INFLUENCE OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF CHILLI

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CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF CHILLI"*** *submitted to the* ***DEPARTMENT OF HORTICULTURE****, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.) in HORTICULTURE,*** *embodies the results of a piece of bona fide research work carried out by* ***MD. RIZVI ISLAM****, Registration. No. 09-03668, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.*

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

Dated: June, 2015

Dhaka, Bangladesh

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TO

MY BELOVED PARENTS

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ABSTRACT

A field experiment was carried out during the period from November 2013 to May 2014 at Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to investigate the influence of nitrogen and phosphorus on growth and yield of chilli. The two factorial experiment were laid out in Randomized Complete Block Design with three replications. Four levels of nitrogen N_0: 0 kg N ha^{-1}, N_1: 100 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 140 kg N ha^{-1} and three levels of phosphorous P_0: 0 kg P_2O_5 ha^{-1}, P_1: 30 kg P_2O_5 ha^{-1}, P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 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 gave the highest plant height (cm) and most of the growth parameters increased with increasing nitrogen levels up to N_3. The dose of P_2 gave the highest plant height (cm) and most of the growth parameters increased with increasing phosphorus levels up to P_3. The treatment combination N_3 and P_3 gave the highest plant canopy (33.25 cm), fruit diameter (0.95 cm), fruit pedicel (2.87 cm), fruit length (5.60 cm), yield of fruits $plant^{-1}$ (235.00 g), average fruit yield $plot^{-1}$ (3.39 kg), individual fruit weight (2.52 g) and average fruit yield (12.32 t ha^{-1}). Based on the present results, it can be suggested that the combined use of 140 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1} increased plant growth and fruit yield of chilli.

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LIST OF ABBREVIATIONS

%	=	Percent
@	=	At the rate of
°C	=	Degree Celsius
AEZ	=	Agro Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
cv.	=	Cultivar (s)
DAT	=	Days After Transplanting
DMRT	=	Duncan’s Multiple Range Test
EC	=	Emulsifiable Concentrate
et al.	=	And Others
FAO	=	Food and Agriculture Organization
kg	=	Kilogram
g	=	Gram
LSD	=	Least Significant Difference
MOP		Muriate of Potash
ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
t/ha	=	Ton per Hectare
Tk./ha	=	Taka per Hectare
N	=	Nitrogen
TSP	=	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Chilli (*Capsicum frutescens*) is an important spice belongs to the family Solanaceae. The genus *Capsicum* contains about 20 species and now five domesticated species *Capsicum annum*, *Capsicum frutescens*, *Capsicum chinense*, *Capsicum baccatum*, *Capsicum pubescens* are only recognized. Pepper cultivars of *Capsicum frutescens* can be annual or short-lived perennial plants. Capsicum has different color-range from green to yellow, red, orange, purple and black. Other capsicum include the red, heart-shaped; the pale green, slender and curved bull's horn which range in color from yellow to red and sweet banana pepper which is yellow and banana shaped (Teshm Tadesse Michael *et al*.,1999). The chilli is a plant of tropical and sub-tropical region. Tropical south America especially Brazil is thought to be the original home of pepper (Shoemaker and Teskey, 1995).

Chilli grows well in warm and humid climate. Deep, loamy, fertile soils rich in organic matter are preferred by the crop for satisfactory growth. Also need well drained soils with adequate soil moisture for the growth of the crop. It grows well in the dry and the intermediate part of the country. Bangladesh by birth possesses very fertile land in which diversified crops grow very easily. Various types of crops are produced in this country. Capsicum is considered as a minor vegetable crop in Bangladesh and its production statistics is not available (Hasanuzzaman, 1999). Chilli is a valuable spice and also one of the most important cash crops grown in Bangladesh. It is available and used in the form of green, dried and powdered. It has become an essential ingredient in Bangladeshi meals. Red chillies contain large amounts of vitamin-C and small amounts of carotene (provitamin-A). Green chillies (unripe fruit) contain a considerably lower amount of both substances. In addition, peppers are a good source of most vitamin-B and vitamin-B6 in particular. They are very high in potassium, magnesium and iron. Chilli is the most essential and important spices crops in Bangladesh. A total of 434757 acres of land are under chilli crop cultivation in Bangladesh. The production of chilli largely depends on the use of fertilizers, irrigation, pesticide etc. The yield of chillies depends on adequate supply of the essential nutrients (Alabi, 2006) and (Peck and MacDonald, 1975). In absence of other production constraints, nutrient uptake and yield are very closely related.

The profit from the use of commercial fertilizer has been so often demonstrated by experiment that there is no doubt about the necessity of using the right fertilizer and the economic returns resulting from them. The optimum proportion of fertilizer enhances the growth and development of a crop as well as ensures the availability of other essential nutrients for the plant. Use of inorganic and organic fertilizers has amused a great significance in recent years in vegetables production, for two reasons. Firstly, the need for continued increase production and per hectare yield of vegetables requires the increase amount of nutrients. Secondly, the results of a large number of experiments on inorganic and organic fertilizers conducted in several countries reveal that inorganic fertilizer alone cannot sustain the productivity of soils under highly intensive cropping systems (Singh, 2004). Fertilizer rates influenced capsaicin content and colour of powdered pepper (Yodpetch, 1997). The mineral nutrients, N, P and K are known to affect growth and yield of the capsicums. Nitrogen progressively increases the marketable yield (Obreza and Vavrina). In Bangladesh, urea is mostly used as the source of Nitrogen and split application of this fertilizer is commonly practiced (Hossain, 1990). On the other hand nutrient availability in a soil depends on some factors. Growth, development and yield of chilli depends on various factors among them balanced fertilizer is important one. Crop variety is another important factor for the increase the production of chilli. Many researchers reported that different varieties of crop have different effect for the reducing higher rate of flower/ fruit dropping and fruit setting condition as well as the marketable yieldof chilli. Different varieties respond to differential cultivation practices and prevailing environmental condition during growing season. Generally large amount of nitrogen is required for the production of vegetable (Opena *et al.*, 1988). It is also the most essential element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Anon., 1972).

Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll (Devlin, 1972). Nitrogen is essential for building up protoplasm and protein, which induce cell division and initial meristematic activity when applied in optimum quantity (Singh and Kumar, 1969). Adequate nitrogen increases the quality, fruit size, keeping quality, color and taste (Shukla and Nair, 1993). Nitrogen influences flower development of several vegetable crops including pepper, tomato and cucumber (Kinet *et al* 1985). According to Bhatnagar and Panditu (1981), increase in nitrogen levels and spacing resulted in the production of quality fruits. Adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Yoshizawa *et al*., 1981). Excessive application of nitrogen on the other hand is not only uneconomical but also induces physiological disorder and pollutes the environment.

Phosphorus is also one of the important macro essential element for normal growth and development of plant Phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). The effect of phosphorus on the formation and translocation of carbohydrates, roots development, nodulation, growth and other agronomic characters are well recognized. Phosphorus induces earliness in flowering and fruiting including seed formation (Buckman and Brady, 1980). Again secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Santos *et al*., 2004).To attain considerable production and quality yield for any crops it is necessary to proper management including ensuring the availability of essential nutrient components in proper doses.

Considering the importance of chilli cultivation, the present research work has been undertaken with the following objectives:

1. To study the effect of nitrogen and phosphorus fertilizers on growth and yield of chilli cv. BARI Morich-1.

2. To determine the optimum doses of nitrogen and phosphorus fertilizers on growth and yield of chilli cv. BARI Morich-1.

CHAPTER II

REVIEW OF LITERATURE

Chilli (*Capsicum frutescence*) is one of the popular solanaceous crop cultivated in Bangladesh. Very few research works have been done for the improvement of this crop in Bangladesh and other countries of the world. Nitrogen and phosphorus are important fertilizers, which were reported to enhance the growth, yield and yield contributing characters of some crops. However, available literature related to the present study on chilli has been reviewed and presented in this section under the following.

Naeem *et al*. (2002) was conducted an experiment the effect of different levels of nitrogen (0, 30,60,90 kg ha^{-1}) and phosphorus (0, 30, 60 kg ha^{-1}) with a constant dose of potash (30 kg ha^{-1}) on the growth and yield of chilli cultivar Sanam. Minimum days to flowering (42 days) and days to flowering (54 days) were recorded in plots fertilized with (30-60-30 kg NPK ha^{-1}) and (30-30-30 kg NPK ha^{-1}) respectively. Maximum number of brunches per plant (10.00), plant height (98.27 cm), number of fruits per plant (51.73) and total yield (7679.66 kg ha^{-1}) was recorded in plots fertilized with 90-60-30 kg NPK ha^{-1}. However maximum number of fruits was recorded at fertilized level of 60-30-30 kg NPK ha^{-1}. It is suggested that chilli cv. Sanam should be fertilized with 90-60-30 kg NPK ha^{-1} under the agronomic conditions of Peshawar.

Singegol *et al*. (2007) conducted a field experiment to know the effect of nitrogen and phosphorus on growth and yield of green chilli (*Capsicum annuum* L.) cv. Pusa Jwala during kharif season. The experiment was laid out in a factorial randomized block design with four levels of 0, 50, 100 and 150 kg nitrogen and four levels of 0, 25, 50 and 75 kg phosphorus per ha in combination. Among nitrogen levels studied, 150 kg per ha was significantly better with respect to growth characters like plant height, plant spread, number of primary and secondary branches per plant as well as yield attributing characters like number of fruits per plant and average fruit weight. Similar was the response of most of characters to higher phosphorus (75 kg/ha) resulting in higher yield. Uptake of nitrogen, phosphorus and potassium was significantly higher with higher level of nitrogen and phosphorus.

Khan *et al*. (2010) conducted an experiment to study the effects of nitrogen and phosphorus on the growth and yield of capsicum. The treatments were 4 levels of N (0, 50, 100 & 150 kg ha^{-1} designated as N_0, N_{50}, N_{100} & N_{150} respectively) and 3 levels of P (0, 30 & 60 kg ha^{-1} designated as P_0, P_{30} & P_{6000} respectively). Plant height, number of branches and number of fruits per plant at first flowering increased significantly with increasing nitrogen doses up to 100 kg N ha^{-1}. However, plant height and number of branches at final harvest increased significantly up to 150 kg N ha^{-1} (N_3 treatment). On the other hand plant height at first flowering and number of branches at first harvest increased significantly with increasing levels of P up to the treatment P1 (30 kg P ha^{-1}), whereas plant height and number of branches at final harvest and number fruits per plant enhanced significantly up to the treatment P_2 (60 kg P ha^{-1}). Considering the combined effect of nitrogen and phosphorus, the maximum plant height at final harvest were obtained from N_2P_2 (100 kg N + 60 kg P ha^{-1}). On the other hand, maximum number of fruits per plant was found in the treatment combination N_3P_1 (150 kg N + 30 kg P ha^{-1}).

Iqbal *et al*. (2014) observed the promotion of biomass, photosynthetic rate, yield and quality of Chilli (*Capsicum annuum* L.) by interactive effect of nitrogenous fertilizer and wastewater. Four different doses of nitrogen at the rate of 0, 30, 60 and 90 kg N/ha along with a constant dose of phosphorus at the rate of 60 kg P/ha and potassium at the rate of 50 kg K/ha were applied one day prior to sowing. Seedlings were irrigated with three levels of waters (GW, 50%WW and 100%WW). The data were recorded at 60 (DAS) while yield and quality characteristics were determined at harvest. Fruit length, number and fresh yield were recorded at harvest while ascorbic acid was tested in green chillies. Among nitrogen treatments, N_{60} proved best for most of the characteristics while among interactions the lower nitrogen dose N_{30} with 100% WW proved optimum by giving at par result with combination of higher nitrogen treatment N_{60} with GW indicating that fertilizer rates could be lowered with the use of wastewater which can serve not only as the source of water but of nutrients also.

Diaz *et al*. (2013) conducted an experiment that the effects of nitrogen (N) fertilization on the population dynamics of chilli thrips on Jalapeño peppers (*Capsicum annuum*) that were grown in a hydroponic system with different (2%, 4%, 5.5%, 7%, and 8.5%) concentrations of N. A 4% N concentration was found to be the most favorable since it resulted in the fewest chilli thrips per leaf (0.86), produced the highest mean number of marketable fruit per plant (9.75), and produced the largest average fruit size per plant (85.76 g). This study will help pepper growers manage populations of the chilli thrips, a major economic pest, by altering N fertilizer concentrations to optimum levels. This research study has significant potential in developing an integrated management program against chilli thrips in fruit, ornamental, and vegetable crops.

Khan *et al*. (2014) reported that the effect of different levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}) and potassium (0, 30, 40 and 50 kg ha^{-1}) on all growth and yield parameters. Nitrogen application at the rate of 180 kg ha^{-1} significantly affected plant height (68.3 cm), number of leaves per plant(294), number of branches per plant (18.3), stem thickness (2.43 cm), fruits per plant (59.4), fruit length (6.83 cm), seeds per fruit (152) and yield (8.803 tons ha^{-1}). The maximum number of fruits per plant (47.7), fruit length (5.76 cm), seeds per fruit (109) and higher yield (7.102 tons ha^{-1}) were recorded with 50 kg K ha^{-1} which was statistically at par with 40 kg K ha-1 except for fruit length. Application of 180-40 kg N-K_2O are recommended for better growth and yield of chillies under the agro-climatic conditions of Dargai, Malakand Pakistan.

Murugan (2001) observed that nitrogen and phosphorus application increased the ascorbic acid content and capsaicin content in green, ripe and dry chilli. Sources of phosphorus did not have any significant effect on the ascorbic acid content. The maximum ascorbic acid content was recorded in green fruit which decreased gradually with maturity of fruit, recording the lowest value in dry pod, while capsaicin content was lowest in green fruit and maximum in dry pod.

Suryakumari *et al*. (2015) conducted a field experiment the comparative efficacy of three sources of nitrogen viz., urea, calcium ammonium nitrate and ammonium sulphate and two sources of potassium viz., muriate of potash and sulphate of potash on yield attributes and yield in chilli cv LCA 353 was evaluated. Among the treatments tested the highest number of fruits per plant and yield was recorded in the treatment where the recommended nitrogen of 300 kg ha^{-1} was given 50% as urea and remaining 50% as CAN and recommended potassium of 120 kg ha^{-1} as 50% MOP and remaining 50% as SOP (228.4 fruits $plant^{-1}$ and 48.85 q ha^{-1}).These doses were also economical with C:B ratio of 1:1.95 as against control with 1:1.64 where split application of recommended N and K was given in single source as urea and muriate of potash.

Johnson and Decoteau (1996) reported that the influence of N and K rates in Hoagland’s nutrient solution on Jalapeno pepper (*Capsicum annuum* L.) plant growth and pod production was determined on greenhouse-grown plants in sand culture. Varying the rates of N (1 to 30 mM) and K (1 to 12 mM) in Hoagland’s solution identified optimum concentrations for Jalapeno plant growth and pod production. Optimum N rate for pod yield was 15 mM. Nitrogen rate affected pungency of pods, with 1 mM N reducing capsaicin levels in fruit compared to other N rates. The optimum K rate for pod yield was 6 mM. Potassium rates did not affect pod pungency. Jalapeno peppers grown in sand culture required 15 mM N and at least 3 mM K for optimum pod production.

Medina-Lara *et al*. (2008) conducted an experiment to find out the effect of N or K fertilization on Habanero pepper development and fruit pungency. Nitrogen fertilization significantly increased plant growth and fruit while maintaining high capsaicin levels. Optimum response was produced with 15 mM urea as the N source. Potassium fertilization had no positive effects on growth or productivity. The K : N ratio (specifically in leaves and roots) varied between treatments with values greater than 1 in the K treatments, near 0.5 in the control, and less than 0.5 in the N treatments.

Payero and Bhangoo (1990) reported that the effects of six applied N treatments differing by rates and frequencies of application on the yield and quality of pepper *(Capsicum annuum* var. *annuum* L. 'Anaheim Chili') grown for seed was studied. Rate of mature (green and red) fruit production was unaffected by any treatment except weekly applications of 28 kg ha^{-1} of N, which stopped production of mature fruit before all other treatments. Red fruit production tended to be maximized with total seasonal applied N levels of 240 kg ha^{-1} and below, although weekly applications of N reduced production. Nitrogen use efficiency (NUE) for red fruit production also decreased with N rates >240 kg ha^{-1}. Seed mass was reduced with weekly N applications of 28 kg ha^{-1}. These findings indicate that different N management strategies are needed to maximize seed yield compared to fruit yield and, therefore, there may be an advantage to growing 'Anaheim Chili' pepper specifically for seed.

Ramirez *et al*. (2011) conducted a field experiment that Habanero chili pepper (*Capsicum chinense* Jacq.) was cropped in an open field. Fruit quality was evaluated in relation to four nitrogen fertilization doses (32, 80, 160 & 320 kg N ha^{-1}), with the objective to identify their effect on several chemical and biochemical compounds. Total soluble solids (TTS), titratable acidity (TA), pH, antioxidant activity, and total phenols were determined. TA increase twice as high nitrogen dose was applied, but bioactive compounds as antioxidant activity and total phenols were not affected significantly with any nitrogen dose applied. In conclusion it is possible to obtain appreciable nutritional quality on habanero chili pepper fruit, independently of nitrogen management fertilization.

Aminifard *et al*. (2012) was carried out an experiment to evaluate response of paprika pepper (*Capsicum annuum* L.) to nitrogen (N) fertilizer under field conditions. Nitrogen was supplied in four levels (0, 50, 100 and 150 kg ha^{-1}). The results showed that plant height, lateral stem length and leaf chlorophyll content were influenced by N fertilizer. Data indicated that fertilization with 50 g N ha^{-1} resulted to the best yield and quality components at ripening stage. Thus, these results showed that fertilization with 50 kg N ha^{-1} had strong impact on vegetative and reproductive growth of paprika pepper under field conditions.

Khan *et al*. (2012) was conducted an experiment to study the effect of inoculation with biological nitrogen fixers on growth and yield of chilli (*Capsicum annuum* L.) cv. “Pusa Jawala” in relation to disease incidence caused by plant-parasitic nematodes. The growth, yield, and quality parameters of chilli increased significantly with the inoculation of biological nitrogen fixers using *Azospirillum* and *Azotobacter*. Performance of *Azospirillum* was found better as compared to *Azotobacter*. Simultaneous inoculation with bio-fertilizers (100% recommended dose of N-fertilizer 100 kg N per ha and farmyard manure 15 t per ha) resulted the maximum growth, yield, and quality parameters. Thus, the associative nature of the above bio-fertilizers helps to save 25% nitrogenous fertilizer in chilli crop. Disease intensity was recorded in decreasing order in all the treatments but more pronounced in those where bio-fertilizers were added.

Wahocho *et al*. (2016) reported that nitrogen (N) is one of the most important nutrients for plant growth and productivity. Hence its judicious use in crop cultivation is essential for achieving desirable productivity of crops. The results exhibited that all growth and yield characters of chilli were significantly ($P<0.05$) influenced by N levels and cultivars. However, interaction between N levels × cultivars was only significant ($P<0.05$) for plant height (cm) and branches plant^{-1}. The plants treated with higher N level of 250 Kg ha^{-1} produced maximum plant height (71.27 cm), number of branches (9.42), fruit length (3.12 cm), fruits plant^{-1} (142.00), weight of single fruit (3.44 g) and fresh weight of fruit plant^{-1} (486.36). There was significant reduction in all the growth and yield attributed parameters at control, where N was not applied to plants. The findings of the current study demonstrated that although higher N level 250 kg ha^{-1} showed greater values for all traits, but these results were statistically similar to results obtained from 150 kg ha^{-1}, Hence, it is concluded that N 150 Kg ha^{-1} is an economic dose for better growth and fruit yield of chillies.

Aldana (2005) was evaluated in a preliminary experiment conducted the effects of P and K fertilization on Tabasco plant growth and fruit quality; 4 levels of P (0.25, 1.0, 1.75, and 2.5 mM) and 4 levels of K (0.75, 1.75, 2.75, and 3.75 mM) in hydroponic culture with a factorial randomized design. The dry root weights of plants grown with the highest K rate (K_4) were significantly higher than the lowest k rate (K_1). Potassium source was changed for the main plant growth experiment. Phosphorus and potassium rates significantly affected plant growth, increasing plant height, weight, stem diameter, leaf area, and dry weights of plant sections with increasing rates in nutrient solution. For the fruit quality experiment, all plants were grown until the flowering stage with the same nutrient solution (2 mM P; and 3.75 mM K). Increasing P and K rates affected plant yield and some fruit quality variables. Results were consistent for most of the variables, suggesting that the 0.25 mM concentration for both P and K was insufficient for pepper production. Concentrations higher than 1.25 mM and close to 2.5 mM are the most appropriate for hydroponic tabasco pepper production.

Bhuvaneswari *et al*. (2014) was carried out an experiment to evaluate response of sweet pepper (*Capsicum annuum* L.) to plant density and nitrogen fertilizer under field conditions. Plant density at four levels (20 × 50 cm, 30 × 50 cm, 20 × 100 cm and 30 × 100 cm) and nitrogen treatments at four levels (0, 50, 100 and 150 kg N/ha) were applied. The results showed that vegetative growth characteristics (plant height, lateral stem number and leaf dry matter) and reproductive factors (fruit volume, fruit weight and plant yield) decreased with increasing plant density, but total yield (kg/ha) increased with increasing plant density. The highest and lowest total yields were obtained by plant density 20 × 50 cm and 30 × 100 cm respectively. Nitrogen fertilizer was significantly affected on plant height, lateral stem number and leaf chlorophyll content. It was observed that fertilization with 50 kg N/ha resulted to the highest fruit volume and plant yield.

Baloch *et al*. (2013) reported that the effect of nitrogen (N) in presence and absence of phosphorus (P) and potassium (K) on growth and yield characteristics of chilli (*Capsicum annuum* L.) was studied at Coastal Agricultural Research Station, Southern Zone Agricultural Research Centre, PARC, Karachi. The crop under investigation was fertilized with a total of six treatments i.e. 90-0-0, 90-60-75, 0-60-75, 120-0-0, 120-90-105 and 0-90-105 kg/ha of NPK. The analyses of data revealed that it was possible to harvest a satisfactory crop yield without addition of P or K, but it would not be possible to get desired crop yields without application of N, because an adverse effect on fruit yield was noted in absence of N. However, combined application of NPK positively enhanced growth and yield characters. It was concluded that N in presence of P and K (120-90-105 kg/ha) proved best for better production of chilli var. Malir local under agro climatic conditions of Malir district, Sindh.

Thomas and Leong (1985) were conducted three experiments to study the influence of nutrition on the production of container-grown *Capsicum annuum* 'Fips': the first was a central composite design which examined the influence of five rates of N, P, K and lime: 0 to 600 g N m^{-3}, 0 to 400 g P m^{-3} , 0 to 332 g K m^{-3} and 0 to 12 kg lime m^{-3}.The second experiment was a 4 × 2 × 2 factorial with 4 rates of Mg from 0 to 450 g m^{-3} , 2 rates of P at 50 and 400 gm^{-3} and 2 rates of K at 83 and 415 g m^{-3}. The third experiment was a simple randomized block design with 5 rates of K from 300 to 700 g m^{-3}. Lime had no apparent effect at low N rates but influenced growth significantly at high N by raising the pH from 4.2 to 5.8. Foliage growth, plant quality and fruiting were optimal at 600 g N, 300 g P and 500 g K m^{-3}. Lime at 6 kg m^{-3} was recommended (optimum pH 5.8 - 6.1). Suggested tissue composition of good quality ornamental pepper 'Fips' are given as 3.4 to 3.8% N, 0.4% P, 4.6% K, 3.4% Ca, and 1.4% g.

Emongor and Mabe (2012) were conducted an field experiment to evaluate the effects of phosphorus on growth, yield and yield components of chilli pepper variety ‘Long Slim Cayenne’. Phosphorus was applied during transplanting at the rate of 0, 20, 40 and 60 kg P/ha. The results showed that phosphorus application significantly ($P<0.05$) increased plant height (28-59%), leaf area (10-11%), shoot (54-118%) and root dry matter (37-59%), number of fruit/plant (50-117), fruit length (8-9%), fruit water content and fruit yield/ha (92-178%) compared to control plants. The increase in chilli plant variables measured with increasing P application was quadratic with 40 kg P/ha giving the optimum vegetative growth, fruit length, fruit number/plant, fruit water content and fruit yield/ha. However, phosphorus application significantly ($P<0.05$) decreased fruit dry matter content. Due to the increase in growth, yield and yield components of chilli paper due to P application, the authors concluded that under sandy loam soils, farmers should apply 40 kg P/ha at transplanting in order to optimize on chilli fruit yield.

Kotur *et al*. (2010) was conducted a field experiment involving ‘Arka Lohit’, a high yielding variety and ‘ECL’, and F_1 hybrid chilli (*Capsicum annuum* L.) using 15N-enriched (1% N abundance) urea as the tracer to evaluate direct and residual of applied nitrogen in chilli–radish (*Raphanus sativus* L.) system. The highest yield 'Arka Lohit' was obtained when 100% N dose (120 and 200 kg/ha, respectively) was applied in 2 equal splits as basal + top-dress due to its slower growth habit. A significant residual effect of N was exhibited by 'Arka Nishant' radish raised in terms of fresh yield, dry matter production and different parameters of N-use efficiency compared with the 'control'. Response of radish decreased as the dose of N input to chilli decreased. The highest overall recovery of residual fertilizer N was observed under 100% N dose applied to chilli crop as 3 splits (basal + 2 top-dresses), followed by the same dose applied in 2 splits (basal + top-dress) and 3 splits (deferred by 3 days) in radish raised after both the chilli varieties.

Yasuor *et al*. (2013) observed that producers of horticultural products face new and growing standards regarding food quality and safety as well as environmental responsibility and sustainability. Pepper cultivars with different vegetative vigor were drip-irrigated with solutions containing 9.2, 56.2, 102.3, and 158.5 mg L^{-1} nitrogen (N). Maximum yields were found when peppers were irrigated with 56.2 mg·L^{-1} N. Nitrogen concentrations of 102.3 and 158.5 mg L^{-1} N loaded 400 and 800 kg ha^{-1} N into the environment, respectively, whereas for the 56.2 mg L^{-1} N concentration, N was almost completely taken up and used by the plants. Nitrogen treatments had no significant negative effect on pepper fruit physical or chemical quality parameters including sugar content and acidity. Reduced N application did not affect nutritional quality components of the pepper fruit such as b-carotene and lycopene content or total antioxidant activity. The vigorous cultivar used N more efficiently.

Chauhan *et al*. (2005) conducted an experiment to investigate the effects of N (60, 120, 180 or 240 kg/ha) and P (60, 120 or 180 kg/ha) fertilizers, singly or in combination, on the growth and yield of capsicum (*Capsicum annuum* hybrid PRC-2) were studied in Ranichauri, Uttaranchal, India, during the summer season. N at 120 kg/ha gave the highest fruit yield (256.71 quintal/ha), plant height (62.90 cm), number of leaves per plant (111.89), and leaf area (30.76 cm^2).

Hasan *et al*. (1993) reported that Green pepper (*Capsicum annuum* L. cv. Lady Bell) was grown for 7 weeks and transplanted into the field. The following rates of N were applied: 112, 224, 336 and 448 kg/ha. As N rates increased, plants exhibited poor early growth and produced lower early and total fruit yields. Doubling the N rate from 112 to 224 kg/ha resulted in a 21% increase in flower buds, but the percentage of fruit set decreased as N rates increased. Fruit set correlated negatively with total leaf N and positively with plant weight, suggesting that a high leaf N content and a lower plant weight were detrimental to fruit set and yield of green pepper

Stroehlein and Oebker (1979) conducted an experiment that nitrogen applications affected plant growth characteristics, color, nutrient content of leaves and yield of chili peppers as shown by results in this two-year study. Moderate rates of N (100–150 kg/ha) tended to produce a more desirable type of plant and highest yields. Phosphorus treatments did not affect yields under these conditions. Analysis of stem-petiole samples for nitrate appeared to be a good indicator of the N status of the plant. A heavy fruit set in August accompanied with NO_3-N values below 8,000 to 10,000 ppm resulted in harvest time N deficiencies and lower yields.

Sajan *et al*. (2002) were carried out investigation to study the effect of nitrogen and phosphatic bio-fertilizers along with different levels of nitrogen and phosphorus on growth and yield chillies (*Capsicum annuum*) cv Byadagi Dabba. The maximum plant height, leaf are per plant and dry matter production per plant were in the treatment supplied with 75 % N, P plus 100 % K in addition to the inoculation of *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM). The plants inoculated with *Azotobacter Azospirillum*, PSB and VAM along with 75 % N, P plus 100 % K produced more number of fruits per plant and higher yield of dry chillies. Application of bio-fertilizers along with reduced levels of chemical fertilizers has beneficial effect compared to application of chemical fertilizers or bio-fertilizers alone.

Vidyavathi *et al*. (2011) carried out a field experiment to study the effect of organic, inorganic and integrated nutrient management practices on soil fertility, nutrient uptake, productivity and economics of soybean-wheat, groundnut-sorghum, maize-chickpea, potato-chickpea and chilli + cotton. Whereas integrated application of manure and fertilizers resulted in significantly higher available N, P_2O_5, K_2O and S than chemical fertilizers alone. The available , P_2O_5, K_2O and S were significantly higher in legume based cropping systems during both the seasons of the study than non-legume system. The B:C ratio of chilli + cotton was found to be significantly higher (3.35) than other cropping systems. The organic nutrient management recorded significantly higher B:C ratio of 2.99 than inorganic (2.38) and integrated (2.59) nutrient management practices.

Revanappa *et al*. (1998) conducted an experiment to know the influence of nitrogen of three genotype of green chilli, a factorial experiment was laid out at the University of Agricultural Sciences, Dharwad. Navagi recorded the highest number of branches of all orders, fresh weight and dry of the plant and green chilli yield. The treatment of 250 kg N/ha was found as best to register maximum chilli yield by recording the highest dry weight and fresh weight of plant with maximum number of primary, secondary and tertiary branches per plant.

Bajaj *et al*. (1979) conducted an experiment that the effect of different levels of nitrogen N_0 (0), N_1 (60), N_2 (80) and N_3 (100) kg/ha and phosphorus P_0 (0), P_1 (32), P_2 (48) and P_3 (64) kg/ha on the nutrient composition of sweet peepers fruit was investigated. Dry matter content was found to increase at N_0 level at high concentration of phosphorus and as well as at P_0 level at highest concentration of nitrogen. At P_2 concentration, at different levels of nitrogen, the ascorbic acid content was more as compared to that at other levels of phosphorus. Protein content was found to increase with increasing nitrogen doses and was also found to increase at maximum dose of nitrogen with increasing concentration of phosphorus. Capsicum content was found to be more at P_2 level at different dose of nitrogen. The uptake of phosphorus by the peeper fruit was found to increase at N_0 and N_2 levels. Maximum uptake of phosphorus and dry matter content was observe at N_oP_3 levels. Maximum protein, ascorbic acid and capsicum content was found at N_3P_2 level.

Jadhav *et al.* (2014) conducted an experiment that the effect of nitrogen fixing viz., *Azotobacter* and *Azospirillum* with different levels of N (60%, 85% and 100%) on growth and yield of chilli (*Capsicum spp*. L.) cv. Acharya at ASPEE ARDF, Tansa (Maharashtra). Recommended dose of NPK @ 90:60:50 kg/ha and N-fixing culture @ 500g/ha were applied. All the growth characters like plant height (61.50cm) and number of branches/plant (25.25) was found higher with T7-*Azospirillum* + 100%N + 100% PK, which was statistically at par with T6-*Azotobacter* + 100% N + 100% PK. Results showed that the inoculation with T5-*Azospirillum* + 80% N along with 100% P & K recorded maximum fruit length (6.40 cm), fruit diameter (10.70 mm), number of fruits/plant (78.50) and fruit yield (10.35 t/ha). Considering the cost: benefit ratio and yield of the crop, *Azospirillum* was considered better over *Azotobacter*.

Mavengahama *et al*. (2003) were conducted an on-farm trials experiment in the Chinyika Resettlement Area of Zimbabwe to study the response of paprika (*Capsicum annuum* L.) to four basal fertilizer treatments [no basal fertilizer, 500 kg/ha cattle manure, 200 kg/ha Compound D ($7N:14P_2O_5:7K_2O$), or 200 kg/ha Compound L ($5N:17P_2O_5:10\ K_2O$)] and three ammonium nitrate (AN) topdressing treatments (no AN application, application of 350 kg/a AN as single dose or 2-split application). The non-application of AN significantly reduced total and marketable yields, pod number per plant and pod mass. However, there were no differences in fruit yields and fruit parameters due to the application of AN either as a single dose or in 2-split application. The concentrations of N, P, K, Ca and Mg in pods were not affected by AN topdressing at both sites. Phosphorus concentration in leaves decreased significantly with the application of AN. There were no significant differences in fruit ASTA content among the treatments

Haasan *et al*. (1995) was conducted a field experiment 10 study the influence of levels of potassium fertilizer (0, 66 and 132 kg ha^{-1}) and types of mulching (black plastic, reflective plastic and coconut fronds) on growth and yield of chilli. Plant height, yield, fruit number and dry weight of plant increased with increasing K levels and mulching. Yields were increased by 89% and 142% with K levels of 66 and 132 kg ha^{-1}, respectively. Highest yield was obtained from plant grown under reflective plastic mulch. Nitrogen, P, K and Ca content in leaf tissues, soil temperature and moisture under mulched conditions were higher than without mulch. There was a positive correlation between plant dry weight with soil temperature and moisture.

Reyes *et al*. (2008) was conducted an experiment to compare different formulations of a slow-release fertilizer with a conventional fertilizer program to determine their impact on yield and growth of bell pepper (*Capsicum annuum*). Treatments were compared with the extension-recommended rate of 200 lb/acre nitrogen (N) (NC-200) and a high-input fertilizer rate of 300 lb/acre N (HI-300) from calcium nitrate injected in 12 weekly applications of drip irrigation. The slow-release granular formulation at 200 lb/acre N produced the highest marketable yield and better canopy quality in eastern soil. Low rates (150 lb/acre N) of one of the liquid formulations performed better in total and marketable NUE than NC-200 and HI-300. Liquid and dry formulations of slow-release fertilizer showed a potential to be used on bell pepper production across the state at reduced N rates, with greater impact on yield in coarse-textured soils found predominantly in the eastern coastal plain region.

Alonso Baez *et al*. (2002) conducted a field experiment with different fertigation treatments to determine their effect on growth, yield and quality of jalapeno pepper (*Capsicum annuum* L.). Three factors at four levels each were evaluated: soil-water tension head (30, 60, 90, and 120 k Pa), nitrogen fertilizer (290, 340, 390, and 440 kg ha^{-1}), and potassium fertilizer (10, 50, 90, and 130 kg ha^{-1}). The highest growth rate observed was under the soil-water tension head of 90 kPa throughout the cropping season, 390 kg ha^{-1} nitrogen, and 90 kg ha^{-1} potassium. The highest yield of 5289.7 kg ha^{-1} was obtained with the treatment of 120 kPa soil-water tension head, 341.6 kg ha^{-1} nitrogen and 130 kg ha^{-1} potassium. Finally, the best fruit quality with a grade of 10 was obtained with a soil-water tension head of 114.31 k Pa, 435 kg ha^{-1} nitrogen and 10 kg ha^{-1} potassium.

Bahuguna *et al*. (2016) conducted a field experiment at the research farm of Institute of Medicinal and Aromatic Plants, Gairsain, Uttarakhand University of Horticulture and Forestry, to find out the effects of optimum levels of fertilizer on growth and yield attributes of capsicum, consisting four levels of nitrogen (0, 40, 80 & 120 kg ha^{-1}), three levels of phosphorus (0, 40 & 70 kg ha^{-1}), three levels of potash (0, 30 & 60 kg ha^{-1}) and one level of vermi compost (200 q ha^{-1}) along with control on sweet pepper in randomized block design with three replications. Plant height at harvest, number of fruits per plant, fruits maturity and fruits yield increased significantly with T_{20} treatment (nitrogen, phosphorus, potash and vermi-compost 120:40:60:20000 kg ha^{-1}). However, fruits length, fruits width and fruits weight increased significantly with increasing T_{10} treatment (nitrogen, phosphorus and potash 120:40:60 kg per ha) level.

Mujiyati and Supriyadi (2009) observed the effect of manure and NPK to increase soil bacterial population of *Azotobacter* and *Azospirillum* in chili (*Capsicum annuum*) cultivation. The plant populations were treated (i) whithout fertilizer as the control, (ii) with manure fertilizer, and (iii) with NPK fertilizer. The results showed that the manure fertilizer can increase the population of bacteria as many as 0.02% (*Azotobacter*) and 0.46% (*Azospirillum*) when they were compared to the control one. So that it can increase the soil fertility when they were used in long time. Therefore increasing the nutrient availability in the soil was occurred. Application of manure fertilizer could increase the total nitrogen content in the soil and it is very useful for the fertilizing of plants.

Simon and Tesfaye (2014) was conducted a field experiment to assess the growth and productivity of hot pepper (*Capsicum annuum* L.) at Jinka, southern Ethiopia cropping season under rain fed condition using supplementary irrigation. The study consisted of 3 released hot pepper varieties (Mareko Fana, Melka Shote and Melka Zala), 4 levels of nitrogen (0, 50, 100 and 150 kg N ha-1) and 4 levels of phosphorous (0, 46, 92 and 138 kg P2O5 ha-1) in Split- Split plot design with three replications where, variety was assigned as main plot factor nitrogen and phosphorous were arranged as sub and sub-sub plot factors, respectively. In this study, the highest dry fruit yield was achieved using Mareko Fana variety at 150 kg N/ha and phosphorus at 138 kg P_2O_5/ha which was by 91% higher than the control. However, according to the partial budget analysis, the highest economic benefits of 74,096 birr/ha was obtained at 50 kg N/ha and 92 P_2O_5/ha.

Huez-Lopez *et al*. (2011) reported that the response to two nitrogen sources on water and nitrogen use efficiencies, and tolerance of salt-stressed chilli pepper plants (*Capsicum annuum* L.) cv. Sandia was investigated in a greenhouse experiment. Low, moderate and high (1.5, 4.5, and 6.5 dS m^{-1}) salinity levels, and two rates of organic-N fertilizer (120 and 200 kg ha^{-1}) and 120 kg ha^{-1} of inorganic fertilizer as ammonium nitrate were arranged in randomized complete block designs replicated four times. The liquid organic-N source was an organic, extracted with water from grass clippings. Nitrogen use efficiency decreased either by increased salinity or increased N rates. An apparent increase in salt tolerance was noted when plants were fertilized with organic-N source compared to that of inorganic-N source.

Ghoneim (2005**)** were conducted two field experiments on sweet pepper plants (cv. *California wonder*) in the Agricultural Experimental station, Alexandria University, at Abies. The objective of these experiments was to determine the effects of nitrogen rates (60, 90 and 120 kg fed^{-1}) and their application systems (three, four, five and six split applications), on vegetative growth, fruit yield and quality of sweet pepper. The obtained results indicated that increasing N applied rate was accompanied with significant increases in plant height, number of leaves, leaf area and dry mass per plant. The interaction between N rates and their application systems reflected significant differences for most of the studied characters, and revealed that the rate of 90 Kg N fed^{-1} when applied at six split doses; at transplanting, 4, 6, 8, 10, and 12 weeks after transplanting, appeared to be the most efficient combination treatment, which favored the production of high yield with acceptable fruit quality.

Roy *et al*. (2011) conducted a field experiment to study the effects of nitrogen and phosphorus on the fruit size and yield of Capsicum. The treatments comprised 4 levels of N (0, 50, 100 & 150 kg ha^{-1}) and 3 levels of P (0, 30 & 60 kg ha^{-1}). Length and breadth of fruit and number of fruits per plant increased significantly with increasing nitrogen doses up to 100 kg N ha^{-1}. However, average weight of fruit content increased significantly up to 150 kg N ha^{-1}. On the other hand, average weight of fruit and yield increased significantly with the increasing levels of P up to the treatment 30 kg P ha^{-1}, whereas length of fruit and number fruits per plant was increased significantly up to the 60 kg P ha^{-1}. Considering the combined effect of nitrogen and phosphorus, the maximum significant length of capsicum, breadth of capsicum, number of fruits per plant and, average weight of fruit as well as yield were found in the treatment combination of 150 kg N and 30 kg P ha^{-1}.

Alabi (2006) reported that the effect of five phosphorus levels (0, 25, 50, 75, 100 and 125 kg/ha) and five poultry dropping (0, 100, 200, 300, 400 and 500 kg/ha) levels on the growth, growth yield, yield components, nutrients concentration and food values of pepper (*Capsicum annuum* L) were observed.

Phosphorus levels significantly increased pepper plant height, number of leaves per plant, number of branches per plant and leaf area up to 125 kg (p/ha) level. The phosphorus application also significantly increased early flowering, maturity and yield (ton/ha) of the treated plants.

Silva *et al*. (1999) was conducted an experiment to evaluate the effect N and K_2O on the production and yield of sweet pepper plants, related to the characteristics of growth (weight, length and diameter) and total number of fruits per plant, per area. The experiment was conducted with the following treatments: control and combination of three rates of N (13.3, 26.6, and 39.9 g m^{-2}) and three rates of K_2O (13.3, 26.6 and 39.9 g m^{-2}). Nitrogen fertilizer increased the maximum dry matter of the stem, leaves and roots, but not of fruit dry matter production. The optimal rate for maximum dry matter accumulation of N was 27.0 g m^{-2}.

Aliyu (2000) reported that the response of pepper to various mixtures of organic manures was studied with and without supplementary addition of mineral fertilizer under field conditions. Application of farmyard manure + poultry manure at 5 t ha^{-1} each, supplemented with 50 kg N ha^{-1} resulted in significantly higher fruit yield compared with other treatments. Farmyard manure at 10 t ha^{-1} + poultry manure at 5 t ha^{-1} out-yielded other treatments. Mineral nitrogen fertilization resulted in higher concentrations of N, P and K in pepper fruits.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Location of the experiment field

The experiment was conducted at Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2013 to May 2014. The location of the experimental site was at 23°75′ N latitude and 90°34′ E longitudes with an elevation of 8.45 meter from sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September (Anonymous, 1988) and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix III.

3.3. Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 (Haider *et al*., 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix IV.

3.4 Plant materials collection

The seeds of chilli were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Chilli seedlings were raised in different polybags. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. 3-5 seeds was sown on each polybag on 15^{th} November 2013. After sowing, seeds were covered with light soil. The emergence of the seedlings took place within 5 to 6 days after sowing. Weeding, mulching and irrigation were done as and when required. After 25 days of seed sowing they are ready for transplanting.

3.6 Treatments of the experiment

The experiment was consisted on four levels of nitrogen N_0: 0 kg N ha^{-1}, N_1: 100 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 150 kg N ha^{-1} and four levels of phosphorous P_0: 0 kg P_2O_5 ha^{-1}, P_1: 30 kg P_2O_5 ha^{-1}, P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}. There were in total 16 (4×4) treatment combinations such as: N_0P_0, N_0P_1, N_0P_2, N_0P_3, N_1P_0, N_1P_1, N_1P_2, N_1P_3, N_2P_0, N_2P_1, N_2P_2, N_2P_3, N_3P_0, N_3P_1, N_3P_2, N_3P_3.

3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 25.5 m x 5.5 m was divided into three equal blocks. Each block was consists of 16 plots where 16 treatments were allotted randomly. There were 48 unit plots in the experiment. The size of each plot was 1.2 m x 1.2 m, which accommodated 4 plants at a spacing 0.3 m x 0.3 m. The distance between two blocks and two plots were kept 1.0 m and 0.5 m respectively.

3.8.1 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on November 2013. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design or the experiment was followed after land preparation.

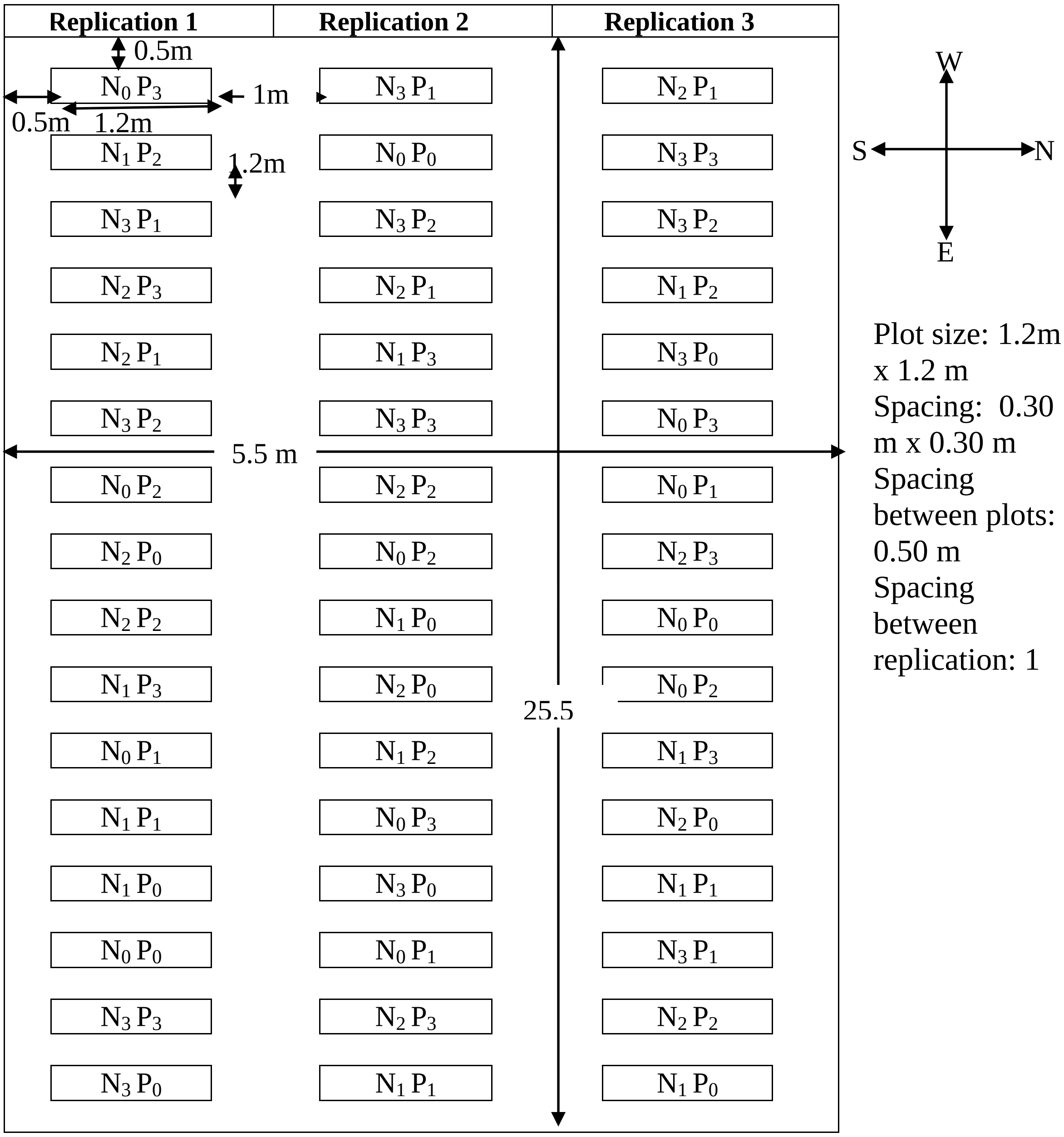


Fig: Layout of the experiment

3.8.2 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, MP, borax and 50% of urea were applied as basal doses during final land preparation. The remaining 50% urea was applied as top dressing at 40 days after transplanting during flowering and fruiting start stage.

3.8.3 Transplanting of seedlings

Healthy and uniform 25 days old seedlings were uprooted separately from the polybag and were transplanted in the experimental plots in 20th December, 2013 maintaining a spacing of 30 cm x 30 cm between the plants and rows respectively. This allowed an accommodation of 16 plants in each plot. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.4 Intercultural operations

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

3.8.4.1 Gap filling

Gap filling of seedlings was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.8.4.2 Weeding

The crop field was weeded out thrice at 25, 55 and 75 DAT and also done whenever necessary to keep the crop free from weeds.

3.8.4.3 Irrigation

Number of irrigation was given throughout the growing period by Garden pipe, watering cane. The first irrigation was given immediate after the transplantation where as other were applied when and when required depending upon the condition of soil.

3.8.4.4 Plant protection

Chilli plants infected with anthracnose and die back were controlled by spraying cupravit (3g/L) at 15 days interval. Few plants found to be infected by bacterial wilt were uprooted. The established plants were affected by aphids. Diazinon 60EC (15cc/10 L) was applied against aphids and other insects.

3.9 Harvesting

Fruits were harvested at 6 to 7 days intervals during early ripe stage when they attained marketable size. Harvesting was started from 15th April, 2014 and was continued up to 19th of May 2014.

3.10 Data collection

Five 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.

3.10.1 Plant height

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 15 days interval starting from 25 days of planting up to 85 days to observe the growth rate of plants. The average height was computed and expressed in centimeters.

3.10.2 Number of leaves per plant

The number of leaves per plant was measured with a meter scale from five selected plants at 25, 40, 55, 70 and 85 days after transplanting on tagged plants. The average of primary branches from five plants were computed and expressed in average number of leaves per plant.

3.10.3 Leaf length of plant

The leaf length of plant was measured with a meter scale from five selected tagged plants. The average of five plants were computed and expressed in average leaf length of plant.

3.10.4 Leaf breadth of plant

The leaf breadth of plant was measured with a meter scale from five selected tagged plants. The average of five plants were computed and expressed in average leaf breadth of plant.

3.10.5 Number of branches per plant

The number of primary branch per plant was manually counted at 50 days after transplanting from tagged plants. The average of primary branches from five plants were computed and expressed in average number of primary branch per plant.

3.10.6 Canopy of plant

The canopy of plant was manually counted at 50 days after transplanting from tagged plants. The average of five plants were computed and expressed in average canopy of plant.

3.10.7 Length of fruit

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

3.10.8 Diameter of fruit

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

3.10.9 Length of pedicel

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

3.10.10 Individual fruit weight

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

3.10.11 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 gram (gm).

3.10.12 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).

3.10.13 Yield of fruits per hectare

It was measured by the following formula:

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

3.10.14 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package programme. The mean for all the treatments was calculated and analysis of variance for all the characters were performed by F-Difference between treatment means were determined by Duncan`s Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained with different levels of nitrogen (N) and phosphorus (P) and their combinations are presented and discussed in this chapter. Data about growth parameters, yield contributing characters and yield of chilli have been presented in both Tables and Figures and analyzes of variance and corresponding degrees of freedom have been shown in Appendix.

4.1 Plant height:

The plant height of chilli was statistically significant with various levels (25, 40, 55, 70 and 85 DAT) of nitrogen (Table 1 and Appendix V). The result revealed that at 25 DAT the tallest plant was recorded from N_2 (14.06 cm) which was statistically similar with N_1 (13.53 cm) and N_3 (13.09 cm) whereas the shortest plant height was found from N_0 (11.98). At 40 DAT the highest plant height (20.19 cm) was observed from the N_2 treatment which was statistically similar to N_1 (20.06 cm) whereas, the lowest (17.81 cm) was observed in N_0 treatment. At 55 DAT the highest plant height (25.27 cm) was observed from the N_2 treatment which was statistically similar to N_1 (24.34 cm) whereas, the lowest (22.08 cm) was observed from N_0 treatment which was statistically similar with N_3 (23.29 cm). At 70 DAT the highest plant height (27.35 cm) was observed from the N_2 treatment which was statistically similar with N_1 (27.17 cm), N_3 (27.79 cm) whereas, the lowest (25.21 cm) was observed from N_0 treatment. At 85 DAT the highest plant height (30.96 cm) was observed from the N_1 treatment which was statistically similar with N_2 (30.63 cm) whereas, the lowest (27.45 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 (1973), Damke *et. al.* (1990) and Nicola *et. al.(1995).* They observed an improvement on plant height with increasing nitrogen application.

Table 1. The effect of different levels of nitrogen and phosphorous on plant height of chilli

Treatments	Plant height (cm)				
	25 DAT	**40 DAT**	**55 DAT**	**70 DAT**	**85 DAT**
Levels of Nitrogen					
N_0	11.98 b	17.81 c	22.08 c	25.21b	27.45 c
N_1	13.53 a	21.06 a	24.34 ab	27.17 a	30.96 a
N_2	14.06 a	20.19 a	25.27 a	27.35 a	30.63 a
N_3	13.09 a	19.04 b	23.29 bc	27.79 a	28.99 b
Levels of Phosphorus					
P_0	12.09 c	18.42 c	23.61 a	27.10 ab	29.54 ab
P_1	12.50 bc	19.10 bc	23.08 a	26.04 b	28.90 b
P_2	14.69 a	20.89 a	24.04 a	27.75 a	30.63 a
P_3	13.38 b	19.69 b	24.25 a	26.63 ab	28.96 b
$LSD_{(0.05)}$	**0.502**	**0.520**	**0.598**	**0.571**	**0.605**
CV%	**9.34**	**6.53**	**6.17**	**5.20**	**5.02**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P ha^{-1} (control); P_1: 30 kg P ha^{-1}; P_2: 45 kg P ha^{-1} and P_3: 60 kg P ha^{-1}

Plant height of chilli varied significantly for different levels (25, 40, 70 and 85 DAT) of phosphorus but except 55 DAT (Table 1 and Appendix V). At 25 DAT the tallest plant (14.69 cm) was observed from P_2 whereas the shortest plant was observed from P_0 (12.09 cm) which was statistically similar to P_1 (12.50 cm). At 40 DAT the highest plant height (20.89 cm) was observed from P_2 whereas the shortest plant was observed from P_0 (18.42 cm) which was statistically similar to P_1 (19.10 cm). At 70 DAT the highest plant height (27.75 cm) was observed from the P_2 treatment which was statistically similar to P_0 (27.10 cm), P_3 (26.63 cm) whereas the lowest (26.04 cm) was observed from P_1 treatment. At 85 DAT the highest plant height was observed from the P_2 (30.63 cm) treatment which was statistically similar to P_0 (29.54 cm) whereas the lowest was observed from P_1 (28.90 cm) treatment which was statistically similar to P_3 (28.96 cm). 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.

Table 2. Combined effect of different levels of nitrogen and phosphorous on plant height of chilli

Treatments	Plant height (cm)				
	25 DAT	40 DAT	55 DAT	70 DAT	85 DAT
N_0P_0	7.92 g	13.00 i	20.33 g	22.33 e	25.00 g
N_0P_1	11.58 f	19.00 efg	21.83 efg	24.25 de	26.97 fg
N_0P_2	14.08 bcde	20.08 cdef	24.17 cde	25.50 cd	27.83 ef
N_0P_3	14.33 bc	19.17 defg	26.17 bc	28.75 ab	30.00 cde
N_1P_0	14.77 ab	23.00 b	26.93 ab	28.50 ab	31.17 bc
N_1P_1	12.25 def	21.17 bcd	24.33 cd	29.00 ab	30.00 cde
N_1P_2	14.25 bcd	20.83 cde	20.83 g	24.33 de	32.50 ab
N_1P_3	12.83bcdef	19.25 defg	25.25 bc	26.83 bc	30.17bcde
N_2P_0	13.58bcdef	20.17 cdef	26.17 bc	28.58 ab	32.00 abc
N_2P_1	12.17 ef	15.42 h	24.50 bcd	26.17 cd	28.17 def
N_2P_2	16.50 a	26.67 a	28.83 a	30.67 a	34.17 a
N_2P_3	14.00 bcde	18.50 fg	21.58 fg	24.00 de	28.17 def
N_3P_0	12.08 ef	17.50 gh	21.00 g	29.00 ab	30.00 cde
N_3P_1	14.00 bcde	20.83 cde	21.67 fg	24.75 cd	30.48 bcd
N_3P_2	13.92 bcde	16.00 h	22.33defg	30.50 a	28.00 ef
N_3P_3	12.35 cdef	21.83 bc	24.00 cdef	26.93 bc	27.50 f
$LSD_{(0.05)}$	**1.004**	**1.041**	**1.197**	**1.142**	**1.211**
CV%	**9.34**	**6.53**	**6.17**	**5.20**	**5.02**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Combined effect of different levels of nitrogen and phosphorus showed significant variation on plant height of chilli at 25, 40, 55, 70 and 85 DAT (Table 2 and Appendix V). At 25 DAT the tallest plant (16.50 cm) was observed from N_2P_2 which was statistically similar to N_1P_0 (14.77 cm) whereas the shortest plant was recorded from N_0P_0 (7.92cm). At 40 DAT the tallest plant (26.67 cm) was observed from N_2P_2 whereas the shortest plant was recorded from N_0P_0 (13.00 cm). At 55 DAT the tallest plant was observed from N_2P_2 (28.83 cm) which was statistically similar with N_1P_0 (23.00 cm) whereas the shortest plant was recorded from N_3P_0 (20.33 cm) which was statistically similar to N_0P_0 (21.00 cm), N_0P_1 (21.83 cm), N_1P_2 (20.83 cm), N_2P_3 (21.58

cm). At 70 DAT the tallest plant was observed from N_2P_2 (30.67cm) which was statistically similar to N_0P_3 (28.75 cm), N_1P_0 (28.50 cm), N_1P_1 (29.00 cm), N_2P_0 (28.58 cm), N_3P_0 (29.00 cm) whereas the shortest plant was recorded from N_0P_0 (22.33 cm) which was statistically similar to N_0P_1 (24.25 cm), N_1P_2 (24.33 cm), N_2P_3 (24.00 cm). At 85 DAT the tallest plant was observed from N_2P_2 (34.17 cm) which was statistically similar to N_1P_2 (32.50 cm) whereas the shortest plant was recorded from N_0P_0 (25.00 cm) which was statistically similar to N_0P_1 (26.97 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.

4.2 Number of leaves plant^{-1}

Nitrogen fertilizer doses showed significant effect on number of leaves per plant of chilli at 25, 40, 55, 70 and 85 DAT (Table 3 and Appendix VI). At 25 DAT the highest number of leaves per plant (31.17) was observed from the N_3 treatment which was statistically similar to N_1 (30.54) and N_2 (30.69) whereas the lowest (26.35) was observed from N_0 treatment. At 40 DAT the highest number of leaves per plant (71.52) was observed from the N_3 treatment whereas the lowest (54.81) was observed from N_0 treatment. At 55 DAT the highest number of leaves per plant was observed from the N_3 (143.45) treatment whereas the lowest was observed from N_0 (94.70) treatment. At 70 DAT the highest number of leaves per plant was observed from the N_3 (160.88) treatment which was statistically similar to N_2 (159.58) whereas the lowest was observed from N_0 (140.98) treatment. At 85 DAT the highest number of leaves per plant (200.83) was observed from the N_3 treatment whereas the lowest (173.57) was observed from N_1 treatment. As data shown, N fertilization increased leaf number which were in agreement with findings of Ayodele (2002) and Boroujerdnia and Ansari (2007).

Number of leaves per plant of chilli varied significantly for different levels (25, 40, 55, 70 and 85 DAT) of phosphorus (Table 3 and Appendix VI). At 25 DAT the highest number of leaves (30.73) was recorded in P_1 which was statistically identical (29.96) to P_2 whereas the lowest number of leaves was recorded from P_0 (28.92) which was statistically similar to P_3 (29.15). At 40 DAT the highest number of leaves (71.44) was recorded in P_1 whereas the lowest number of leaves was recorded from P_3 (59.73) which was statistically similar to P_0 (60.02). At 55 DAT the highest number of leaves was recorded in P_1 (143.73) whereas the lowest number of leaves was recorded from P_0 (102.98). At 70 DAT the highest number of leaves was recorded in P_1 (167.93) whereas the lowest number of leaves was recorded from P_0 (125.79). At 85 DAT the highest number of leaves (197.10) was recorded in P_2 whereas the lowest number of leaves was recorded from P_0 (165.73). The results showed significant variation in number of leaves per plant with increasing phosphorus in P_1 treatment up to P_2 treatment.

Table 3. The effect of different levels of nitrogen and phosphorous on number of leaves plant^{-1} of chilli

Treatments	Number of leaves plant^{-1}				
	25 DAT	40 DAT	55 DAT	70 DAT	85 DAT
Levels of Nitrogen					
N_0	26.35 b	54.81 d	94.70 d	140.98 c	181.00 c
N_1	30.54 a	67.69 b	131.15 c	149.85 b	173.57 d
N_2	30.69 a	66.00 c	139.79 b	159.58 a	186.83 b
N_3	31.17 a	71.52 a	143.45 a	160.88 a	200.83 a
Levels of Phosphorus					
P_0	28.92 b	59.73 c	102.98 d	125.79 d	165.73 d
P_1	30.73 a	71.44 a	143.73 a	167.93 a	194.45 b
P_2	29.96 ab	68.83 b	128.12 c	166.08 b	197.10 a
P_3	29.15 b	60.02 c	134.27 b	151.48 c	184.96 c
$LSD_{(0.05)}$	**0.650**	**0.639**	**0.585**	**0.900**	**0.810**
CV%	**5.37**	**2.41**	**1.13**	**1.44**	**1.07**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Table 4. Combined effect of different levels of nitrogen and phosphorous on number of leaves plant^{-1} of chilli

Treatments	Number of leaves plant^{-1}				
	25 DAT	**40 DAT**	**55 DAT**	**70 DAT**	**85 DAT**
N_0P_0	22.00 g	40.58 j	83.83 l	122.50 i	160.00 i
N_0P_1	29.08 de	74.17 c	106.33 i	148.17 f	183.83 f
N_0P_2	30.08 de	64.25 g	91.90 k	153.50 e	196.50 d
N_0P_3	24.25 fg	40.25 j	96.75 j	139.75 g	183.67 f
N_1P_0	34.00 ab	64.83 g	66.17 m	120.00 i	150.25 j
N_1P_1	33.58 ab	83.42 b	156.08 d	145.42 f	172.25 h
N_1P_2	25.17 f	52.17 i	142.17 e	170.17 c	188.30 e
N_1P_3	29.42 de	70.33 e	160.17 c	163.83 d	183.50 f
N_2P_0	28.25 e	66.42 fg	130.33 f	140.42 g	180.17 g
N_2P_1	30.08 de	54.08 hi	123.83 g	170.23 c	186.65 ef
N_2P_2	34.25 a	88.27 a	164.83 b	195.50 b	208.33 b
N_2P_3	30.17 cde	55.25 h	140.17 e	132.17 h	172.17 h
N_3P_0	31.42 bcd	68.25 ef	131.57 f	120.25 i	172.50 h
N_3P_1	30.17 cde	74.08 c	188.67 a	207.92 a	235.08 a
N_3P_2	30.33 cde	70.65 de	113.58 h	145.17 f	195.25 d
N_3P_3	32.75 abc	73.08 cd	140.00 e	170.17 c	200.50 c
$LSD_{(0.05)}$	**1.301**	**1.278**	**1.169**	**1.800**	**1.621**
CV%	**5.37**	**2.41**	**1.13**	**1.44**	**1.07**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Significant combined effect between nitrogen and phosphorus on number of leaves was observed of chilli at 25, 40, 55, 70 and 85 DAT (Table 4 and appendix VI). At 25 DAT N_2P_2 showed the maximum (34.25) number of leaves which was statistically similar to N_1P_0 (34.00), N_1P_1 (33.58), N_3P_3 (32.75) while N_0P_0 condition showed the minimum (22.00) number of leaves which was statistically similar to N_0P_3 (24.25). At 40 DAT N_2P_2 showed the maximum (88.27) number of leaves while N_0P_3 condition showed the minimum (40.25) number of leaves which was statistically similar to N_0P_0 (40.58). At 55 DAT the maximum (186.67) number of leaves observed in N_3P_1

while N_1P_0 condition showed the minimum (66.17) number of leaves. At 70 DAT N_3P_1 showed the maximum (207.92) number of leaves while N_1P_0 condition showed the minimum (120.0) number of leaves which was statistically similar to N_0P_0 (122.50) and N_3P_0 (120.25). At 85 DAT the maximum (235.08) number of leaves observed in N_3P_1 while N_1P_0 showed the minimum (150.25) number of leaves. 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 NP.

4.3 Plant canopy

Nitrogen fertilizers doses had significant effect on plant canopy of chilli (Figure 1 and Appendix VII). The highest plant canopy (30.50 cm) was attained from N_3 treatment which was statistically similar to N_2 (30.19 cm) while the lowest (27.83 cm) was observed from N_0 treatment. The results showed that increased in nitrogen treatment with increase in plant canopy but (Grindlay, 1997) reported that the nitrogen distribution between the leaves of a canopy is not uniform.

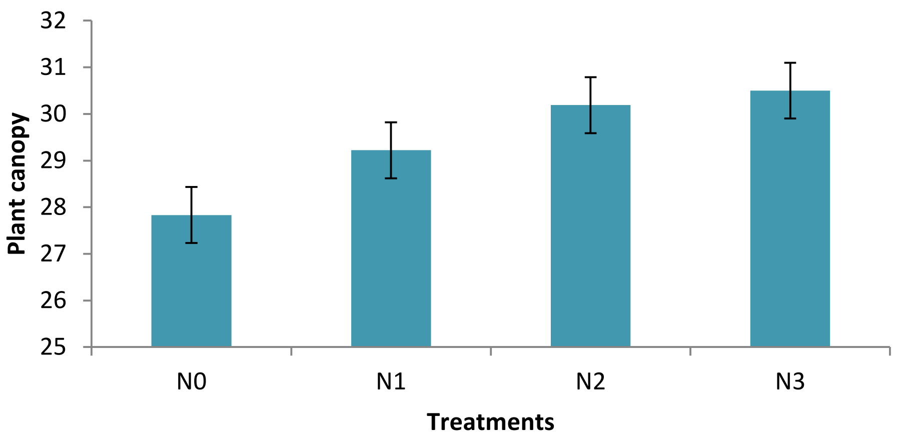


Fig 1. Effect of different nitrogen levels on plant canopy of chilli

N_0: 0 kg N ha^{-1} (control)
N_1: 100 kg N ha^{-1}
N_2: 120 kg N ha^{-1}
N_3: 140 kg N ha^{-1}

Doses of phosphorus had significant effect on plant canopy of chilli (Figure 2 and Appendix VII). The highest plant canopy (30.00 cm) was attained from P_3 treatment which was statistically similar to P_1 (29.54 cm) and P_2 (29.54 cm) whereas the lowest plant canopy (28.27 cm) was observed from P_0 treatment. Results showed plant canopy increased with increase in phosphorus level.

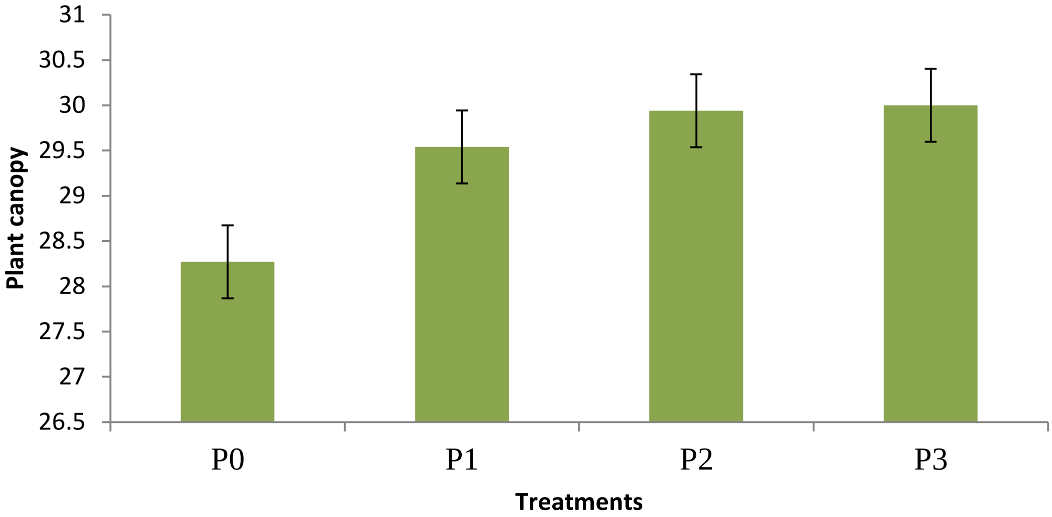


Fig 2. Effect of different phosphorus levels on plant canopy of chilli

P_0: 0 kg P_2O_5 ha^{-1} (control)
P_1: 30 kg P_2O_5 ha^{-1}
P_2: 45 kg P_2O_5 ha^{-1}
P_3: 60 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus doses showed significant variation on plant canopy of chilli (Table 6 and Appendix VII). The highest plant canopy (33.25 cm) was recorded from N_3P_3 which was statistically similar to N_2P_2 (33.00 cm) while the lowest plant canopy (25.00 cm) was observed in N_0P_0 or control treatment.

4.4 Leaf length

Leaf length of chilli was statistically influenced by different levels of nitrogen (Table 5 and Appendix VII). The longest length of leaf (9.18 cm) was observed from N_3 while the shortest length of leaf (7.96 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, 2002) because N stimulated the cell division and cell expansion (Lemaire, 2001).

Table 5. The effect of different levels of nitrogen and phosphorous on morphological parameters of chilli

Treatments	Leaf length (cm)	Leaf breadth (cm)	Number of branches plant^{-1} (cm)
Levels of Nitrogen			
N_0	7.96 c	2.06 c	9.42 c
N_1	8.584 b	2.59 b	11.46 b
N_2	8.79 b	2.74 ab	11.89 b
N_3	9.18 a	2.88 a	13.73 a
Levels of Phosphorus			
P_0	8.08 c	2.36 b	11.00 b
P_1	9.03 a	2.66 a	11.78 ab
P_2	8.64 b	2.58 a	11.42 ab
P_3	8.77 ab	2.67 a	12.29 a
$LSD_{(0.05)}$	**0.171**	**0.104**	**0.466**
CV%	**4.85**	**9.96**	**9.82**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Length of leaf of chilli varied significantly for different levels of phosphorus (Table 5 and Appendix VII). The longest length of leaf (9.03 cm) was observed from P_1 which was statistically identical to P_3 (8.77 cm) whereas the shortest length of leaf was recorded from P_0 (8.08 cm) or control condition. The beneficial effect of phosphorus on the leaf length has been reported by (Rao, 1990) in cowpea (Reddy *et al.*, 1991) in groundnut.

Significant influence was observed on leaf length of chilli due to the different doses of nitrogen and phosphorus (Table 6 and Appendix VII). The longest leaf length (10.91 cm) was obtained from N_3P_1. In contrast to the lowest leaf length (6.85 cm) was observed from N_0P_0 or control condition**.**

4.5 Leaf breadth

Leaf breadth of chilli was statistically influenced by different doses of nitrogen (Table 5 and Appendix VII). The highest leaf breadth (2.88 cm) was observed from N_3 which was statistically identical to N_2 (2.74 cm) while the shortest leaf breadth (2.06 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 120 kg/ha and then a decrease trend was observed with increase in nitrogen levels (Gupta and Sangar, 2000).

Breadth of leaf of chilli varied significantly for different levels of phosphorous (Table 5 and Appendix VII). The highest leaf breadth (2.67 cm) was observed from P_3 which was statistically identical to P_1 (2.66 cm) & P_2 (2.58 cm) whereas the shortest length of leaf was recorded from P_0 (2.36 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.

Significant influence was observed on leaf length of chilli due to the different doses of nitrogen and phosphorus (Table 6 and Appendix VII). The longest leaf length (3.40 cm) was obtained from N_3P_3 which was statistically identical to N_2P_2 (3.00 cm) & N_3P_3 (3.03 cm). In contrast to the lowest leaf length (1.54 cm) was observed from N_0P_0 or control condition.

4.6 Number of branches plant^{-1}

Number of branches of chilli varied significantly for different levels of nitrogen (Table 5 and Appendix VII). The maximum number of branches (13.73) was observed from N_3 and the minimum number of branches was recorded from N_0 (9.42) 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.

Table 6. Combined effect of different levels of nitrogen and phosphorous on morphological parameters of chilli

Treatments	Plant canopy (cm)	Leaf length (cm)	Leaf breadth (cm)	Number of branches plant^{-1} (cm)
N_0P_0	25.00 e	6.85 e	1.54 g	7.67 h
N_0P_1	29.08 bcd	8.20 d	2.03 f	8.50 gh
N_0P_2	29.25 bcd	8.56 bcd	2.2 ef	10.33 efg
N_0P_3	28.00 d	8.23 d	2.43 cdef	11.17 def
N_1P_0	29.00 bcd	8.57 bcd	2.79 bc	11.83 cde
N_1P_1	30.00 b	8.56 bcd	2.56 cde	9.83 fg
N_1P_2	28.08 cd	8.21 d	2.33 def	11.83 cde
N_1P_3	29.83 bc	9.00 bc	2.68bcd	12.33 cd
N_2P_0	29.58 bcd	8.71 bcd	2.77 bc	12.83 bcd
N_2P_1	28.75 bcd	8.46 cd	2.66 bcd	13.40 bc
N_2P_2	33.00 a	9.20 b	3.00 ab	10.33 efg
N_2P_3	29.17 bcd	8.79 bcd	2.53 cde	11.00 def
N_3P_0	29.50 bcd	8.18 d	2.32 def	11.67 cdef
N_3P_1	30.33 b	10.91 a	3.03 ab	14.67 ab
N_3P_2	29.17 bcd	8.60 bcd	2.77 bc	13.17 bc
N_3P_3	33.25 a	9.04 bc	3.40 a	15.40 a
$LSD_{(0.05)}$	**0.863**	**0.342**	**0.209**	**0.931**
CV%	**3.59**	**4.85**	**9.96**	**9.82**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Number of branches of chilli was statistically influenced by different doses of phosphorous (Table 5 and Appendix VII). The maximum number of branches (12.68) was observed from P_2 which was statistically identical to P_3 (12.29) while the minimum number of branches (11.00) was found from P_0 (11.00) or control condition. Phosphorus had a significant effect on number of branches per plant and increased with the increasing of phosphorus rate.

Significant influence was observed on number of branches of chilli due to the different doses of nitrogen and phosphorus (Table 6 and Appendix VII). The maximum number of branches (15.40) was obtained from N_3P_3 which was statistically identical to N_3P_1 (14.67). In contrast to the minimum number of branches (7.67) was observed from N_0P_0 or control condition which was statistically identical to N_0P_1 (8.50). These results showed that higher dose of nitrogen and phosphorus was influential nutrients for number of branches per plant at final harvesting stage. Similar result was found by Tumbare and Bhoite, (2002).

4.7 Fruit length

Significant variation was observed among the different treatments due to different doses of nitrogen in respect of average fruit length of chilli (Table 7 and Appendix VIII). Fruit length was recorded 4.74 cm, 4.89 cm, 5.16 cm and 5.10 cm in N_0, N_1, N_3 and N_2 treatments respectively. Maximum (5.16 cm) fruit length was found in N_3 treatment which was statistically similar to N_2 (5.10 cm) treatment whereas minimum fruit length was recorded from N_0 (4.74 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 nitrogen application.

Significant variation was found among the different treatments due to different doses of phosphorus in respect of fruit length of chilli (Table 7 and Appendix VIII). Average fruit length was recorded 4.90 cm, 4.93 cm, 5.25 cm and 4.81 cm in P_2, P_1, P_3 and P_0 treatments respectively. However, maximum (5.25 cm) fruit length was found in P_3 treatment whereas minimum fruit length was recorded in P_0 (4.81 cm) which was statistically similar to P_2 (4.90 cm).

Combined effect of nitrogen and phosphorus doses showed significant variation on fruit diameter of chilli (Table 8 and Appendix VIII). Maximum (5.60 cm) fruit length was recorded in N_3P_3 treatment whereas minimum (4.27 cm) fruit length was recorded in N_0P_0 or control treatment. These results are are similar to that of Lal and Pundrik (1971) and Ludilov and Ludilova (1977). Lal and Pundrik (1971) obtained highest yield due to an improvement in fruit size in response to 80 kg N and 90 kg P.

4.8 Fruit pedicel

The effect of different doses of nitrogen application had significant influence on fruit pedicel in chilli (Table 7 and Appendix VIII). However, result revealed that the longest fruit pedicel was recorded in N_3 (2.42 cm) which was statistically similar to N_2 (2.37 cm) whereas the shortest fruit pedicel was recorded in N_0 (2.09 cm) which was statistically similar to N_1 (2.18 cm).

The effect of different levels of phosphorus application had significant influence on fruit pedicel in chilli (Table 7 and appendix VIII). However, result showed that the longest fruit pedicel was found in P_3 (2.43 cm) which was statistically similar to P_1 (2.33 cm) whereas the shortest fruit pedicel was found in P_0 (2.05 cm).

Combined effect of nitrogen and phosphorus doses showed significant variation on fruit pedicel of chilli (Table 8 and Appendix VIII). Longest (2.87 cm) fruit pedicel was recorded in N_3P_3 treatment whereas the shortest (1.77 cm) fruit pedicel was recorded in N_0P_0 which was statistically similar to N_1P_3 (2.00 cm).

4.8 Fruit diameter

Significant variation was observed among the different treatments due to different doses of nitrogen in respect of average fruit diameter of chilli (Table 7 and Appendix VIII). Fruit diameter was recorded 0.68, 0.79, 0.82 and 0.79 cm in N_0, N_1, N_3 and N_2 treatments respectively. Maximum (0.82 cm) fruit diameter was found in N_3 treatment which was statistically similar to N_1 (0.79 cm) treatment whereas minimum fruit diameter was recorded in N_0 (0.68 cm) or control treatment. Roy *et. al.* (2011) documented the similar report on fruit diameter of chilli. According to them length and diameter of fruits and nos. fruits per plant increased significantly with increasing nitrogen dose at N_2 treatment (100 kg N ha^{-1}).

Significant variation was found on fruit diameter due to the effect of different levels of phosphorus in chilli (Table 7 and Appendix VIII). Fruit diameter was recorded 0.75, 0.76, 0.79 and 0.78 cm in P_0, P_1, P_3 and P_2 treatments respectively. Maximum (0.79 cm) fruit diameter was found in P_3 treatment which was statistically similar to P_1 (0.76 cm) and P_2 (0.78 cm) treatments whereas minimum fruit diameter was recorded in P_0 (0.75 cm) or control treatment.

Table 7. The effect of different levels of nitrogen and phosphorous on yield contributing parameters of chilli

Treatments	Fruit length (cm)	Fruit pedicel(cm)	Fruit diameter(cm)
Levels of Nitrogen			
N_0	4.74 c	2.09 b	0.68 c
N_1	4.89 b	2.18 b	0.79 ab
N_2	5.10 a	2.37 a	0.79 b
N_3	5.16 a	2.42 a	0.82 a
Levels of Phosphorus			
P_0	4.81 c	2.05 c	0.75 b
P_1	4.93 b	2.33 ab	0.76 ab
P_2	4.90 bc	2.24 b	0.78 ab
P_3	5.25 a	2.43 a	0.79 a
$LSD_{(0.05)}$	**0.056**	**0.069**	**0.014**
CV%	**2.76**	**7.49**	**4.48**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus doses showed significant variation on fruit diameter of chilli (Table 8 and Appendix VIII). Maximum (0.95 cm) fruit diameter was recorded in N_3P_3 treatment whereas minimum (0.57 cm) fruit diameter was recorded in N_0P_0.

Table 8. Combined effect of different levels of nitrogen and phosphorous on yield contributing parameters of chilli

Treatments	Fruit diameter (cm)	Fruit pedicel (cm)	Fruit length (cm)
N_0P_0	0.57 h	1.77 f	4.27 i
N_0P_1	0.72 fg	2.20 cde	4.67 gh
N_0P_2	0.69 g	2.23 bcde	5.00 cde
N_0P_3	0.74 efg	2.17 cde	5.03 cde
N_1P_0	0.82 bc	2.10 de	5.00 cde
N_1P_1	0.78 cdef	2.40 bc	4.87 efg
N_1P_2	0.74 efg	2.20 cde	5.13 bc
N_1P_3	0.85 b	2.00 ef	4.57 h
N_2P_0	0.80 bcd	2.16 cde	5.20 bc
N_2P_1	0.74 efg	2.33 bcd	5.10 bcd
N_2P_2	0.75 defg	2.50 b	4.90 def
N_2P_3	0.79 cde	2.30 bcd	4.73fgh
N_3P_0	0.82 bc	2.17 cde	5.13 bc
N_3P_1	0.80 bcd	2.40 bc	5.10 bcd
N_3P_2	0.77 cdef	2.40 bc	5.27 b
N_3P_3	0.95 a	2.87 a	5.60 a
$LSD_{(0.05)}$	**0.028**	**0.138**	**0.112**
CV%	**4.48**	**7.49**	**2.76**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

4.10 Individual fruit weight

There was a significant variation in single fruit weight among different doses of nitrogen treatments (Table 9 and Appendix VIII). Individual fruit weight was recorded 1.54, 2.00, 2.12 and 2.50 gm in N_0, N_1, N_2 and N_3 treatments respectively. Highest individual fruit weight (2.50) was found in N_3 treatment whereas the lowest individual fruit weight was found in N_0 (1.54) 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).

There was a significant variation in single fruit weight among different doses of phosphorus treatments (Table 9 and Appendix VIII). Individual fruit weight was recorded 1.30, 1.82, 2.02 and 2.42 gm in P_0, P_1, P_2 and P_3 treatments respectively. Highest individual fruit weight (2.42) was found in P_3 treatment whereas the lowest single fruit weight was found in P_0 (1.30) or control treatment.

Table 9. The effect of different levels of nitrogen and phosphorous on yield contributing parameters of chilli

Treatments	Individual fruit weight (g)	Yield plant^{-1} (g)	Yield plot^{-1} (kg)	Yield ha^{-1} (ton)
Levels of Nitrogen				
N_0	1.54 d	162.20 d	2.59 d	8.88 d
N_1	2.00 c	200.00 c	3.20 c	10.95 c
N_2	2.12 b	212.00 b	3.39 b	11.60 b
N_3	2.50 a	235.00 a	3.75 a	12.83 a
Levels of Phosphorus				
P_0	1.30 d	145.25 d	2.24 d	7.68 d
P_1	1.82 c	170.55 c	2.72 c	9.33 c
P_2	2.02 b	190.81 b	3.05 b	10.44 b
.P_3	2.42 a	220.25 a	3.52 a	12.06 a
$LSD_{0.05}$	**0.016**	**1.297**	**0.021**	**0.0711**
CV%	**3.10**	**2.24**	**2.24**	**2.24**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

Combined effect of nitrogen and phosphorus doses showed significant variation on single fruit weight (Table 10 and Appendix VIII). Highest single fruit weight (2.52) was found in N_3P_3 treatment whereas the lowest single fruit weight was found in N_0P_0 (1.56) or control treatment.

4.11 Yield of fruits plant^{-1}

There was a significant variation on number of fruits per plant among different treatments (Table 9 and Appendix IX). Highest number of fruits per plant was found in N_3 (235.00) treatment whereas lowest number of fruits per plant was found in N_0 (162.20) or control treatment. It was revealed that at optimum level nitrogen fertilizer gave highest yield plant^{-1} and increase nitrogen fertilization delayed flowering. Guohua *et al*. (2001) found that flowering was delayed with increase in nitrogen fertilization due to diversion of photosynthates for vegetative growth of plant. Shrivastava (2003) also found similar results.

Significant variation was found among the different treatments due to different doses of phosphorus in respect of number of fruits per plant (Table 9 and Appendix IX). Highest number of fruits per plant was found in P_3 (220.25) treatment whereas lowest number of fruits per plant was found in P_0 (145.25) 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 being at P_2 levels in pea.

Combined effect of nitrogen and phosphorus doses showed significant variation on number of fruits per plant (Table 10 and Appendix IX). Highest number of fruits per plant (235.00) was found in N_3P_3 treatment whereas whereas lowest (160.73) 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.

4.12 Fruit yield plot^{-1}

Yield of green fresh fruit of chilli was recorded 2.59, 3.20, 3.39 and 3.75 kg/plot in N_0, N_1, N_2 and N_3 treatments respectively (Table 9 and Appendix IX). Maximum (3.75 kg/plot) yield was obtained in N_3 treatment and minimum (2.59 kg/plot) was found in N_0 treatment or control treatment. N 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 @ 100 kg ha^{-1} significantly increased brinjal yield. Likewise, Bahuguna *et al.* (2014) also observed the same results in pea.

Yield of fruits of chilli was recorded 2.24, 2.72, 3.05 and 3.52 kg/plot in P_0, P_1, P_2 and P_3 treatments respectively (Table 9 and Appendix IX). Maximum (3.52 kg/plot) yield was obtained in P_3 treatment and minimum (2.24 kg/plot) was found in P_0 treatment or control treatment.

Significant influence was observed on yield of chilli per plot due to the different doses of nitrogen and phosphorus (Table 10 and Appendix IX). The maximum yield 3.39 kg/plot was obtained from N_3P_3. In contrast to the minimum (2.22 kg/plot) was observed from N_0P_0 or control condition. The result were similar with that of Lal and Pundrik (1973) and Ludilov and Ludilova (1977). Lal and Pundrik (1971) obtained highest yield due to an improvement in fruit size in response to 80 kg N, 90 kg P (N_2P_2). It means that recommended fertilization will may affect the fruit size and other growth parameter as well.

Table 10. Combined effect of different levels of nitrogen and phosphorous on yield contributing parameters of chilli

Treatments	Individual fruit weight (g)	Yield plant^{-1} (g)	Yield plot^{-1} (kg)	Yield ha^{-1} (ton)
N_0P_0	1.56 j	160.73 i	2.22 i	7.20 i
N_0P_1	1.72 hi	170.83 h	2.35 h	8.00 h
N_0P_2	1.66 i	206.67 def	2.78 def	9.04 def
N_0P_3	1.80 h	208.03 de	2.95 de	9.44 de
N_1P_0	1.88 g	209.33 d	3.06 d	9.74 d
N_1P_1	2.02 fg	188.17 gh	2.50 gh	8.13 gh
N_1P_2	2.10 e	208.73 d	3.07 d	9.40 d
N_1P_3	1.89 g	189.40 fgh	2.42 fgh	8.25 fgh
N_2P_0	2.05 ef	215.80 c	3.15 c	10.26 c
N_2P_1	2.37 c	219.07 b	3.25 b	10.85 b
N_2P_2	2.40 b	218.17 b	3.22 b	10.82 b
N_2P_3	2.08 e	191.17 efg	2.65 efg	9.41 efg
N_3P_0	2.25 d	190.93 gh	2.58 gh	9.12 gh
N_3P_1	2.38 c	215.67 c	3.18 c	10.22 c
N_3P_2	2.36 c	216.33 c	3.17 c	10.45 c
N_3P_3	2.52 a	235.00 a	3.39 a	12.32 a
$LSD_{(0.05)}$	**0.033**	**2.594**	**0.042**	**0.1421**
CV%	**3.10**	**2.24**	**2.24**	**2.24**

N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 120 kg N ha^{-1}; N_3: 140 kg N ha^{-1} and P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 30 kg P_2O_5 ha^{-1}; P_2: 45 kg P_2O_5 ha^{-1} and P_3: 60 kg P_2O_5 ha^{-1}

4.13 Fruit yield ha^{-1}

Yield of green fresh fruit of chilli was recorded 8.88, 10.95, 11.60 and 12.83 ton/ha in N_0, N_1, N_2 and N_3 treatments respectively (Figure 3 and Appendix IX). Maximum (12.83 ton/ha) yield was obtained in N_3 treatment and minimum (8.88 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 @ 100 kg ha^{-1} significantly increased brinjal yield. In pea, Bahuguna *et al.* (2013) also found the same results.

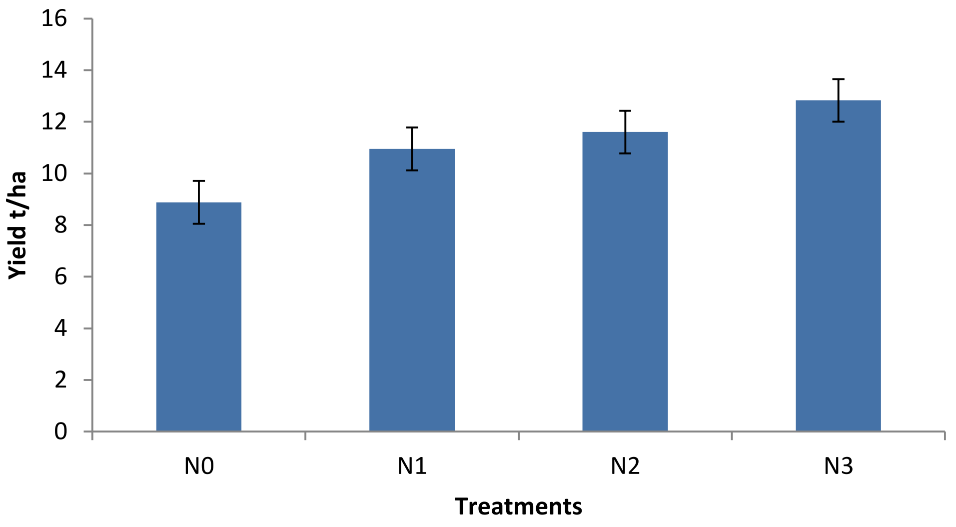


Fig 3. Effect of nitrogen on fruit yield ton ha^{-1} of chilli

N_0: 0 kg N ha^{-1} (control)

N_1: 100 kg N ha^{-1}

N_2: 120 kg N ha^{-1}

N_3: 140 kg N ha^{-1}

Yield of fruits of chilli was recorded 7.68, 9.33, 10.44 and 12.06 ton/ha in P_0, P_1, P_2 and P_3 treatments respectively (Figure 4 and Appendix IX). Maximum (12.06 ton/ha) yield was obtained in P_3 treatment and minimum (7.68 ton/ha) was found in P_0 treatment or control treatment.

Significant influence was observed on yield of chilli per plot due to the different doses of nitrogen and phosphorus (Figure 5 and Appendix IX). The maximum yield 12.32 ton/ha was obtained from N_3P_3. In contrast to the minimum (7.20 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.

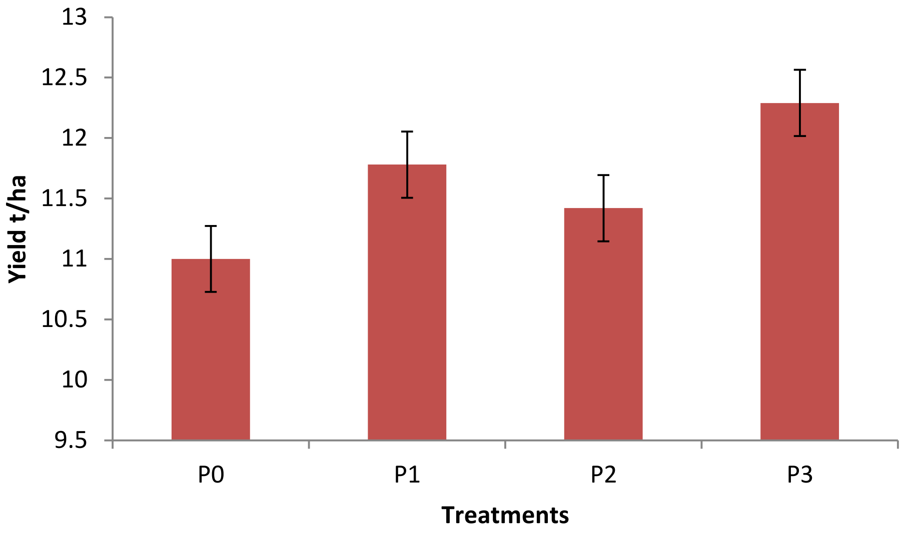


Fig 4. Effect of phosphorus on average fruit yield ton ha^{-1} of chilli

P_0: 0 kg P_2O_5 ha^{-1} (control)

P_1: 30 kg P_2O_5 ha^{-1}

P_2: 45 kg P_2O_5 ha^{-1}

P_3: 60 kg P_2O_5 ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2013 to May 2014 to find out the influence of nitrogen and phosphorus on the growth and yield of chilli. In this experiment, the treatments consisted of four different nitrogen levels viz. N_0= 0 kg ha^{-1}, N_1= 100 kg ha^{-1}, N_2 = 120 kg ha^{-1}, N_3= 140 kg ha^{-1} and four different levels of phosphorus viz. P_0 = 0 kg ha^{-1}, P_1 = 30 kg ha^{-1}, P_2 = 45 kg ha^{-1} and P_3 = 60 kg ha^{-1}. The experiment was laid out in two factors Randomized complete Block Design (RCBD) with three replications. Data on different growth parameters and yield with yield contributing characters of chilli were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatments was found while different nitrogen and phosphorus levels were applied in different combinations.

There are significant differences among the influence of different levels of nitrogen in case of almost all the parameters. At 25, 55 and 70 DAT, plant height (14.06, 25.27 and 27.35 cm respectively) were maximum at N_2 levels while the lowest was (11.98, 22.08 and 25.21 cm respectively) found from N_0 treatment. At 40 and 85 DAT plant height (21.06 and 30.96 cm) was maximum at N_1 levels respectively while the lowest was (17.81 and 27.45 cm) found from N_0 treatment respectively. At 25, 40, 55, 70 and 85 DAT, the maximum (31.17, 71.52, 143.45 and 200.83) number of leaf were found in N_3 treatment respectively whereas the lowest were (26.35, 54.81, 94.7, 140.98 and 181.00) observed from N_0 treatment respectively. At highest plant canopy, leaf length, leaf breadth and number of branches plant^{-1} were (30.50, 9.18, 2.88 and 13.73 cm) observed in N_3 respectively whereas the lowest (27.83, 7.96, 2.06 and 9.42

cm) were found from N_0 respectively. The maximum fruit diameter, fruit pedicel, fruit length, individual fruit weight, yield plant^{-1}, yield plot^{-1} and yield ha^{-1} (0.82 cm, 2.42 cm, 5.16 cm, 2.50 gm, 235.00 gm, 3.75 kg and 12.83 ton respectively) were recorded from N_3 while the lowest were (0.68 cm, 2.09 cm, 4.74 cm, 1.54 gm, 162.20 gm, 2.59 kg and 8.88 ton respectively) observed from N_0.

Phosphorus significantly influenced maximum parameters selected for data collection but not significant in 55 DAT. At 25, 40, 70 and 85 DAT the highest plant height (14.69, 20.89, 27.75 and 30.63 cm respectively) were obtained from P_2 while at 25 and 40 DAT the lowest were (12.09 and 18.42 cm respectively) found from P_0 treatment. At 70 and 85 DAT the lowest plant height were (26.04 and 28.90 cm respectively) found from P_1 treatment. At 85 DAT the maximum plant height was 197.10 cm found from P_2 treatment. At 25, 40, 55 and 70 DAT the maximum number of leaves were (30.73, 71.44, 143.73 and 167.93 cm respectively) were obtained from P_1 while the lowest were (28.92, 59.73, 102.98, 125.79 and 165.73 respectively) found from P_0 treatment. At maximum (9.03 cm) leaf length was observed in P_1 treatment while the lowest (8.08 cm) was from P_0 treatment. At maximum plant canopy, leaf breadth and number of branches plant^{-1} were (30.00, 2.67 and 12.29 cm) observed in P_3 respectively whereas the lowest (28.27, 2.36 and 11.00 cm) were found from P_0 respectively. The maximum fruit diameter, fruit pedicel and fruit length, individual fruit weight, yield plant^{-1}, yield plot^{-1} and yield ha^{-1} (0.79 cm, 2.43 cm, 5.25 cm, 2.42 gm, 220.25 gm, 3.52 kg and 12.06 ton) were recorded from P_3 while the lowest were (0.75 cm, 2.05 cm, 4.81 cm, 1.54 gm, 145.25 gm, 2.24 kg and 7.68 ton) respectively observed from P_0.

The combinations of nitrogen and phosphorus significantly influenced almost all the parameters. At 25, 40, 55, 70 and 85 DAT, the highest plant height were 16.50, 26.67, 28.83, 30.67 and 34.17 cm respectively observed under N_2P_2 treatment whereas the lowest height were 7.92, 13.00, 20.33, 22.33 and 25.00

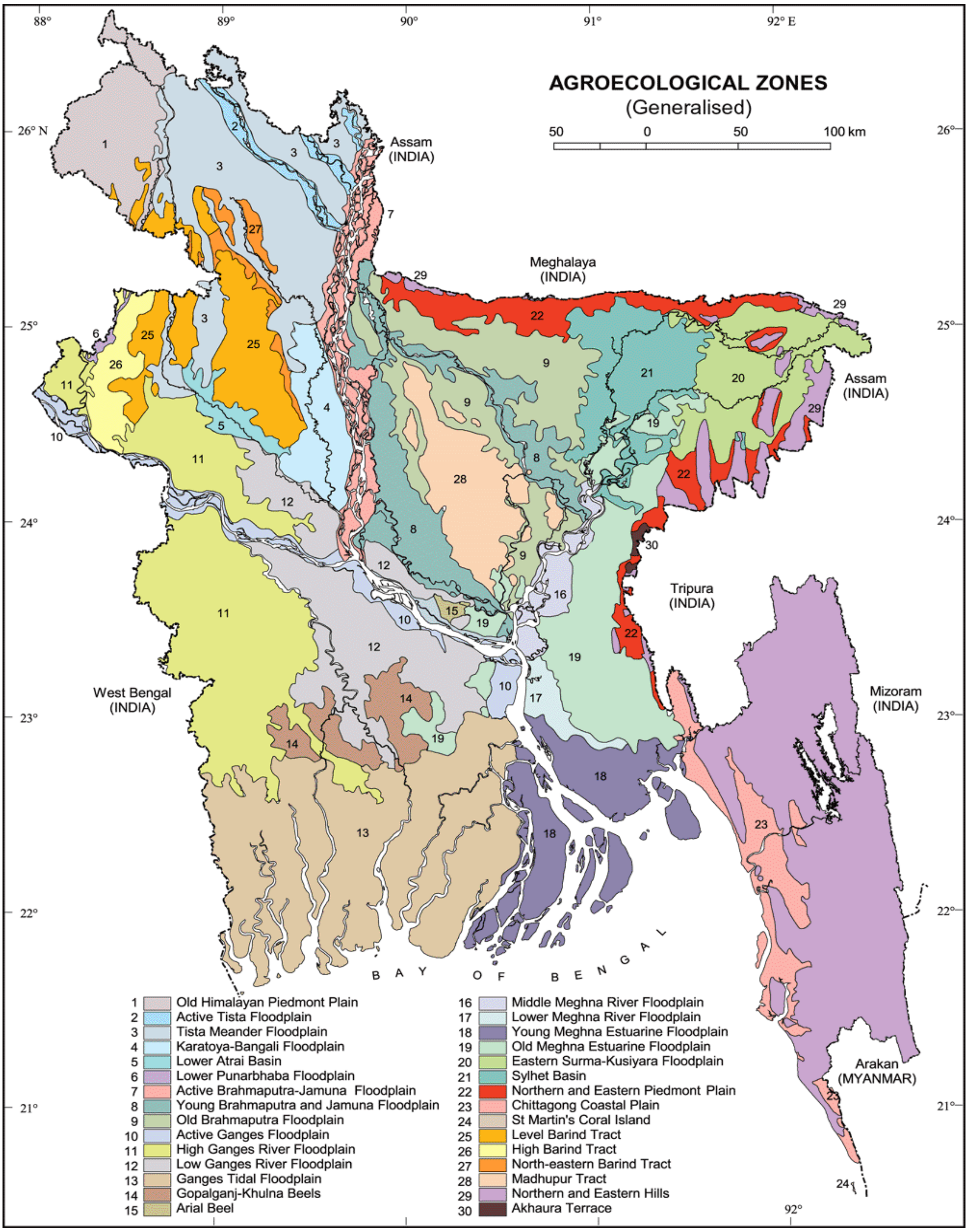
cm at N_0P_0 treatments respectively. The maximum number of leaves plant^{-1} at 25 and 40 DAT was N_2P_2 (34.25 cm and 88.27 cm respectively) whereas the lowest found from N_0P_0 (22.00 cm) and N_0P_3 (40.25 cm). At 55, 70 and 85 DAT the maximum number of leaves plant^{-1} were N_3P_1 (188.67, 207.92 and 235.08 cm respectively) whereas the lowest was (66.17, 120.00 and 150.25 cm) respectively. The highest leaf length and leaf breadth (10.91cm and 3.40 cm) were recorded in N_3P_1 and N_3P_3 whereas the lowest (6.85 cm and 1.54 cm) were recorded from N_0P_0. The maximum plant canopy, number of branches plant^{-1}, fruit diameter, fruit pedicel, fruit length, individual fruit weight, yield plant^{-1}, yield plot^{-1} and yield ha^{-1} was found from N_3P_3 (33.25 cm, 15.40, 0.95 cm, 2.87 cm, 5.60 cm, 2.52 gm, 235.00 gm, 3.39 kg and 12.32 ton respectively) whereas lowest were N_0P_0 (25.00 cm, 7.67, 0.57 cm, 1.77 cm, 4.27 cm, 1.56 gm, 160.73 gm, 2.22 kg and 7.20 ton respectively).

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 chilli. The effect of N @ 140 kg ha^{-1} with application of P_2O_5 @ 60 kg ha^{-1} on chilli yield was statistically highest. It was revealed that application of 140 kg N ha^{-1} along with 60 kg P_2O_5 ha^{-1} (N_3P_3) produce maximum yield and yield contributing characters of chilli.

APPENDICES

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



Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from August to December 2015

Month (2015)	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4
October	26.5	19.4	81	22	6.9
November	25.8	16.0	78	00	6.8
December	22.4	13.5	74	00	6.3

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1212*

Appendix III. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	Horticultural Garden, SAU, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Shallow Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(SAU Horticultural Farm, Dhaka)

Appendix IV. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

(SAU Farm, Dhaka)

Appendix V. Analysis of variance of the data on plant height of chilli as influenced by different levels of nitrogen and phosphorus at different days after transplanting

Source of variation	Degrees of freedom	Mean sum of square				
		Plant height (cm)				
		25 DAT	40 DAT	55 DAT	70 DAT	85 DAT
Replication	2	6.71	15.69	5.192	11.86	15.25
Nitrogen	3	9.39 **	50.97 **	42.61 **	30.78 **	31.39 **
Phosphorus	3	15.87 **	16.16 **	4.23 *	8.03 **	7.66 *
Interaction	9	9.26 **	28.54 **	14.72 **	18.66 **	14.05 **
Error	30	1.51	1.62	2.24	1.96	2.19

** indicates significant at 5% level of probability*
*** indicates significant at 1% level of probability*

Appendix VI. Analysis of variance of the data on number of leaves plant^{-1} of chilli as influenced by different levels of nitrogen and phosphorus at different days after transplanting

Source of variation	Degrees of freedom	Mean sum of square				
		Number of leaves plant^{-1}				
		25 DAT	40 DAT	55 DAT	70 DAT	85 DAT
Replication	2	4.27	49.73	12.87	3.05	4.48
Nitrogen	3	60.11 **	617.93 **	5977.10 **	1038.28 **	571.90 **
Phosphorus	3	8.18 *	434.84 **	3643.55 **	4546.63 **	2319.62 **
Interaction	9	37.15 **	573.60 **	2163.60 **	1414.21 **	997.42 **
Error	30	2.54	2.45	2.05	4.86	3.94

** indicates significant at 5% level of probability*
*** indicates significant at 1% level of probability*

Appendix VII. Analysis of variance of the data on morphological parameters of chilli as influenced by different levels of nitrogen and phosphorus at different days after transplanting

Source of variation	Degrees of freedom	Mean sum of square			
		Plant canopy (cm)	Leaf length (cm)	Leaf breadth (cm)	Number of branches plant^{-1} (cm)
Replication	2	1.32	0.149	0.33	4.48
Nitrogen	3	17.23 **	3.14 **	1.56 **	1597.28 **
Phosphorus	3	7.75 **	1.96 **	0.26 *	2423.22 *
Interaction	9	9.37 **	1.58 **	0.34 **	621.09 **
Error	30	1.12	0.18	0.07	3.94

** indicates significant at 5% level of probability*
*** indicates significant at 1% level of probability*

Appendix VIII. Analysis of variance of the data on yield contributing parameters of chilli as influenced by different levels of nitrogen and phosphorus at different days after transplanting

Source of variation	Degrees of freedom	Mean sum of square			
		Fruit length (cm)	Fruit diameter(cm)	Fruit pedicel (cm)	Individual fruit weight (gm)
Replication	2	0.158	0.002	0.03	0.003
Nitrogen	3	0.44 **	0.04**	0.29 **	0.83 **
Phosphorus	3	0.44 **	0.003 *	0.31 **	0.16 **
Interaction	9	0.19 **	0.02 **	0.09 **	0.07 **
Error	30	0.02	0.001	0.03	0.002

** indicates significant at 5% level of probability*
*** indicates significant at 1% level of probability*

Appendix IX. Analysis of variance of the data on yield contributing parameters of chilli as influenced by different levels of nitrogen and phosphorus at different days after transplanting

Source of variation	Degrees of freedom	Mean sum of square		
		Yield plant^{-1} (gm)	Yield plot^{-1} (kg)	Yield ha^{-1} (ton)
Replication	2	42.20	0.01	0.13
Nitrogen	3	1839.21 **	0.47 **	5.53 **
Phosphorus	3	781.54 **	0.20 **	2.35 **
Interaction	9	518.32 **	0.13 **	1.55 **
Error	30	10.09	0.003	0.03

** indicates significant at 5% level of probability*
*** indicates significant at 1% level of probability*