen fertilization significantly increased fruit number, yield per plant and total yield comparing to control, that were in agreement with Tumbare and Niikam (2004), Law-Ogbomo and Egharevba (2009). Jilani *et al.* (2008) reported that nitrogen application at the rate of 100 kg ha^{-1} significantly increased brinjal yield. Likewise, Bahuguna *et al.* (2014) also observed the same results in pea.

Effect of various doses of phosphorus

Yield of fruits of chili was recorded 0.440, 0.647 and 0.665 kg/plot in P_0, P_1 and P_2 treatments, respectively (Appendix V, Table 20). Maximum (0.665 kg/plot) yield was obtained in P_2 treatment and minimum (0.44 kg/plot) was found in P_0 treatment or control treatment.

Table 20. The effect of different levels of nitrogen and phosphorous on yield per plot (kg) of chili

Treatment	Yield Plot-1 (kg)
Levels of Nitrogen	
N_0	0.458 c
N_1	0.698 b
N_2	0.786 a
Levels of Phosphorus	
P_0	0.440 b
P_1	0.647 a
P_2	0.665 a
LSD (0.01)	0.1847
CV%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus

Significant influence was observed on yield of chili per plot due to the combined effect of nitrogen and phosphorus (Appendix V, Table 21). The maximum yield 0.807 kg/plot was obtained from N_2P_2. In contrast to the minimum yield (0.328 kg/plot) was observed from N_0P_0 or control condition. The result were similar with that of Lal and Pundrik (1971) and Ludilov and Ludilova, (1977). Lal and Pundrik, (1971) obtained the highest yield due to an improvement in fruit size in response to 100 kg N, 80 kg P (N_2P_2). It means that recommended fertilization will may affect the fruit size and other growth parameter as well.

Table 21. The combined effect of different levels of nitrogen and phosphorous on yield plot-[1] (kg) of chili

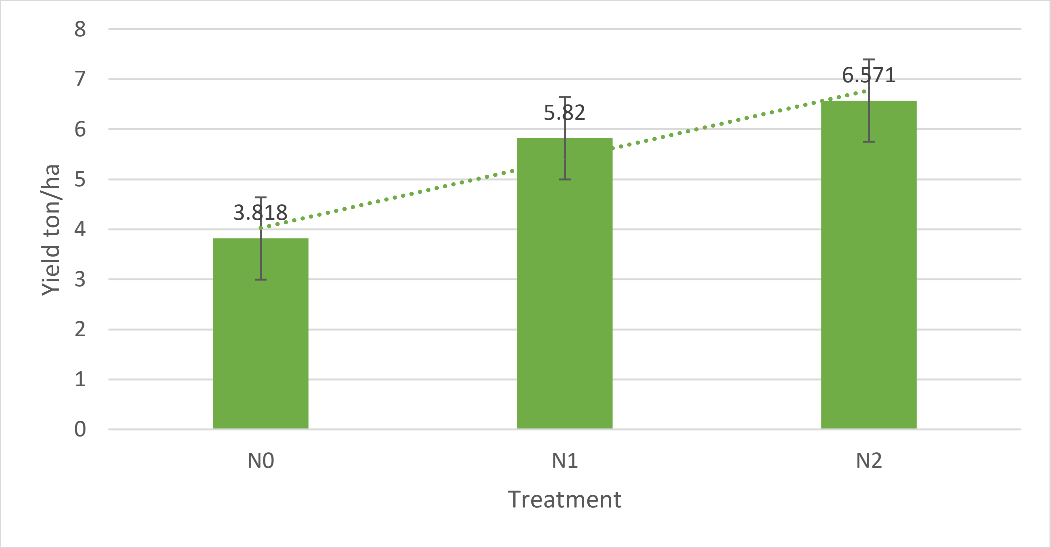
Treatment	Yield Plot-[1] (kg)
N_0P_0	0.328 h
N_0P_1	0.450 g
N_0P_2	0.473 f
N_1P_0	0.680 e
N_1P_1	0.700 d
N_1P_2	0.714 c
N_2P_0	0.770 b
N_2P_1	0.780 b
N_2P_2	0.807 a
LSD (0.01)	2.878
CV%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}
P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

4.11 Fruit yield ha-[1] (ton) of chili

Effect of various doses of nitrogen

Yield of green fresh fruit of chili was recorded 3.82, 5.82 and 6.57 ton/ha in N_0, N_1 and N_2 treatments respectively (Appendix V, Figure 3). Maximum (6.57 ton/ha) yield was obtained in N_2 treatment and minimum (3.82 ton/ha) was found in N_0 treatment or control treatment. Nitrogen fertilization improved plant growth, but did not influence fruiting time. Jilani *et al.* (2008) reported that nitrogen application at the rate 110-130 kg ha^{-1} significantly increased brinjal yield. In pea, Bahuguna *et al.* (2013) also found the same results.

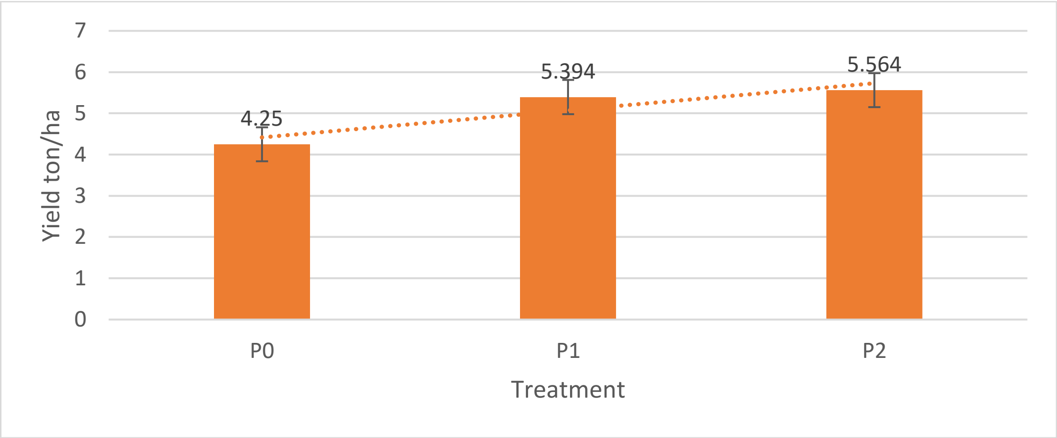


Here, N_0: 0 kg N ha-[1] (control); N_1: 100 kg N ha-[1]; N_2: 130 kg N ha-[1]

Figure 2: Effect of nitrogen on fruit yield (ton ha-^{1}) of chili

Effect of various doses of phosphorus

Yield of fruits of chili was recorded 4.25, 5.39 and 5.56 ton/ha in P_0, P_1 and P_2 treatments respectively (Appendix V, Figure 4). Maximum (5.564 ton/ha) yield was obtained in P_2 treatment and minimum (4.25 ton/ha) was found in P_0 treatment or control treatment.



Here, P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

Figure 3: Effect of phosphorus on fruit yield (ton ha-^{1}) of chili

Combined effect of nitrogen and phosphorus

Significant influence was observed on yield of chili per plot due to application of different doses of nitrogen and phosphorus (Appendix V, Table 22). The maximum yield 6.79 ton/ha was obtained from N_2P_2. In contrast to the minimum (2.67 ton/ha) was observed from N_0P_0 or control condition. These results are in accordance with the findings of Tesfaw (2013) who assessed the growth and yield performance of hot pepper varieties to various doses of nitrogen and phosphorous. Naeem *et al.* (2002) reported that different dozes of nitrogen and phosphorus behaved significantly different for total yield.

Besides the sun beating down on the roof, there is ambient heat being reflected from the roof surface, surrounding buildings, streetcars and metal exhaust and utility structures (Awal *et al*. 2010). The higher temperature greatly reduced the yield of chili because of the lack of moisture content in soil. But in agricultural field condition, the frequently irrigation facilitate to maintain the moisture content as well as maintain the soil temperature which increase the yield performance of chili.

Table 22. The combined effect of different levels of nitrogen and phosphorous on yield ha-^{1} (ton) of chili

Treatment	Yield ha-^{1} (ton)
N_0P_0	2.667 h
N_0P_1	3.833 g
N_0P_2	4.025 f
N_1P_0	5.667 e
N_1P_1	5.840 d
N_1P_2	5.953 c
N_2P_0	6.417 b
N_2P_1	6.510 b
N_2P_2	6.787 a
LSD (0.01)	2.878
CV%	2.41%

Here, N_0: 0 kg N ha-^{1} (control); N_1: 100 kg N ha-^{1}; N_2: 130 kg N ha-^{1}

P_0: 0 kg P_2O_5 ha-^{1} (control); P_1: 50 kg P_2O_5 ha-^{1}; P_2: 80 kg P_2O_5 ha-^{1}

4.12 Comparison of total yield of chili in rooftop garden to agricultural field

Chili, an important spice crop of Bangladesh is widely grown both in winter and summer seasons. Area under chili cultivation was 93.55 thousand hectares producing about 102.25 thousand tons in the year 2015-16 (BBS 2015). For BARI MORISH-1, average yield should be gained around 10-12 ton/ha. In field condition For BARI Morish-3, the average production is around 8-10 ton/ha and the average plant height is around 75-85 cm (Krishi Projockti Hathboi-7th edition-2017).

But in the roof top garden, the highest yield obtained from N_2P_2 treatment which is 6.787 ton/ha and the lower production obtained from N_0P_0 treatment which is around

2.67 ton/ha. In field condition the average yield is around 8-10 ton but in rooftop garden the average yield production is very attractive.

Table 23. Comparison of the morphological feature and yield of chili in agricultural field to the rooftop for BARI Morish-3

Feature	Agricultural field	Rooftop garden
1. Plant height (cm)	70-80	55-92
2. Number of branch^{-1} plant	15-20	10-12
3. Number of fruit per plant	300-400	150-200
4. Yield (ton)	8-10	5-7

Source: Krishi Projockti Hathboi-7th edition-2017

Average highest soil temperature (32.98 ^{0} C) was recorded from N_0P_0 treatment which create negative effect on chili production. The lowest soil temperature was recorded from N_2P_1 treatment (27.12 ^{0} C) which increase chili yield. The highest moisture was recorded 34.44 N_2P_0 and the lowest moisture was recorded 28.09 % in N_0P_0 (control) treatment. The highest light intensity was observed (34.59 klux) from N_1P_2 treatment whereas the lowest light intensity was recorded (30.79 klux) from N_0P_1 treatment. Due to the lack of soil moisture and light availability the yield of chili in roof top garden were lower than field condition. Temperature also play a significant role in rooftop farming. In roof top garden, the temperature always higher than normal field condition which was greatly influence on morphology and yield of chili. Wind can whip down straight urban streets, especially on high-rises. That's why flower and fruit dropped at a high extent than normal field condition and the fruit number greatly reduced by the interaction of high wind.

4.13 Light availability on chili Crop

Light availability play a significant role in chili production. Light availability on the chili plant on plots was measured at 20 days interval over the growing season (Table 24). The highest light intensity was observed (34.59 klux) from N_1P_2 which was statistically similar with N_2P_1 treatment. The lowest light intensity was recorded (30.79 klux) from N_0P_1 treatment which was also statistically similar with N_0P_0 treatment.

4.14 Soil moisture in chili field

The soil moisture (%) availability over the time (days after measurement) in chili field was recorded (Table 24). At the initial stage of chili growing season, soil moisture was higher but gradually decreased with increasing day after measurement. The highest moisture was recorded 34.44 N_2P_0 and the lowest moisture was recorded 28.09 % in N_0P_0 (control) treatment.

4.15 Soil temperature in chili field

Soil temperature (^{0}C) was recorded from various treatment at 10 days interval in chili field and significant variation was found ((Table 24). In general, soil temperature was increased in bare soil. The highest soil temperature (32.98 ^{0} C) was recorded from N_0P_0 treatment. However the lowest soil temperature was recorded from N_2P_1 treatment (27.12 ^{0} C). It was noticed that lower soil temperature helped to increased higher soil moisture which helped to increase chili yield.

Table 24. Availability of light intensity, soil moisture and soil temperature on chili field

Treatment	Light Intensity	Soil Moisture	Soil Temperature
N_0P_0	31.43 ^{e}	28.09 f	32.98 a
N_0P_1	30.79 ^{e}	29.77 cd	31.66 b
N_0P_2	32.87 ^{c}	29.04 e	30.76 c
N_1P_0	31.38 ^{cd}	29.89 cd	30.43 c
N_1P_1	32.21 ^{c}	30.96 cd	29.72 d
N_1P_2	34.59 ^{a}	31.57 c	28.23 e
N_2P_0	33.03 ^{ab}	34.44 a	27.58 ef
N_2P_1	34.14 ^{a}	33.03 b	27.12 ef
N_2P_2	33.54 ^{ab}	33.05 b	28.03 ef
CV%	6.42%	4.98%	3.91%

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The experiment was conducted at the roof of third floor of Biotechnology department of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2016 to March, 2017. The experiment consisted of two factors. Factor A: Nitrogen (3 levels) N_0: 0 kg/ha (Control); N_1: 100 kg/ha and N_2: 130 kg/ha; Factor B: Plant spacing (3 levels), P_0: 0 kg/ha (Control), P_1: 50 kg/ha; P_2: 80 kg/ha. The experiment was laid out in Complete Randomized Design (CRD) with three replications. Data on different yield contributing characters and yield at different days after transplanting (DAT) were recorded.

Nitrogenous effect was considered significant under the present study. On the growth parameters; plant height, number of leaves/plant and leaf breadth were the highest with higher nitrogen doses at 130 kg/ha (N_2) in rooftop garden. At 30, 45, 60 and 75 DAT the tallest plant (44.79, 59.91, 74.44 and 87.45 cm, respectively), maximum number of leaves/plant (67.00, 103.11, 144.00 and 182.44, respectively) and the highest leaf breadth (3.87 cm) found from N_2 (130 kg/ha) treatment. The highest leaf length (11.663 cm) found from N_1 (100 kg/ha) treatment. But At 30, 45, 60 and 75 DAT the shortest plant (23.09, 37.98, 50.95 and 55.78 cm, respectively), minimum number of leaves/plant (42.11, 54.89, 84.33 and 135.44, respectively), the lowest leaf length (9.66 cm) and the lowest leaf breadth (3.00 cm) were recorded from control treatment (N_0). Yield parameters were also significantly influenced by different doses of nitrogen application. The yield contributing characters remarked as fruit length, fruit diameter, individual fruit weight, yield/plat, yield/plot and yield/ha were also higher with the higher nitrogen doses. The highest fruit length (4.83 cm), highest fruit diameter (0.81), highest individual fruit weight (1.91 gm), highest yield per plant (195.33 gm), highest yield per plot (0.79 kg) and highest yield per hectare (6.57 ton) was found from N_2 treatment.

Phosphorus effect was considered significant under the present study. On the growth parameters; the plant height, number of leaves/plant and leaf breadth were highest with higher nitrogen doses at 80 kg/ha (P_2). At 30, 45, 60 and 75 DAT the tallest plant (37.24, 52.66, 67 and 79.45 cm, respectively), maximum number of leaves/plant (58.44, 87.00, 121.33 and 164.78 cm respectively) the highest leaf breadth (3.87 cm), the highest leaf length (11.09 cm) found from P_2 (80 kg/ha) treatment. But At 30, 45, 60 and 75 DAT the shortest plant (32.39, 45.65, 61.26 and 71.08 cm, respectively), minimum number of leaves/plant (50.89, 79.89, 86.00 and 157.44, respectively), the lowest leaf length (10.89 cm) and the lowest leaf breadth (3.26 cm) were recorded from control treatment (P_0). The yield contributing characters remarked as fruit length, fruit diameter, individual fruit weight, yield/plat, yield/plot and yield/ha were also higher with higher nitrogen doses. The highest fruit length (4.46 cm), highest fruit diameter (0.75), highest individual fruit weight (1.69 gm), highest yield per plant (164.78 gm), highest yield per plot (0.67 kg) and the highest yield per hectare (5.56 ton) was found from P_2 treatment.

Interaction of nitrogen and phosphorus had significant effect on growth, yield and yield contributing characters of chili crop. Results showed at 30, 45, 60 and 75 DAT the tallest plant (47.57, 64.02, 77.04 and 92.90 cm, respectively), maximum number of leaves/plant (70.33, 106.33, 153.67 and 187.67, respectively) and the highest leaf breadth (4.26 cm), highest leaf length (11.91 cm) found from N_2P_2 (100 kg N/ha and

80 kg P/ha) treatment. But At 30, 45, 60 and 75 DAT the shortest plant (23.09, 37.98, 50.95 and 55.78 cm, respectively), minimum number of leaves/plant (39.00, 51.33, 86.89 and 131.00, respectively), the lowest leaf length (9.55 cm) and the lowest leaf breadth (2.96 cm) were recorded from control treatment (N_0P_0). The yield contributing characters remarked as fruit Length, fruit diameter, individual fruit weight, yield/plat, yield/plot and yield/ha were also higher with the higher nitrogen doses. The highest fruit length (4.99 cm), highest fruit diameter (0.84), highest individual fruit weight (2.20 gm), highest yield per plant (200 gm), highest yield per plot (0.81 kg) and the highest yield per hectare (6.79 ton) was found from N_2P_2 combination. But the lowest fruit length (3.89 cm), fruit diameter (0.66 cm), individual fruit weight (1.24 gm), yield per plant (111.00), yield per plot (0.33 kg), yield per hectare (2.67 ton) observed from N_0P_0 combination.

5.2 Conclusion

Considering the above mentioned results, it may be concluded that, different doses of nitrogen and phosphorus varied significantly for growth and yield of chili.

1. The yield components and yield of chili were positively influenced by the application of nitrogen and phosphorus on rooftop garden.
2. It was revealed that application of 130 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1} (N_2P_2) produce maximum yield and yield contributing characters of chili in the rooftop garden.
3. It can be suggest that growth and yield of chili may be increased by using nitrogen and phosphorus which create favorable climatic condition in soil environment at the roof top garden.

5.3 Recommendation

The following recommendations were made for undertaking further research.

1. Another higher level of nitrogen and phosphorus may be included for precise result.
2. Similar research work should be conducted by the researchers in wide range with variety of crops.
3. Encourage and motivate the city dwellers about the beneficial effect of roof top farming.

CHAPTER VI

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APPENDICES

Appendix I. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
Soil type	Deep red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	28
Sily	45
Clay	27
Textural class	Silty clay
Chemical characteristics	
Soil characters	Value
pH	5.8
Organic carbon (%)	0.48
Organic matter (%)	0.76
Total nitrogen (%)	0.03
Available P (ppm)	21.54
Exchangeable K (me/100 g soil)	0.10

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix II. Monthly meteorological information during the period from October, 2016 to March, 2017

Year	Month	Air Temperature (^{0} c)		Relative Humidity (%)	Total Rainfall (mm)
		Maximum	Minimum		
2016	October	30.45	22.34	60	54
	November	28.10	18.76	69	43
	December	26.76	13.89	71	0
2017	January	25.32	11.78	67	0
	February	27.65	18.45	71	36
	March	31.70	22.23	61	28

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix III: Analysis of variance for morphological parameters of chili

Source of variation	Degree of freedom	Mean Sum of Square (MSS)							
		Plant Height at different days after transplanting (cm)				Number of leaves at different days after transplanting			
		30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
Nitrogen (A)	2	2189.034*	2172.19**	2600.56*	5199.04**	2787.630*	11530.89**	19120.519*	10351.63**
Phosphorus (B)	2	109.111*	220.079**	148.205*	315.859**	257.185*	227.556**	346.741*	260.963**
A×B	4	17.211 NS	4.766 NS	18.742 NS	11.154 NS	13.704 NS	2.222 NS	7.926 NS	59.704 NS
Error	16	102.618	96.506	157.299	162.021	30.148	65.111	75.259	243.704
CV		7.22%	4.98%	4.89%	4.23%	2.51%	2.42%	1.75%	2.41%

****= Significant at 1% level, *= Significant at 1% level, NS= Non Significant**

CV= Coefficient of Variation

Appendix IV: Analysis of variance for morphological parameters of chili

Source of variation	Degree of freedom	Mean Sum of Square (MSS)		
		Leaf Length (cm)	Leaf Breath (cm)	Number of Branches Plant-^{1} (cm)
Nitrogen (A)	2	22.637**	3.328*	288.296**
Phosphorus (B)	2	0.246**	0.413*	24.519**
A×B	4	0.526 NS	0.456 NS	0.370 NS
Error	16	4.279	0.310	17.704
CV		4.72%	4.09%	9.50%

****= Significant at 1% level, *= Significant at 1% level, NS= Non Significant**

CV= Coefficient of Variation

Appendix V: Analysis of variance for yield contributing parameters of chili

Source of variation	Degree of freedom	Mean Sum of Square (MSS)					
		Fruit Length (cm)	Fruit Diameter (cm)	Individual Fruit Weight (g)	Yield Plant-[1] (gm)	Yield Plot-[1] (kg)	Yield ha-[1] (ton)
Nitrogen (A)	2	3.318**	0.100**	1.947*	31525.630**	0.518**	36.462**
Phosphorus (B)	2	0.152*	0.009**	0.054*	280.519**	0.005**	0.446**
A×B	4	0.071 NS	0.001 NS	0.016 NS	10.370 NS	0.000 NS	0.026 NS
Error	16	0.211	0.024	0.046	69.926	0.001	0.093
CV		2.62%	5.65%	3.28%	3.28%	2.41%	2.41%

****= Significant at 1% level, *= Significant at 1% level, NS= Non Significant**

CV= Coefficient of Variation

Appendix VI: Some photographs related to the study

Plate 1: Structure of the rooftop garden

Plate 2: Transplanting of seedling

 

Plate 3: Vegetative growth stage

Plate 4: Flowering stage

Plate 5: Fruiting stage

Plate 6: Harvesting time