EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH, YIELD AND QUALITY OF *CAPSICUM*

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CERTIFICATE

This is to certify that the thesis entitled " EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH, YIELD AND QUALITY OF *CAPSICUM* " submitted to the *DEPARTMENT OF SOIL SCIENCE*,, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE (M.S.) in SOIL SCIENCE*, embodies the results of a piece of *bona fide* research work carried out by *SHIB SANKAR ROY* , Registration. No. 06-02158, 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 have been duly acknowledged.

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DEDICATED TO

MY

BELOVED PARENTS

AND

BROTHERS

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Abstract

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka during November 2006 to March 2007 to study the effects of nitrogen and phosphorus on growth, yield and quality of capsicum in a Randomized Complete Block Design (RCBD) with three replications. 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_{60}, respectively). Days to flower bud emergence, days to first flower opening, plant height at first flowering and at first harvest, number of branches at first flowering , 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, plant height at final harvest, number of branches at first and final harvest, average weight of fruit, yield, thickness of pericarp and dry matter content increased significantly up to 150 kg N ha^{-1} (N_3 treatment). On the other hand, days to flower bud emergence, plant height at first flowering, number of branches at first harvest, average weight of fruit, yield, thickness of pericarp and dry matter content increased significantly with increasing levels of P up to the treatment P_1 (30 kg P ha^{-1}), where as plant height and number of branches at final harvest, length of *Capsicum*, 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 significant days to flower bud emergence, days to first flower opening, days to first fruit set and plant height at final harvest were obtained from N_2P_2 (100 kg N + 60 kg P ha^{-1}). On the other hand, maximum length of *Capsicum*, breadth of *Capsicum*, number of fruits per plant, average weight of fruit, yield and dry matter content were found in the treatment combination N_3P_1 (150 kg N + 30 kg P ha^{-1}). The highest N content (1.71%) was observed in N_{100} treatment, but the highest concentration of N was obtained with $N_{150}P_{60}$ treatment. The highest P concentration (0.035%) was recorded in P_{60} treatment. Phosphorus content in plants was ranged from 0.027 to 0.035%.

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ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
@	At the rate
CEC	Cation Exchange Capacity
cm	Centimeter
C. annum	*Capsicum annum*
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
CPE	Cumulative Pan Evaporation
CS	Color Spots
DMRT	Duncan's Multiple Range Test
DAT	Day After Transplanting
DW	Dry Weight
e.g.	Exempli gratia (for example)
et al	Sequentially All
FYM	Farm Yard Manure
1 Feddon	1 feddon = 0.42 ha
FW	Fruit Weight
g	Gram
IRP	Incubated Rock Phosphate
i.e.	that is
IW	Irrigation Water
K	Potassium
kg	Kilogram
$kg\ ha^{-1}$	Kg per hectare
K_2SO_4	Potassium Sulfate
LSD	Least Significant Difference
LAR	Leaf area rate
m	Meter
m^{-2}	Per Meter Squire
mm	Millimeter
MP	Muriate of Potash
MRP	Mussoorie Rock Phosphate
N	Nitrogen
NPK	Nitrogen, Phosphorus and Potassium
NS	Not Significant
NAR	Net assimilation rate
OM	Organic matter
pH	Hydrogen ion concentration
P	Phosphorus
PM	Poultry Manure
WAP	Week After Planting
WRS	Within Row Spacing

CHAPTER 1
INTRODUCTION

Sweet pepper botanically referred to as the genus *Capsicum* is the member of *Solanaceae* family. It is the native to the Tropical South America and Brazil (Shoemaker and Teskey, 1955). Columbus introduced it to Spain and Portuguese brought *capsicum* to India from Brazil. The genus *Capsicum* consists of about 20 species and only four species are under cultivation, out of which *C. pendulum* and *C. pubescens* are restricted to the South and Central America. The other two species such as *C. annum* and *C. frutescens* are commonly cultivated throughout the world. *C. annum* is the most commonly cultivated species and all green chilies in the market and most of the dry chilies belong to this species.

Within *capsicum* a tremendous range in size, shape and mature color of fruits are found and it has been selected on the basis of the types used in commerce throughout the world (Somos, 1984). The species *Capsicum annum* includes eleven groups (Farris, 1988), which can be divided into Sweet pepper and Hot peppers. Sweet pepper is relatively non-pungent or less pungent with thick flesh and it is the world second most important vegetables after tomato (AVRDC, 1989).

Sweet pepper is also known as bell pepper, green pepper or *capsicum*. It may be used as cooked or raw salad. The leaves are also consumed as salad, soups or eaten with rice (Lovelook, 1973). It was also discovered to be a good source of medicinal preparation for black vomit, tome for gout and paralysis (Knott and Deanon, 1967). Sweet pepper is minor vegetables in Bangladesh and its production statistics is not available (Hasanuzzaman, 1999). Small scale cultivation is found in Dhaka and Gazipur districts to supply in the market of Dhaka city. It has got a good demand to some big hotels in the Capital city of Bangladesh to feed foreigners (Rashid, 1999). This crop is recently introduced in Bangladesh but it has high nutritional value as well as high demand for export.

In Bangladesh, half of the population is under the poverty level and suffer from various health problems. Severity of malnutrition and iron deficiency is the highest among female and all groups of children. Approximately one million Bangladeshi children have clinical signs of vitamin A deficiency and more than 9, 00,000 children less than six years of age suffer from some degree of xeropthalmia and over 30,000 children go under blind each year due to severe vitamin A deficiency (Javior, 1992). Almost 80 % of blind children come from landless household. Recent studies have been shown that vitamin A is not only important to prevent blindness but also has impact on digestion of food, child morbidity, and mortability. It is estimated that about 90 % of the population suffers from vitamin C deficiency. Sweet pepper has little energy value but the nutritive value of sweet pepper is high especially for vitamin A and vitamin C.

Horticultural hot pepper and sweet pepper are two different crops. Hot pepper has been adopted in diverse environmental condition in Bangladesh. But sweet pepper is not an established crop in Bangladesh, although the environment of Bangladesh is suitable for growing sweet pepper. However, its production has some constrains which include flower dropping, poor fruit set, susceptibility to viral disease, etc. The most frequent causes of bell pepper abscission are environmental factors such temperature is the most important factor causing flower abscission (Wien, 1997). The maximum fruit set of bell pepper occurs at temperature from 16^0C to about 23^0C, but night temperature below 16^0C and day temperature above 32^0C prevent the fruit set (Hasanuzzaman,1999). Low humidity and high temperature will cause abscission of bud, flowers and small fruits (Deanon, 1967). At least three month cool weather is required for good yield of sweet pepper. Poor fruit set is also associated with low light intensity (Kato and Tanaka, 1971) and low moisture (Cochran, 1936). However, there is no established variety of sweet peppers in Bangladesh. Therefore, the investigation is necessary to select ideal genotype of sweet pepper for this country.

Fertilizer is one of the major factors of crop production. Among the factors, nitrogen is very much essential for good plant establishment and expected growth (Uddin and Khalequzzaman, 2003). 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 can not sustain the productivity of soils under highly intensive cropping systems (Singh and Yadev, 1992).

Optimum dose of fertilizers increase the proper growth, development and maximize the yield of sweet pepper. Slow release fertilizers also hold great promise for the production of solanaceous vegetables such as egg plant and tomato (Gezerel and Donmez, 1988). They found that slow-release fertilizers produce 92 t ha^{-1} of tomato, compared to only 42 t ha^{-1} when ordinary commercial fertilizers are used. Many researchers of different countries of the world have been attempting for commercial cultivation of sweet pepper under various cultural aspects. Fertilizer rate influenced quantity and quality of *capsicum*. Fertilizer rates influenced capsaicin content and colour of powdered pepper (Yodpetch, 1997).

Therefore, the present investigation was undertaken with the following objectives:

1. To study the effect of nitrogen and phosphorus fertilizers on growth and yield of sweet pepper.
2. To find out the optimum dose of fertilizer for successful growth and yield of sweet pepper.

CHAPTER 2

REVIEW OF LITERATURE

Sweet pepper is an important vegetable in many parts of the world. It is sensitive to various environmental factors *viz.* soil, temperature, humidity, light intensity and moisture for proper growth and yield. Many researches have been conducted on various cultural aspects of sweet pepper in different countries. Literature regarding the studies on effect of influence of nitrogen and phosphorous on growth and yield and quality of capsicum are scanty in Bangladesh. Sweet pepper, egg plant, and tomato belonging to the same family have more or less same growth habit and nutrient requirements. Because of the published report on sweet pepper, relevant literature on tomato and eggplant is included in this chapter along with sweet pepper. The available literatures related to the present study are reviewed here.

Effect of nitrogen

Kacha *et al.* (2007) conducted a field experiment in Anand, Gujarat, India, during the kharif-rabi seasons of 2002-03 and 2003-04 to study the effects of levels of spacing (60 x 60 and 90 x 60 cm), castor (*Ricinus comunis*), cake (0 and 1 t ha^{-1}) and N (100, 150, 200 and 250 kg ha^{-1}) on the green fruit yield of green chilli (*C. annum*) on a loamy sand soil. Transplanting chilli at the narrow spacing of 60 x 60 cm significantly decreased the number of secondary branches, green fruits per plant, plant height and green fruit yield compared to the wider spacing of 90 x 60 cm. Application of N at 150 kg ha^{-1} significantly increased the growth, yield, and yield components compared to the control; on the other hand, it was at par with the 200 and 250 kg ha^{-1} treatments. Transplanting chilli at 60 x 60 cm spacing, applying castor cake at 1.0 t ha^{-1} including 150 kg N ha^{-1} increased the green fruit yield.

Lee-WeiLi *et al.* (2007) conducted a field experiment in which *Capsicum annum* cultivars Beauty Zest and California were hydroponically-grown and supplemented with N fertilizer (6, 10 and 14 mM) to study plant and fruit development, capsaicin content and capsaicin biosynthesis. N at 6 mM gave short plants, light weight, small leaf area and more deficient in total chlorophyll content, and lower activities of nitrate reductase and glutamine synthesize. However, the root: shoot ratio of Beauty Zest increased. The placenta ratio also increased with 6 mM N while fruit set and yield were significantly lower than in the other treatments. The amount of capsaicin in Beauty Zest fruit was highest with 6 and 10 mM N treatments while California fruit was highest with 10 and 14 mM N treatment.

Grazia *et al.* (2007) was introduced fast-growing seedlings have larger immediate nutrient demands compared with adult plants. A tray experiment was conducted to evaluate the fertilizer supplementation of sweet pepper transplants growing on different substrates like farmyard compost, vermin-compost, and commercial fertilizer with weekly applications of N at 150 and 300 mg/liter, compared to a control without fertilizer. The leaf area and fresh and dry weights of leaves, stems and roots were measured for the transplants. N application had positive effects on most growth parameters of seedlings growing on substrates with compost, promoting increased precocity and yield in the transplanted crop. Few benefits from N fertilizer application were observed for seedlings growing on substrates without compost.

Kumar *et al.* (2006) were conducted a field experiments in Andhra Pradesh, India, during the 2002-03 and 2003-04 kharif seasons, to study the effect of organic manure (1.0 and 2.0 q neem cake and 5.0 and 10 t poultry manure ha^{-1}) in combination with N fertilizer applications on the growth and yield of chilli. Poultry manure at 10 t + 75% recommended rate of N fertilizer ha^{-1} recorded significantly maximum fresh (76.9 q ha^{-1}) and dry pod yields (24.5 q ha^{-1}). Plant height, spread, fruit length and girth were insignificant. Mean number of fruits (176.6), fresh weight (300.7 g) and dry weight (106.5 g) per hill were significantly maximum in poultry manure at 10 t + 75% recommended N fertilizer rate.

Hari *et al.* (2006) recommended the effects of nitrogen rate (50, 75 and 100%), in combination with neem cake (1 and 2 t ha^{-1}), poultry manure (5 and 10 t ha^{-1}) and sheep manure (6 and 12 t ha^{-1}) on the yield and nutrient uptake of paprika (*C. annum*) were determined in a field experiment conducted in Andhra Pradesh, India during the kharif season of 1998-2000. Application neem cake at 2 t h^{-1} in combination with 75% recommended nitrogen rate resulted in the highest dry pod yield (4.078 g), dry plant weight (141.67 g), N uptake (168.43 kg ha^{-1}) and K uptake (177.80 kg ha^{-1}), whereas application of poultry manure at 10 t ha^{-1} in combination with 75% recommended nitrogen fertilizer resulted in the highest P uptake (42.17 kg ha^{-1}) of the plant.

Ghoname *et al.* (2005) studied on the effects of different N fertilizer sources, i.e. organic (chicken manure at 4 and 8 cm3), mineral (100-75-50 kg NPK ha^{-1}) and biofertilizer (rhizobacteria as commercial product called Microbin at 2 kg/greenhouse) on the growth and productivity of sweet pepper (*C. annum*) grown on a sandy soil in a greenhouse. Application of organic manure combined with biofertilizer and mineral N resulted in vigorous plants, expressed as plant length, number of leaves and stems as well as shoots dry weight. In addition, it recorded the best values for total acidity, vitamin C content, total soluble solids percentage, dry matter and N, P, K, Fe, Mn, Zn, Cu, Ni and Pb contents of fruits.

Zhu *et al.* (2005) was conducted a randomized-block greenhouse plot experiment on N utilization efficiency and N losses in intensive hot pepper (*Capsicum frutescens* L.) production systems typical of commercial practice in Shouguang, snortheast China. Crop yield and N utilization, soil mineral N dynamics and potential nitrate leaching losses were studied in control plots receiving no N fertilizer or organic manure and in experimental plots receiving 0, 600, 1200 or 1800 kg urea-N ha^{-1} plus a basal dressing of 15 t ha^{-1} air-dried poultry manure supplying 178 kg N ha^{-1}. Ammonia volatilization from the soil surface was monitored. A microplot was established in each of the plots receiving 1200 kg urea-N ha^{-1} (the local average commercial fertilizer N application rate), the urea applied to the microplot was labelled with 10 atom % 15N tracer and residual soil 15N and 15N in harvested plant parts were determined. Previous intensive cropping led to a very high residual soil mineral N content (1117 kg N ha^{-1}) before the experiment began and control plots gave a satisfactory mean fruit yield of 5.7 t DM ha^{-1} with no significant yield response to applied fertilizer and poultry manure. Only 10% of applied fertilizer N was recovered in the aboveground parts of the crop and about 52% was lost from the soil-plant system. Substantial nitrate leaching losses occurred using the two highest fertilizer N application rates but there was little NH volatilization from the soil surface.

Rocha *et al.* (2003) carried out a field trial in Rio de Janeiro, Brazil, from May to December 2002, the sweet pepper cultivars Magda and Cascadura Itaipu and the hybrid Magali were sprayed weekly with bacteridides (streptomycin sulfate + oxytetracycline at 0.8 g a.i./litre, or copper oxychloride at 2.4 g a.i./litre) or the biofertilizer Agrobio (5%). Yield was greater in Magali (11.57 t ha^{-1}), than in Cascadura Itaipu (6.03 t ha^{-1}) or Magda (4.47 t ha^{-1}), but was not affected by any of the treatments. Application of Agrobio resulted in lower N and K levels in fruits.

Sharu *et al.* (2001) conducted a field experiment in Vellayani, Kerala, India, during 1999-2000 to study the effect of poultry manure, vermin-compost, and neem cake, singly (100%) or in combination (25, 50, or 75%) with inorganic N (25, 50, or 75%), on chilli yield and quality. The highest fruit yield (9.66 t ha^{-1}) was obtained with 50% poultry manure+50% inorganic N. The best keeping quality and highest ascorbic acid content was recorded for 100% poultry manure, 50% inorganic N+50% poultry manure, 25% inorganic N+75% poultry manure, 25% inorganic N+75% vermin-compost, 100% vermin-compost, 25% inorganic N+75% neem cake, and 100% neem cake. Poultry manure was superior among the organic fertilizers, and a 1:1 ratio of inorganic to organic fertilizer was best for increasing chilli yield and quality.

Singh *et al.* (2000) conducted an experiment to determine the optimum plant density and nitrogen requirement of dwarf chilli variety KDCS- 810. Three levels of N (90, 120, and 150 kg ha^{-1}) and five levels of spacing (30 x 45, 30 x 22.5, 30 x 30, 30 x 37.5 and 30 x 45 cm) with its basal dose of P_2O_5 and K_2O each at 60 kg ha^{-1}. As regards the yield of chilli, nitrogen showed direct response more pronouncedly at the lower levels of fertilization.

During first and second year, significant increase in fruit yield (54.7 and 80.5 q ha^{-1}, respectively) was obtained up to 120 kg N ha^{-1} and in the third year, it yield was non significant. Closer spacing was beneficial and 30 x 22.5 cm spacing produced the maximum yield followed by 30 x 15 cm spacing. N at 120 kg ha^{-1} and 30 x 22.5 cm spacing yielded the highest number of chilli.

Ruiz *et al.* (2000) grew capsicum plants under controlled conditions and N was applied as at 6, 12, 18 or 24 g m^2 and K at 4, 8 or 12 g m^2). Applying high rates of N and K led to an increase in the absorption and translocation of nitrate to the shoot. However, ammonium was the main N form assimilated by the plant. The products of assimilation, mainly proteins, increased with higher N and K rates. Acid phosphates activity was a good indicator of plant P status.

Pulgar *et al* (2000) conducted an experiment in which *Capsicum annum* were grown in controlled greenhouse conditions in artificial soil with application of 6, 12, 18 or 24 g N/m^2 and 4, 8 or 12 g K/m^2. There was an increase in foliar inorganic anions in proportion to the increase in NK rates applied. In general, citric acid levels in leaves were lower at the lower NK rates, and they increased with increase in NK application. No clear response was observed of ascorbic acid to rate of NK application. The internal cationic excess led to an increase in hydrogen ions, either extruded or integrated into the tissue.

Owusu *et al.* (2000) conducted a field trial in sandy loam Ferric acrisols. All of four sources of nitrogen, urea, ammonium sulfate, ammonium nitrate and potassium nitrate, significantly increased plant growth parameters, number of fruits and yield per hectare of four capsicum pepper varieties. The nitrate forms gave taller plants with bigger girths, which looked greener, had more fruits and gave higher yields than the other sources. Ammonium nitrate gave 72-101% greater yields than ammonium sulfate.

Baghour *et al.* (2000) grew *Capsicum annum* in controlled greenhouse conditions in artificial soil with application of 6, 12, 18 or 24 g N/m^2 and 4, 8 or 12 g K/m^2. Leaf S concentrations were related to the influence of NK application rate. The highest concentrations of total S were obtained with the treatment in which the rhizospheric concentration of N was low, while K was intermediate. It was suggested that N has a more direct effect than K on leaf levels of total organic S. Sulphate concentration was closely related to total S.

Aliyu *et al.* (2000) was studied the response of pepper to various mixtures of organic manures with and without supplementary addition of mineral fertilizer under field conditions. Application of farmyard manure and 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 in 1995. Farmyard manure at 10 t ha^{-1} and poultry manure at 5 t ha^{-1} out-yielded with other treatments in 1996. High rates of combined organic and mineral fertilizers significantly reduced crop establishment in 1996 and caused excessive vegetative growth in both years. Mineral N fertilization resulted in higher concentrations of N, P and K in pepper fruits.

Hasanuzzaman (1999) reported that sweet pepper is considered as minor vegetables in Bangladesh and its production statistics is not available. Application of 150 kg ha^{-1} in equal splits, at planting, 30 days and 60 days after planting gave continuously higher yield of sweet pepper cv. 'California Wonder' under Hessarghata (Bangalore) condition (Srinivas and Probhokar, 1982).

Sontakke *et al.* (1995) performed a field trial in kharif (monsoon) 1990-91 at Parbhani, Maharashtra, India, capsicum cultivars Pusa Jwala and Pant C-1 were sown at 30 x 45, 45 x 45 or 45 x 60 cm spacings and were given 0-120 kg N ha^{-1}. Red dry chilli yield was highest in cv. Pusa Jwala, it increased with rate of N application and it was highest at the 30 x 45 cm spacing.

Santamaria *et al.* (1995) performed an experiment on Sweet pepper was grown in growth chambers (starting at the 3 to 4-true-leaf-stage) in modified Hoagland's solution for 39 days to determine the influence of $NH_4^+ + NO_3^-$ ratio (100:0, 70:30, 30:70 and 0:100) on growth and water uptake. Ammonium-fed plants (100: 0 ratios) were characterized by poor root and shoot development, darker green coloured foliage and the lowest number of flower buds. Results from this study suggest that NO_3^- is the form of N preferred by sweet pepper.

Gulati *et al.* (1995) conducted a field trial in the winter (Rabi) season of 1992-93 on a sandy-clay loam with Capsicum cv. NP 46. A seedlings planted on 1 Dec. N was applied at 40, 60, 80 or 100 kg ha^{-1}, with half applied after establishment and the remainder 3 weeks later. Irrigation was applied at an irrigation water: cumulative pan evaporation (IW: CPE) ratio of 0.4, 0.6, 0.8 or 1.0. Dry chilli yield and net return increased with increasing N and irrigation rates, being highest with 100 kg N $ha^{-1}$and 1.0 IW: CPE (14.58 q $ha^{-1}$and Rs 18 475 ha^{-1}, respectively); however, yield was not significantly lower with 80 kg N ha^{-1}.

Elia *et al.* (1995) conducted an experiment on Sweet pepper were grown in growth chambers starting at the 3 to 4 true-leaf stage in a modified Hoagland's solution for 30 days to determine the influence of $NH_4 + NO_3^-$ ratio (100:0, 70:30, 30:70 and 0:100) on N, oxalate and ion content in the different plant parts. Increasing NO_3^- and decreasing NH_4^+ in the nutrient solution increased the concentrations of inorganic cations and organic anions, especially in the leaves. On a whole plant DM basis, total inorganic cation concentrations were raised by 25, 22 and 35%, when nitrate in the nutrient solution increased from 0 to 30%, 30 to 70% and 70 to 100% of the total N supplied, respectively. These results suggest that leaves are the most important site of nitrate assimilation in pepper.

Olsen *et al.* (1994) conducted a study to assess the usefulness of petiole sap nitrate and total nitrogen in dried leaves for determining N status and yield response in *Capsicum annum* plants. Five rates of N (0, 70, 140, 210 or 280 kg ha^{-1}) were applied in factorial combination with 2 rates of potassium (0 or 200 kg ha^{-1}) in randomized block experiments. For the fertilizer application strategy, 60% of N was applied before fruit set and 40% after. Sap nitrate concentrations associated with 95 and 100% of maximum marketable fruit yield increased respectively. It was concluded that petiole sap nitrate was a better indicator of plant N status and yield response of capsicums.

Mishriky *et al.* (1994) the effect of N application rates (20, 40 or 60 kg/feddan) to *Capsicum* (cv. California Wonder) grown at various plant spacings (30, 40 or 50 cm). N was applied as ammonium sulphate in 2 equal doses, 3 and 6 weeks after transplanting. Increasing the N rate significantly increased plant height, FW and DW/plant, number and weight of fruits/plant and total fruit yield. Fruit yield was affected by a significant interaction between N rates and plant spacing. The highest total yield increase from 4.88 to 9.00 ton/feddan and from 5.71 to 9.62 ton/feddan in 1991 and 1992 respectively was obtained with an increase in N rate from 20 to 60 kg/feddan combined. Fruit N and P contents increased significantly as the N rate increased to 60 kg/feddan. [1 feddan = 0.42 ha].

Aloni (1994) conducted an experiment "Colour spots" (CS) in pepper fruits is a physiological disorder characteristic of some sweet pepper cultivars. The effects of shading and N supply (100 or 250 mg N/litre) on the susceptibility of 3 sweet pepper cultivars (Maor, Lady Bell and 899) to CS were investigated. The incidence of CS was promoted by high N and shading. The fruits of all cultivars had lower N concentrations than the leaves but there were no significant differences in fruit N content between Maor and the CS-insensitive cultivars. Differences in Mg or K concentrations in these spots were less pronounced. Only in Maor fruits was the oxalate concentration increased by 9-fold when the N supply to shaded plants was increased.

Anez *et al.* (1993) evaluated four N application rates (NL, 0, 150, 300 and 450 kg ha^{-1}), 3 between-row spacings (RS, 0.4, 0.8 and 1.2 m) and 2 within-row spacings (WRS, 0.2 and 0.4 m) in a trial with Capsicum (cv. Cacique) plants growing in a sandy clay loam soil. Stem diameter was influenced by NL x RS and NL x WRS interactions. The number of primary shoots was affected by NL x RS and NL x WRS interactions, and the number of secondary shoots was affected by NL x RS x WRS interactions. Fruit yield was influenced independently by RS and WRS but not by NL.

Ingle *et al.* (1992) used the cultivar CA-960 is highly rated in Maharashtra because of its high yield and fruit quality. Split applications of N fertilizer have been recommended by various researchers and a trial was conducted to compare 2 (control), 3, 4, 5, 6 and 7 applications totalling 100 kg N ha^{-1}. A basal dressing of 50 kg each of P_2O_5 and K_2O $ha^{-1}$was applied to all plots. The first split dose in all treatments was applied 8 days after planting and the others were given at 21-day intervals. All growth parameters measured (plant height, plant width, stem diameter and number of branches/plant) and the yields in kg of fresh and dry chillies ha^{-1} were greatest with 4 split applications of N. Yields were almost as high with 3 split applications.

Demirovska *et al.* (1992) carried out the study on the yield and the N, vitamin C, total acids and dry matter contents were determined in fruits of 3 cultivars given N at 0, 180, 240 or 320 kg $ha^{-1}$and grown in soil previously treated with 40 t FYM ha^{-1}. The 2 lower N rates produced higher yields in all 3 cultivars than did the 2 higher rates. Vitamin C content was highest in cv. Sivrija (182 mg/100 g) with 0 or 180 kg N, in cv. Zlatna Medalja (237 mg/100 g) with 320 kg N, and in cv. Kurtovska Kapija (207 mg/100 g) with 180 kg N ha^{-1}.

Aliyu *et al.* (1991) was carried out a field trial at Samaru, Nigeria, during 1990 on cultivars UL 2289 and PL 2289 planted at 3 intra-row spacings (30, 40 or 50 cm) and supplied with 4 N rates (0, 60, 120 or 180 kg ha^{-1}). With respect to intra-row spacing, greatest plant height (38.31 cm), leaf number (166.34), branch number (35.69) and fruit diameter (9.11 mm) were obtained at the 50 cm spacing, whereas highest fresh fruit yield (2953.12 kg ha^{-1}) was obtained at the 30 cm spacing. With respect to N application, greatest plant height (54.12 cm), leaf number (206.31) and branch number (32.67) were obtained with 180 kg ha^{-1}. Highest fruit number (263.44), fruit diameter (8.89 mm) and fresh fruit yield (2747.41 kg ha^{-1}) were obtained with 120 kg N ha^{-1}.

Natarajan (1990) conducted the trials during 1989-90 with the cultivar Ramanathapuram Local growing on soil of low available N, medium to high available P, and high available

K contents, the plants received N at 0, 30, 45, 60 or 75 kg ha^{-1} via the soil; in some cases 1% urea at 2.5 kg N ha^{-1}as a foliar spray was also applied 7 and 14 days after the soil application. Application of 75 kg N ha^{-1} via the soil + 2 foliar sprays gave the highest yield of dry pods (1.83 t ha^{-1}).

Gezerel and Donmez (1988) showed that slow release fertilizers hold great promise for the production of solanaceous vegetables such as eggplant and tomato. They compared slow-release fertilizer (Plantacote) and conventional fertilizers of N, P, K, and Mg. @ 100, 80, 90, 30 Kg h^{-1}. They also found that slow-release fertilizer produced to only 42 t h^{-1} when ordinary commercial fertilizers were used. Nitrozen enhanced the growth and development, which ultimately increased the yield. While conducting an experiment in a solar greenhouse with the aid of a computer,

Hasan (1978) observed that with the increase of nitrogen fertilization the number of fruit yield increased in a certain level.

Gill *et al.* (1974) reported that number of days required for flowering of sweet pepper was found to increase with high dose of nitrogen application.

Effect of phosphorus

Alabi (2006) performed a study with five phosphorus levels (0, 25, 50, 75, 100 and 125 kg ha^{-1}) and five poultry dropping (0, 100, 200, 300, 400 and 500 kg ha^{-1}) levels on the growth, yield, yield components, nutrients concentration and food values of pepper (*Capsicum annum* 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^{-1}. The phosphorus application also significantly increased early flowering, maturity and yield ton ha^{-1} of the treated plants.

Liu-JianLing *et al.* (2005) performed a study to asses the effects of phosphate fertilizer on the yields of Chinese cabbage and *Capsicum*, and on soil P and plant P content were studied. The application of phosphate fertilizer at 56.25-225.00 kg ha^{-1} increased the yield of Chinese cabbage by 47.2-70.3% and that of Capsicum by 116.0-221.3%. A yield response was not observed when phosphate fertilizer was applied at more than 225.0 kg $ha^{-1}$to Chinese cabbage and at more than 450.0 kg $ha^{-1}$to Capsicum. The total P contents of Chinese cabbage and Capsicum, soil total P content, and Olsen-P at the 0-20 cm soil profile increased gradually with the increase in the phosphate fertilizer rate.

Akinrinde *et al.* (2005) carried out an experiment on crop growth is continuously threatened by phosphorus (P) limitation on most tropical and temperate soils. Besides P fertilizer management, soil type could significantly determine the efficiency of P use by specific crop species. The influence of 0, 50, 100, 150 and 200 mg P_2O_5 kg^{-1} soil on the growth, P nutrition and production of two fruit vegetables (hot pepper, *Capsicum frutescens* and okra, *Abelmoschus esculentus*) were evaluated. Increasing rates of P supply had insignificant effect on the growth of the crops on both soil types within the first four weeks after planting (WAP). Phosphorus at 50 mg P_2O_5 kg^{-1} application level, however, produced the tallest pepper plants (27.0 cm) on the Oxic Paleustalf after five weeks while it was the 150 mg P_2O_5 kg^{-1} level that produced the tallest plants (40.0 cm) at the 6th week on the Typic Paleudalf. Soil available P values obtained after cropping increased significantly with increasing rates of added P.

Jaggi *et al.* (2003) performed a pot culture experiment during 1997 and 1998 to compare the performance of S-containing and non-containing P fertilizers on chilli (*C. annum* cv. Surajmukhi) grown on acid Alfisol. Mussoorie rock phosphate (MRP) in combination with 37.5 ppm S, and single superphosphate (SSP) in combination with 12.5 ppm S were superior in terms of dry chilli weight and ratoon yield. The effect of the fertilizers on the number of chilli was significant only in 1997. MRP + 37.5 ppm S and SSP + 12.5 ppm. S resulted in the highest number of chillies per 20 kg weight.

Eissa *et al.* (2003) was conducted a pot experiment during 2000-01 and 2001-02 to study the effects of soil moisture (70, 100 or 125% of the field capacity), P fertilizer (50, 75 or 100 mg/kg of soil as KH_2PO_4) and Fe fertilizer (0.0, 2.5 or 5.0 mg/kg of soil as Fe-

Interaction effect of nitrogen and phosphorus

Chaudhary *et al.* (2007) evaluated the effect of spacing (45x50, 60x50 and 75x50 cm), N (at 100, 150, 200 and 250 kg ha^{-1}) and P (at 100, 150 and 200 kg ha^{-1}) on the growth and yield of *Capsicum annum* var. *grossum* hybrid on sandy loam soil. Decreasing spacing treatments from 75x50 to 60x50 cm improved the yield without adversely affecting the yield attributes. Maximum fruit yield per ha was recorded under 60x50 cm spacing. Maximum fruit yield was obtained with N at 250 kg ha^{-1}a, while P application increased yield by increasing fruit number and fruit yield/plant at concentrations up to 150 kg ha^{-1}

Balliu *et al.* (2007) conducted several experiments to estimate the influence of the major nutrient elements, i.e. nitrogen (N), phosphate(P) and potash (K), and their ratios of the nutrient solutions on the growth rate of pepper and aborigines seedlings in plastic greenhouses. Two sets of nitrogen concentration, i.e. 25, 50, 75 and 100 ppm, and 100, 200 and 400 ppm, were applied in different experiments, while phosphate and potash were in the following respective ratios (N:P:K): 1:0, 4:1, 2; 1:0, 6:1, 8; and 1:1, 2:2, 4. The necessary microelements were also added to the nutrient solutions and equal quantities of 20-50 ml/plant were supplied daily. Significant differences of relative growth rate (RGR) were found due to the N concentration of the nutrient solution. Statistically significant differences were found for both RGR components; net assimilation rate (NAR) and leaf area rate (LAR), at low N concentrations (25 to 100 ppm). Consequently, at low concentration of nutrient solutions, any increase of N concentration increased the seedling growth rate by both faster expansion of the LAR and higher physiological plant productivity. Meanwhile, at higher N concentration (100 to 400 ppm), increased values of RGR were achieved due to higher values of LAR, while the estimated values of NAR were mostly unchanged. RGR was not significantly affected by NPK ratio, neither its components, NAR nor LAR, but strong effect on the LAR components, SLA and LWR, was found.

Kappel *et al.* (2006) studied on the nutrient content of different organs of green pepper (*C. annum*) depends on the actual nutrient supply. The results of a test carried out to determine the specific nutrient requirements of green pepper revealed that the nutrient levels detected in the organs of green pepper plants differed significantly. In the case of N, the highest values were measured in the leaf (also with the highest fluctuation), while the N content in the fruit could be considered as uniform. For P, the highest values were determined in the fruit, and the range of fluctuation was higher in each organ than that of N. However, the P content of fruits proved to be the most uniform among the different organs. As for K, as opposed to N and P, the highest values were measured in the stem. The range of fluctuation was higher in each organ than those of the other 2 elements, in certain cases more than 3 or 4 times as much. Summing up the results of the experiments during the 3-year period, the specific nutrient requirements of green pepper was calculated as follows: 2.4-3.8 kg t^{-1} (N), 0.7-1.1 kg t^{-1} and 4.9-6.9 kg t^{-1}.The nutrient composition of individual plant organs depends on different environmental factors, especially on nutrient supply. The soil nutrient levels influenced the N, P and K levels of the different organs. Among the nutrients and organs, the N content of the fruit had the lowest range of variation and K showed the greatest differences. The nutrient content of the fruit is not a reliable indicator of nutrient supply of the plant or that of the soil, but can constitute the basis for estimating the amounts of nutrients removed from the soil by the fruits.

Chauhan *et al.* (2005) conducted a work on the effects of N (60, 120, 180 or 240 kg ha^{-1}) and P (60, 120 or 180 kg ha^{-1}) fertilizers, singly or in combination, on the growth and yield of capsicum (*Capsicum annum* hybrid PRC-2). N at 120 kg ha^{-1} gave the highest fruit yield (256.71 quintal ha^{-1}), plant height (62.90 cm), number of leaves per plant (111.89), and leaf area (30.76 cm^2). The number of days to 50% flowering and initial harvesting was lowest (36.78 and 55.0, respectively) was lowest with 60 kg N ha^{-1}. Plant height, number of leaves, leaf area and fruit yield increased with the increase in the P rate up to 180 kg ha^{-1} (61.69 cm, 100.00 per plant, 36.08 cm^2, and 234.60 quintal ha^{-1}, respectively). The number of days to 50% flowering and number of days to initial harvesting were also lowest (36.33 and 58.33) with 180 kg P ha^{-1}. Among the various N and P combinations, 120 kg N + 60 kg P ha^{-1} recorded the greatest plant height (64.83 cm), number of leaves per plant (118.0) and fruit yield (262.30 quintal ha^{-1}). [1 quintal=100 kg].

Aguilar-Acuna *et al.* (2005) studied on the efficiency in the use of fertilizers and better technologies for the use of water are needed to produce food in a sustainable way. The objective of this research was to determine the efficiency of chemical fertilizers applied with surface and subsurface drip irrigation in poblano chili pepper (*Capsicum annum*) cv. Ancho San Luis. A field experiment was conducted in Vertisoil of The Bajio Region in Guanajuato, Mexico. Treatments consisted of applying 33, 66 and 100% of the dose 200-100-280 kg ha-1 of N, P respectively, through surface and subsurface irrigation, plus an additional treatment with double row of plants and a control without fertilizer. Treatments were distributed in a complete block design with four replications. Results indicated that the dose 133-67-187 applied by subsurface gave 68% higher yield in comparison to the same dose applied by surface drip irrigation. With the dose 66-33-93 applied with surface drip subsurface, the highest efficiency was obtained for: use efficiency, with 356.70, 713.40 and 253.15 kg of fruit kg^{-1} of N, P and agronomic traits, with 193.15, 386.28, and 137.05 kg of yield increase kg^{-1} of N, P respectively. The efficiency of recovery was 73.6% for N, 18.3% for P.

Shehata *et al.* (2004) carried out this investigation out in Sadat City, Egypt, to study the effect of some organic manures on growth, and chemical composition of pepper (*Capsicum annum*) in a sandy soil during the 1999 and 2001 seasons. This investigation included 16 treatments (NPK, cattle manure, chicken manure and compost containing 165 kg N/feddan and their combination). Treatments which received NPK+chicken manure + compost at a rate of (1/3+1/3+1/3) increased plant height, number of leaves and stems as well as their fresh weight and increased concentration of N, P and K in leaves and stems. The same treatment increased total yield and physical properties, including the length, diameter, weight of fruits and flesh thickness and chemical composition of pepper fruits.

Sarma *et al.* (2004) conducted an experiment during 2000-03 in Gossaigaon, Assam, India to determine the optimum level of NPK for direct-sown chilli (*C. annum*). The treatments comprised 8 different combinations of N, P and K, i.e. 0:0:0, 30:15:15, 60:30:30, 90:45:45, 120:60:60, 150:75:75, 180:90:90 and 210:105:105 kg ha^{-1}. Plant height (27.25 cm), fruit number per plant (64.33), fruit weight (3.33 g) and yield (27.99 q ha^{-1}) of chilli increased significantly with 150:75:75 kg NPK ha^{-1}. The capsaicin contents of green and red ripe fruits were highest at 90:45:45 and 120:60:60 kg NPK ha^{-1}. The capsaicin content decreased with further increase in NPK level. The maximum return per rupee invested (3.92) was obtained at 90:45:45 kg NPK ha^{-1}, followed by 120:60:60 kg NPK ha^{-1} (3.86).

Raj-Narayan *et al.* (2004) conducted a field experiment during kharif to evaluate the effect of organic and inorganic fertilizers and their combinations on the N, P and K uptake, quality in terms of ascorbic acid and total chlorophyll content, and yield of *C. annum* cv. Nishat-1. The treatments comprised 100% recommended dose of NPK (90: 60 kg ha^{-1}) (T_1), 100% poultry manure (PM) at 8 t ha^{-1} (T_2), 100% sheep manure (SM) at 10 t ha^{-1} (T_3), 100% farmyard manure (FYM) at 25 t ha^{-1} (T_4), 75% PM+25% NPK (T_5), 75% SM+25% NPK (T_6), 25% FYM+25% NPK (T_7), 50% PM+50% NPK (T_8), 50% SM+50% NPK (T_9), 50% FYM+50% NPK (T_{10}), 25% PM+75% NPK (T_{11}), 25% SM+75% NPK (T_{12}), 25% FYM+75% NPK, and control (T_{14}). The fruit yield, ascorbic acid, chlorophyll content and N, P and K uptake by capsicum plants were affected significantly by the application of organic and inorganic fertilizers in combination. The maximum N, P and K uptake (134.56, 14.91 and 104.46 kg ha^{-1}, respectively), fruit yield (296.63 q ha^{-1}), ascorbic acid content (114.26 mg/100 g) and chlorophyll content (6.50 mg/g) were recorded in T_8. Thus, the integrated use of organic and inorganic fertilizers proved better in improving the yield, quality and N, P and K uptake than using organic or inorganic fertilizers alone.

Singh *et al.* (2004) conducted an experiments to determine the balanced amount of nitrogen, phosphorus and potassium for the higher yield and economics of chilli cv. Pant C-1 under Tarai conditions. Treatments comprised: 4 nitrogen rates (0, 60, 90 and 120 kg ha^{-1}) 3 phosphorus rates (0, 30 and 60 kg ha^{-1}) and a fixed rate of potassium (60 kg ha^{-1}). The yield of chilli fruits increased with increasing nitrogen levels. The lowest fruit yield was recorded in the control treatment. Among the treatment combinations, the highest fruit yield was recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}, followed by 120 kg N ha^{-1} + 30 kg P ha^{-1}. The lowest fruit yield was recorded in the control treatment where only 60 kg K ha^{-1} was applied as a basal dressing. Gross income and net profit per ha were highest in the 120 kg N + 60 kg P + 60 kg K ha^{-1} treatment combination, followed by the 120 kg N + 30 kg P + 60 kg K ha^{-1} treatment combination.

Maheswari *et al.* (2004) investigated the effects of foliar organic fertilizers (amino acid at 0.5 and 0.75%; humic acid at 0.1 and 0.2%; and vermiwash at 1:3 and 1:5 vermiwash: water ratios) on the quality and economics of chilli (*C. annum*) on sandy loam soil in Tamil Nadu, India. The recommended fertilizer rate was applied as basal and top dressing (complete dose; N: P: K at 160:60:30 kg ha^{-1}), and as basal application alone (80:60:30 kg ha^{-1}). The highest ascorbic acid content (175.23 mg/100 g) was observed in the treatment combination of vermiwash at 1:5 and basal and top fertilizer dressing. Capsaicin content and seed number were highest (0.49%) with 0.75% amino acid + complete fertilizer dose. Amino acid at 0.75% + complete fertilizer dose produced the best returns.

Srivastava *et al.* (2003) conducted a field experiments during the 1996, 1997 and 1998 summer seasons in Pantnagar, Uttaranchal, India, to study the optimum N and P requirement for capsicum hybrid Bharat. The treatments comprised: 60, 120, 180 and 240 kg N ha^{-1}; 60, 120 and 180 kg P ha^{-1}; and 60 kg K ha^{-1}. The pooled analysis of data showed that plant height, number and yield of fruits per plant, average per fruit weight and yield per hectare were not all significantly influenced by either N, P or N x P. However, in individual year, the yield was significantly influenced by N and N x P in 1997 and by N x P in 1998. During 1997, 180 kg N ha^{-1}gave significantly higher yield than 60 and 120 kg N ha^{-1}, however, during 1998; 60 kg N ha^{-1} gave the best yield. P at 60 kg ha^{-1} gave higher yield than 120 kg P ha^{-1} in 1998. The N x P treatment in 1997 showed that 120 kg N + 60 kg P ha^{-1}gave significantly higher yield than the other combinations.

Maheswari *et al.* (2003) conducted an experiment in Annamalai, Tamil Nadu, India to study the nutrient uptake pattern in chilli through the foliar application of organic nutrients. Treatments comprised: amino acid at 0.50 and 0.75%; humic acid at 0.1 and 0.2%, vermiwash at 1:3 and 1:5 dilution and water spray as the control. The recommended dose of fertilizer (RDF) was given as: basal + top dressing (160:60:30 kg NPK ha^{-1}) and basal dose alone (80:60:30 kg NPK ha^{-1}). Six sprays of the foliar nutrients were given at 20-day intervals commencing from the 30th day after transplanting. Among the factorial combinations, application of 0.75% amino acid with complete (100%) dose of RDF resulted in the highest N and K uptake of 59.68 and 31.88 kg ha^{-1}, respectively. The individual effect of amino acid improved the micronutrients, Fe, Zn, Mn and Cu (0.23, 0.04, 0.22 and 0.09 kg ha^{-1}.

Martinez *et al.* (2003) performed a study in which pepper (*C. annum*) fruits at the mature green stage were harvested from plants grown in Lara, Venezuela, and treated with 200+200, 200+400, 300+200, and 300+400 kg of nitrogen + potassium ha^{-1}, respectively. The fruits were washed, sorted and stored either uncovered or in polyethylene bags of 0.05 mm of thickness with 16 holes of 0.6 mm diameter. Three replicates for each treatment were used (one fruit per bag). The fruit were stored at 5 and 10 degrees C for 7, 14, 21 and 28 days for chemical and physical analysis (total soluble solids (TSS), pH, titratable acidity (TA), TSS/TA, colour and firmness). The pH increased in uncovered fruits from plants treated with high levels of potassium fertilizer and stored at 5 degrees C. The TA reached maximum values in fruits from plants treated with any combination of the highest level of potassium and nitrogen fertilizer and stored at 10^0C for 21 days.

Uribe-S *et al.* (2002) conducted a study in Mexico in 1999 to evaluate the effect of application of N (60, 100, 120, 140 and 180 kg ha^{-1}), P (match; 20, 53, 70, 86 and 120 kg ha^{-1}) and K (0, 33, 50, 66 and 100 kg ha^{-1}) on the yield of pepper (*C. annum*) cv. San Luis. The regression analysis with the complete pattern expressed highly significant differences for the lineal effects of N and P, significant for the K, highly significant for the quadratic effect of P, significant for the quadratic effect of K, and significant for the interaction NP. The rest of the variables of the pattern are not significant.

Sajan *et al.* (2002) conducted a field experiment during in Bangalore, Karnataka, India to study the effect of biofertilizers combined with different N, P and K fertilizer rates on the growth and yield of chilli cv. Byadagi Dabba. NPK fertilizer (75 or 100%) was applied alone (100%, the control) or in combination with Azotobacter, Azospirillum, phosphate solubilizing bacteria (PSB), and vesicular arbuscular mycorrhizas (VAM). The plants inoculated with Azotobacter, Azospirillum, PSB and VAM in combination with 75% NPK+100% K recorded the maximum plant height (100.03 cm), leaf area (28.79 dm^2/plant), and dry matter (187.36 g/plant) compared to the control. The plants also produced 36% more fruits per plant (111.38) and 45% more dry fruit yield (2.27 t ha^{-1}) compared to the control (81.68 and 1.56 t ha^{-1}, respectively).

Tumbare *et al.* (2002) conducted a field experiment at Rahuri, Maharashtra, India, during the summer season of 2000 to study the response of C. annum to N: P: K fertilizers applied as fertigation. The treatments consisted of 100% of recommended N: P: K rate with surface or drip irrigation, 100% recommended N rate through fertigation and P and K as band placement, 100% recommended N:P:K through fertigation, 70% N and 80% P and K through fertigation, 70% recommended N:P:K through fertigation, and 50% N and 80 or 70% P and K through fertigation. For treatments of 100% recommended N: P: K with surface or drip irrigation, N, P, and K were applied as urea, single superphosphate, and muriate of potash. For fertigation treatments, the water-soluble fertilizers were applied starting from the first week of transplanting at 19:6:6 + 18:18:18 + urea (6 splits), 13:40:13 + urea (4 splits), and 13:5:26 (4 splits). Plant heights, number of branches per plant, yield, and N and P uptake were recorded higher for 100% recommended N: P: K as fertigation and 70% N + 80% P and K.

Gowda *et al.* (2002) conducted the field experiment to study the effect of nitrogen and phosphorus fixing bio-fertilizers at various levels of nitrogen and phosphorus on growth, yield and quality parameters of red chillies cv. Byadagi Dabba at University of Agricultural Sciences, Bangalore (India). The maximum plant height, number of branches per plant, leaf area and dry matter production per plant were recorded in plant supplied with 75 per cent nitrogen, phosphorus plus 100 per cent potassium in addition to the inoculation of Azotobacter, Azospirillum, PSB and VAM. Besides, the same treatment recorded more number of fruits per plant, fruit length, fruit girth, number of seeds per fruit, dry weight of hundred fruits and higher yield of dry chillies. The maximum TSS, ascorbic acid, oleoresin and capsaicin content in dry chillies were also maximum at this level.

Aliyu (2002) carried out a field trial between 1991 and 1993 at Samaru, Nigeria, to study the effect of N (0, 80, 160, 240 and 360 kg ha^{-1}), P (0, 22 and 44 kg ha^{-1}) and plant density (20 000, 40 000 and 60 000 plants ha^{-1}) on the growth and dry fruit yield of pepper (*Capsicum annum*) cv. L5962-2. Using the classical approach, growth analysis indices were derived at fortnightly intervals. Leaf area index and relative growth rate as well as aerial phytomass showed a positive significant response to N application. The effects of P and plant density on dry weights and growth analysis indices were less marked. Significant increases in the yield both per plant and per hectare were obtained up to 240 kg N ha^{-1}.Application of P at 22 kg P $ha^{-1}$was adequate for dry fruit yield. Although yield per plant decreased with increasing density, the yield ha^{-1}a increased up to 60 000 plants ha^{-1}.

Murugan (2001) conducted a field experiment in Kerala, India to study the effects of P rate (30 or 60 kg ha^{-1}) and source (single superphosphate, rock phosphate incubated with farmyard manure or FYM, and rock phosphate with phosphobacteria) along with N at 0, 60, or 120 kg ha^{-1} on the ascorbic acid and capsaicin contents of *C. annum* cv. CO-3. The increase in P and N rates gave a corresponding increase in the ascorbic acid content of green and ripe fruits; the highest ascorbic acid contents of green (100.4 mg/100 g) and ripe (85.4 mg/100 g) fruits were obtained with 120 kg N and 60 kg P ha^{-1}. Increasing the N level resulted in an increase in the capsaicin content of fruits and pods. The effect of P source was significant only on the capsaicin content of ripe fruits, with the highest value (3.53 mg/g) recorded for single superphosphate at both rates.

Viloria-de-Z *et al.* (2005) performed a study to determine the purpose of different levels of nitrogen, phosphorus and potassium (NPK), and density of plants in pepper vegetative growth. Four doses of NPK (0-0-0; 172-0-0; 137-50-83 and 180-55-124 kg ha^{-1}) and two plant densities (6 and 8 plants/m^2) were evaluated 36, 58, 80 and 102 days after transplanting. NPK at 180-55-124 kg ha^{-1} recorded the highest diameter, fresh weight and dry weight of the stem. Fresh and dry weight of the leaves was highest with 137-50-83 and 180-551-124 NPK ha^{-1}. Dry and fresh weight decreased with increasing plant density.

Basavaraj *et al.* (2000) studying appropriate spacing and fertilizer levels for paprika (*Capsicum annum*) production a field experiment was conducted during the kharif season on medium deep black soil. The treatments were three spacings viz., 60 x 60 cm, 60 x 45 cm and 60 x 30 cm and four levels of fertilizer viz., 0 and NPK at the rate of 75:37.5:37.5, 150:75:75 and 225:112.5:112.5 kg ha^{-1}. The results revealed that the closer spacings were beneficial for growth parameters and closer spacing with increased nutrients level helped in obtaining higher fruit number and yield.

Reddy *et al.* (1999) developed fertilizer adjustment equations in a field experiment during the kharif season to determine optimum fertilizer rates at varying soil test values. The treatment combinations consisting of 4 N rates (40, 60, 80 and 100 kg ha^{-1}), 4 P_2O_5 rates (0, 20, 40 and 60 kg ha^{-1}) and 3 K_2O rates (0, 30 and 60 kg ha^{-1}) were applied. Results indicate that N, P and K requirements to produce one quintal of dry chillies were 4.5, 0.77 and 3.58 kg ha^{-1}, respectively, and that yield targets of 25 and 30 q ha^{-1} were achievable with these application rates. Chillies absorbed 38 and 42% N, 29 and 34% P, and 13 and 27% K from the soil and fertilizers, respectively.

Balakrishnan (1999) manifested nitrogen deficiency in chilli (*Capsicum annum*) plants was by pale yellow colour of older leaves, phosphorus by bluish-green colour on older leaves, potassium by marginal chlorosis and subsequently marginal scorching, magnesium by interveinal chlorosis of the matured leaves and zinc deficiency by producing of small leaves in shorter internodes. Plant growth and fruit yield were reduced considerably in nitrogen deficient treatment but was only slightly affected by calcium deficiency.

Pundir *et al.* (1999) conducted a field trial on the effects of spacing (25 x 25, 35 x 35, 45 x 45 and 55 x 55 cm) and N fertilizers (0, 50, 75 or 100 kg ha) on growth, yield and physical fruit quality of chilli cultivars Local Desi, NP 46 and Jwala were studied at Bikaner, Rajasthan, India. The cultivar Local Desi recorded the highest plant height, plant DW, fruit weight and volume. However, cultivar NP 46 produced the highest number of fruits plant^{-1}, fruit yield plant^{-1} and fruit yield ha^{-1}. Application of 100 kg N in combination with 25 kg P and 50 kg K ha^{-1} recorded the highest number of fruits plant^{-1}. The interaction of spacings, fertilizers and cultivars was non significant with regard to growth, yield and fruit quality attributes.

Singh *et al.* (1999) conducted a trial at Keonjhar, India, during the winter season of 1993-1994; capsicum was supplied with 0, 40, 80 or 120 kg N, 0, 35, 70 or 105 kg K_2O and 75 kg P ha^{-1}. Half the N and K were applied at transplanting and the other half as a top dressing 30 days later. With regard to N application rate, the greatest vegetative growth and fruit yield (5.49t ha^{-1}) were observed at 120 kg N ha^{-1}. Of the K_20 application rates, 105 kg ha^{-1}resulted in the highest yield (4.52t ha^{-1}). Response curves showed quadratic relationships and the optimum levels of N and K_2O were calculated as 104.03 and 50.97 kg ha^{-1} respectively.

Srinivasan *et al.* (1997) conducted a field trial in Tamil Nadu, India, during the rabi seasons of 1996, 1997 and 1998 to determine the effect of different rates of N (60, 120, 180 and 240 kg ha^{-1}) and/or P (60, 120 and 180 kg ha^{-1}) on the yield of hybrid Capsicum cv. Bharath.N at 240 kg ha^{-1} + P at 180 kg ha^{-1} produced the highest mean number of fruits per plant (7.51). N at 180 kg/ha + P at 180 kg ha^{-1} produced the highest yield of 52.1, 64.3 and 80.6 q ha^{-1}during 1996, 1997 and 1998, respectively. Benefit cost ratios were highest (3.25, 4.02 and 4.67 during 1996, 1997 and 1998, respectively) with N at 180 kg ha^{-1} + P at 120 kg ha^{-1}.

Yodpetch (1997) carried out an experiment to find out the optimum fertilizer rates and to determine the quantity and quality of capsaicin and colour of fruits with 10 fertilizer rates on the production of 3 cultiver of *Capsicum annum* was investigated. LARTC-9502 was the best cultivar for producing pepper sauce with a yield of 2135.47 kg rai $^{-1}$. NPK fertilizer rates of 15-15-15 and 15-7.5-7.5 kg rai $^{-1}$ were the best rates for yield (2169.12 and 2125.13 kg rai $^{-1}$). The highest fresh and dry yields (2830.64 and 484.73 kg rai $^{-1}$, respectively) were observed in the LARTC (9502) plot fertilized with 15-15-15 kg ha^{-1}. Fertilizer rate influenced quantity and quality of capsicum. Fertilizers at 30-30-15 kg rai^{-1} produced the highest capsaicin (0.16%) content, and fertilizers at 15-15-15 kg rai^{-1} produced the best colour. (6.25 rai = 1 ha).

Vos *et al.* (1997) conducted field trials, treatments of hot pepper with various nitrogen application rates between 0 and 500 kg N ha^{-1} was combined with mulch treatments in factorial trials carried out under tropical lowland. Nutrient levels of leaves and fruits were analyzed. Crop performance was monitored as plant height, branching and fruiting time, and crop health. Crop production was measured as yield of healthy fruits, mean weight of healthy fruits, and mid-harvest time. Nitrogen fertilization improved plant growth, but did not influence fruiting time. Moderate nitrogen applications (150 kg N ha^{-1}) gave best yields in most field trials. Mean fruit weight and mid-harvest time were not affected by the amount of nitrogen applied. With increasing nitrogen application rates, higher nitrogen levels in both leaves and fruits were found. Moderate amounts of nitrogen, balanced with proper amounts of phosphorus and potassium, are recommended as a fertilizer component of integrated crop management.

Moreno *et al.* (1996) conducted a greenhouse experiment by grownning *Capsicum annum* which was fertilized with NH_4NO_3 (6, 12, 18 or 24 /superscript 2) and K_2SO_4 (4, 8 or 12 gm/superscript 2). N at 18 gm/superscript 2 + K at 4 /superscript to give the best results for fruit production in this experiment. NK treatments affected Fe and Mn nutrition. NK treatments affected leaf Zn and Cu concentrations and also leaf total-B and phenolic compounds concentrations.

Sharma *et al.* (1996) conducted an experiment about the effects of N (0, 60, 90 or 120 kg ha^{-1}) and P (0, 30 or 60 kg ha^{-1}) on the growth of chilli was investigated at Jabalpur, India, during 1991-92. K (40 kg K_2O ha^{-1}) was applied to all plots. The yield of fruits significantly increased with increasing rates of N. The highest yield (10.72 q ha^{-1}) was recorded at the highest N rate. In the P treatments, the highest yield (8.38 q ha^{-1}) was observed following treatment with 30 kg P_2O_5 ha^{-1}. It was concluded that the best treatment to promote yield and profitability was 120 kg N + 30 kg P_2O_5 ha^{-1}.

Shrivastava *et al.* (1996) conducted an experiment effects of N + P + K (200 + 150 + 150, 250 + 200 + 200 or 300 + 250 + 250 kg ha^{-1}, respectively) and spacing (60 x 40, 60 x 50 or 60 x 60 cm) on the growth and yield of Capsicum cv. Hybrid Bharat were investigated. First flowering and 50% flowering were delayed by 4 and 4-6 days, respectively, in plants receiving the highest rate of fertilizers. First fruit set was also delayed in these plants. The highest number of fruits/plant (10.66), fresh weight/fruit (128 g), yield/plant (637.5 g) and yield ha^{-1} (92.95 q ha^{-1}) were observed in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}. Days to 50% flowering, percentage fruit set, number of fruits/plant, fresh weight of fruits, yield/plant and yield ha^{-1}decreased with increasing spacing. The interaction between fertilizer rate and spacing was significant only on the number of days to first fruit set and percentage fruit set.

Mallangouda *et al.* (1995) conducted an experiment on performance of *Capsicum annum* as influenced by companion crops garlic,onions and fertilizer rates (recommended dose of NPK and/or farmyard manure (FYM), or 50% recommended dose of NPK + FYM) was investigated. At all fertilizer rates, the best yields of *C. annum* were observed in the *C. annum* + garlic cropping systems followed by the *C. annum* + onion cropping systems. Among fertilizer treatments, application of the recommended dose of NPK + FYM improved the growth parameters as well as yield and yield components of *C. annum*. The highest fruit yield (2099.8 kg ha^{-1}FW and 577.8 kg ha^{-1}DW) was observed in the *C. annum* + garlic system treated with the recommended dose of NPK + FYM. In the *C. annum* + onion cropping system, the highest uptake of N (62.68 kg ha^{-1}) was observed in the 50% recommended dose of NPK + FYM treatment.

Das *et al.* (1992) conducted a field experiment with cv. BC-14-2 to study the effect of 4 rates of N (0, 60, 90 and 120 kg ha^{-1}) and 3 rates of P (0, 30 and 60 kg ha^{-1}), at a constant

K rate (50 kg ha^{-1}), during the rabi seasons of 1987-88, 1988-89 and 1989-90. The dry chilli yield increased significantly with increasing N and P rates. N at 120 kg ha^{-1}gave 313.8, 103.9 and 24.8% increases in yield, respectively, over 0, 60 and 90 kg ha^{-1}.

Chailloux *et al.* (1992) conducted 2-year trials with the cultivars California Wonder (1st year) and Tropical CW-3 (2nd year), N was applied at 7 rates ranging from 0 to 270 kg ha^{-1}. P_2O_5 at 25 kg ha^{-1} + K_2O at 50 kg ha^{-1} were applied as a basal dressing. One-half of the total N and P + K was applied at transplanting and the other half 50 days later. The crop was planted at 90 x 18 cm. Plant growth was assessed from 15 to 105 days after planting, and it was highly correlated with the N rate. Plants reached 70-80% of their total height in the first 60 days of growth, being tallest with the highest N rate. High and positive linear correlation values were observed between plant height and total yield.

Katwale and Saraf (1990) performed an experiment in which seedlings of *C. annum* (37-days-old) were planted at a spacing of 30 x 45 cm and 25 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} was applied as a basal dose. A further 50 kg N $ha^{-1}$was applied in 2 split doses at 45 and 75 days after transplanting. Urea at 0, 1 and 1.5%, and NAA at 0, 10, 20 and 40 ppm. were applied as foliar sprays one month after transplanting. Green chillies were harvested 110 days after transplanting and thereafter at 20-day intervals. The highest yield (268.25 q ha^{-1}) was obtained with 40 ppm. NAA + 1% urea compared with 84.30 q $ha^{-1}$for the control.

Mary *et al.* (1990) evaluated the capsicum cultivar K.2, growing on soil low in N and K and intermediate in available P, received N at 52.5, 70.0 or 87.5 kg ha^{-1} and K_2O at 17.5, 35.0 or 52.5 kg ha^{-1}. Three irrigation regimes were applied viz. 0.60, 0.75 and 0.90 IW: CPE [irrigation water: cumulative pan evaporation] ratios. The greatest fruit length and girth, highest ascorbic acid content in red ripe fruits (122.04 mg/100 g) and the 2nd highest capsaicin content (125.57 mg/100 g) were obtained from plants receiving the highest NK rates and irrigated at 0.75 IW: CPE ratio.

Azofeifa *et al.* (2005) analyzed the nutrient uptake and partitioning in sweet pepper plants, cultivar UCR 589. A complete-randomized-block experimental design with 4 replications was used. Eleven samplings at 14-day intervals were carried out to measure the dry weight and the content of N, P, K, Ca, Mg and S in each plant section (root, foliage, flower and fruit) and total in the plant. Besides, the nutrient extraction for a plant density of 20 833 plants ha^{-1} and a yield of 46.3 t ha^{-1} of fresh commercial fruit was estimated. The nutrient extraction order was K > N > P > Ca > S and Mg; with values of 180, 139, 26, 38 and 13 kg ha^{-1}, respectively. The main phonological event that regulates those fluctuations is fructification. At the end of the crop cycle, the plant accumulated N, P, Mg, K, and S in higher amounts in the fruits and Ca mainly in the aerial part. The highest rates of nutrient absorption occurred during the stages of fruit formation and accelerated fruit growth.

Gezerel and Donmez (1988) showed that slow release fertilizers hold great promise for the production of solanaceous vegetables such as eggplant and tomato. They compared slow-release fertilizer (Plantacote) and conventional fertilizers of N, P, K, and Mg. @ 100, 80, 90, 30 kg ha^{-1}. They also found that slow-release fertilizer produced to only 42 t h^{-1} when ordinary commercial fertilizers were used. Nitrozen enhanced the growth and development, which ultimately increased the yield. While conducting an experiment in a solar greenhouse with the aid of a computer,

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during November 2006 to March 2007 to examine the effect of nitrogen and phosphorus on the growth, yield and quality of *Capsicum*.

Description of the experimental site

3.1 Location

The experimental field is located at $23^{0}77'$ N latitude and $90^{0}3'$ E longitude with an elevation of 1.0 meter above sea level (Fig. 1).

3.2 Soil

The soil of the experimental field belongs to the Tejgaon series of the Madhupur Tract Agro Ecological Zone (AEZ) 28. The General soil type of the experimental field is Deep Red Brown Terrace Soil. Topsoil is silty clay loam in texture. Organic matter content is very low (0.89%) and soil pH is 5 .8. The land is above flood level and well drained. The initial morphological, physical and chemical characteristics of initial soil are presented in Tables 1 and 2.

Fig.1. Map showing the experimental site under study

Table 1. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Sher-e Bangla Agricultural University Farm, Dhaka
AEZ No. and name	AEZ-28, Madhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 2. Physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis	
% Sand	31.50
% Silt	39.34
% Clay	29.16
2. Soil texture	Silty clay loam
B. Chemical properties	
1. Soil pH	5.8
2. Organic carbon (%)	0.78
3. Organic matter (%)	0.89
4. Total N (%)	0.08
5. C : N ratio	10 : 1
6. Available P ($\mu g\ g^{-1}$)	33.5
7. Exchangeable K (cmd kg^{-1})	0.21
8. Available S ($\mu g\ g^{-1}$)	36.75
9. Available B ($\mu g\ g^{-1}$)	0.36

3.3 Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site was 2152 mm and potential evapotranspiration was 1297 mm. The average maximum temperature was 30.34^0C and average minimum temperature was 21.21^0C. The average mean temperature was 25.17^0C. The experiment was done during the Rabi season. Temperature during the cropping period ranged between 12.2^0 and 29.2^0C. The humidity varied from 71.52 to 81.2 5%. The day length was 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting (Appendix –I)

3.4 Seeds and variety

California Wonder, a high yielding variety of capsicum *(Capsicum annum* Lin.) developed by the scientist of the USA (United State of America) of California State. Now it is more or less found in our country but not cultivated for the commercial purposes.

3.5 Raising of seedlings

The land selected for nursery beds was well drained and sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cow dung at the rate of 5 kg/bed. The size of each seed bed was 3m x 1m raised above the ground level maintaining a spacing of 50 cm between the beds. Two seed beds were prepared for raising the seedlings. Twenty (20) grams of seeds were sown in each seed bed on 25 October 2006. After sowing, the seeds were covered with light soil. Miral 3-GN was applied in each seed bed as precautionary measure against ants and worms. Complete germination of the seeds took place with 6 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

3.6 Design and layout of experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of N (0, 50, 100 and 150 kg N ha^{-1} designated as N_0, N_{50}, N_{100} and N_{150}, respectively) and 3 levels of P (0, 30 and 60 kg P ha^{-1} designated as P_0, P_{30} and P_{60} respectively). There were 12 treatment combinations. The treatment combinations were as follows:

N_0P_0 = Control (without N and P application)
N_0P_{30} = 0 kg N ha^{-1} + 30 kg P ha^{-1}
N_0P_{60} = 0 kg N ha^{-1} + 60 kg P ha^{-1}
$N_{50}P_0$ = 50 kg N ha^{-1} + 0 kg P ha^{-1}
$N_{50}P_{30}$ = 50 kg N ha^{-1} + 30 kg P ha^{-1}
$N_{50}P_{60}$ = 50 kg N ha^{-1} + 60 kg P ha^{-1}
$N_{100}P_0$ = 100 kg N ha^{-1} + 0 kg P ha^{-1}
$N_{100}P_{30}$ = 100 kg N ha^{-1} + 30 kg P ha^{-1}
$N_{100}P_{60}$ = 100 kg N ha^{-1} + 60 kg P ha^{-1}
$N_{150}P_0$ = 150 kg N ha^{-1} + 0 kg P ha^{-1}
$N_{150}P_{30}$ = 150 kg N ha^{-1} + 30 kg P ha^{-1}
$N_{150}P_{60}$ = 150 kg N ha^{-1} + 60 kg P ha^{-1}

Fertilizer treatments were randomly distributed in each block. Each block consisted of 12 plots and individual plot was 2.2 m × 1.8 m i.e., 3.96 sq. m in size. The row to row and plant to plant distance were 55 and 27.5 cm, respectively accommodating 12 plants in each plot. The adjacent block and neighboring plots were separated by 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Fig. 2.

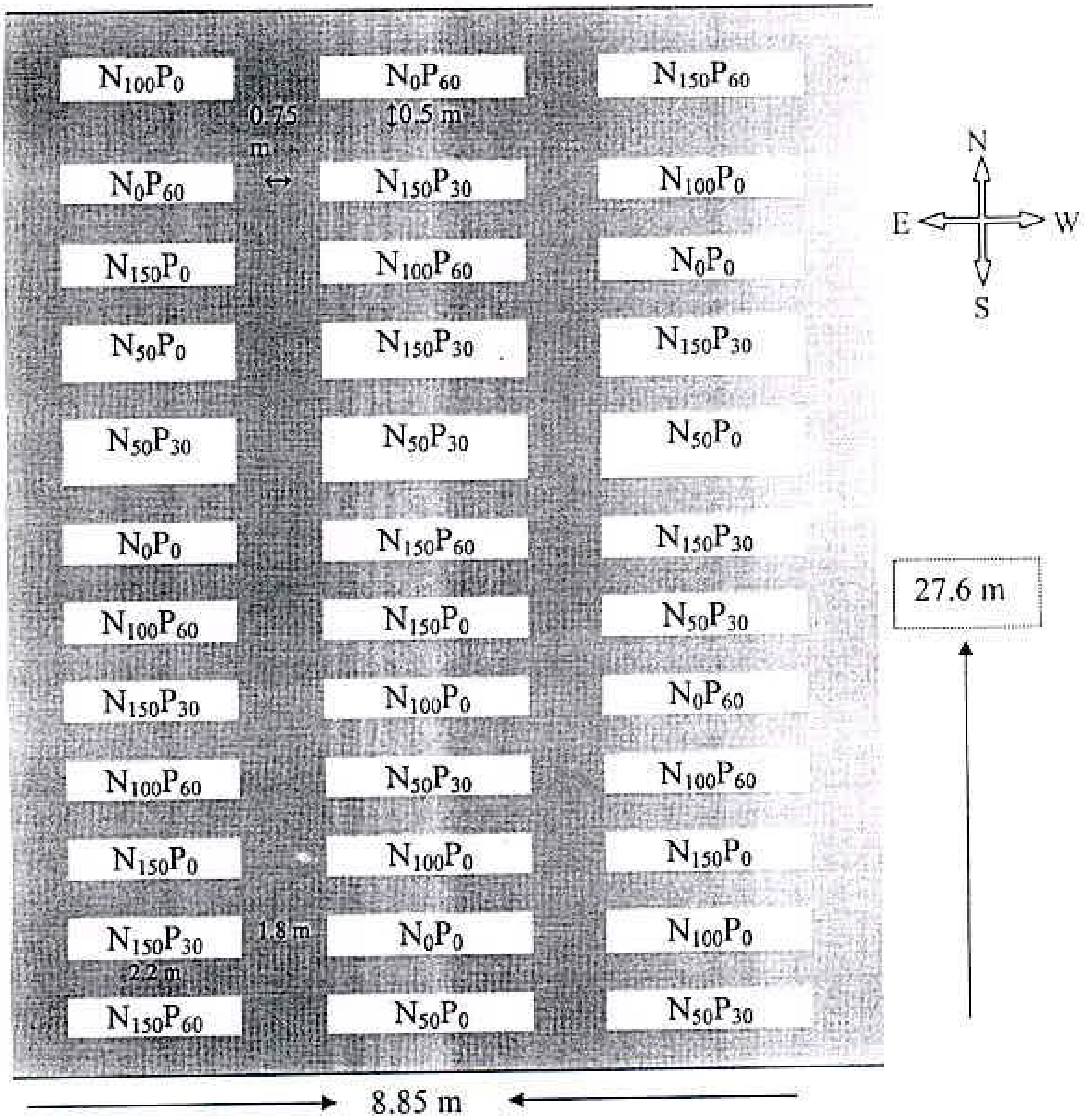

Fig. 2 Layout of the experimental field

3.7 Collection and processing of soil sample

Soil samples from the experimental field were collected before land preparation to a depth of 0 to 15 cm from the surface. The collected soil was air dried, ground and passed through a 2mm sieve and stored in a clean, dried plastic container for physical and chemical analysis.

3.8 Land preparation

The land was first ploughed with a tractor drawn disc plough on 25 November 2006. Ploughed soil was brought into desirable tilth condition by four operations of ploughing and harrowing with country plough and ladder. The stubbles of the previous crops and weeds were removed. The land operation was completed on 27 November 2006. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.9 Application of fertilizers

The N, P, K and Zn fertilizers were applied according to Fertilizer Recommendation Guide (BARC, 1997) through urea, triple super phosphate (TSP), muriate of potash (MP) and zinc oxide, respectively. One third (1/3) of whole amount of Urea and full amount of MP, TSP and zinc oxide were applied at the time of final land preparation for each treatment. The remaining Urea was top dressed in two equal installments- at 20 days after transplanting (DAT) and 50 DAT respectively.

3.10 Transplanting of seedlings

Healthy and uniform sized 30 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 28 November 2006 maintaining a spacing of 55 cm and 27.5 cm between the rows and plants, separately. The seed bed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sunshine. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.11 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually for the first time and removed from the field on 17 December 2006. Second and third weeding were done on 31 December 2006 and 20 January 2007, respectively.

3.12 Irrigation

Three irrigations were done. The first irrigation was given in the field on 18 December 2006 at 20 days after transplanting (DAT) through irrigation channel. The second irrigation was given at the stage of maximum vegetative growth stage (35 DAT), on 2 January 2007. The final irrigation was given at the stage of fruit formation (55 DAT) on 22 January 2007.

3.13 Pest management

The crop was infested with cutworm, leaf hopper and others. The insects were controlled successfully by spraying Malathion 57 EC @ 2ml L^{-1} water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. Miral 3-GN was also applied during final land preparation as soil amendments. During foggy weather precautionary measures against disease infestation especially late blight of tomato was taken by spraying Dithane M-45 fortnightly @ 2 g L^{-1} of water.

3.14 Harvesting

Fruits were harvested at 8 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of size of fruits. Harvesting was started from 6 March 2007 and completed by 29 March 2007.

3.15 Collection of experimental data

Ten (10) plants from each plot were selected randomly and were tagged for the data collection. The sample plants were uprooted and dried properly in the sun.

Data were collected on the following parameters:

1) Plant height at first flowering stage

2) Plant height at first harvesting stage

3) Plant height at final harvesting stage

4) Flower bud emergence

5) Days of first flower opening

6) Days of first fruit set

7) Length of capsicum

8) Breadth of capsicum

9) Thickness of pericarp

10) Number of fruit per plants

11) Average fruit weight

12) Fruit yield

13) Dry matter of fruit

3.16 Methods for Soil Analysis

1) Particle size analysis of soil

Particle size analysis of the soil was done by Hydrometer Method (Bouyoucos, 1926). The textural class was determined using "Marshall's Textural Triangular Coordinate" as designated by USDA system.

2) Organic carbon (%)

Organic carbon in soil was determined by Walkley and Black's (1934) Wet Oxidation Method. The underlying principle is to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. The result was expressed in percentage.

3) C/N ratio

The C/N ratio was calculated from the percentage of organic carbon and total N.

4) Soil organic matter

Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942).

% organic matter = % organic carbon × 1.724

5) Soil pH

The pH of the soil was determined with the help of a Glass Electrode pH meter using soil: water ratio being 1 : 2.5 (Jackson, 1973).

6) Total nitrogen (%)

Total nitrogen content of soil was determined by Micro Kjeldahl Method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se powder = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

7) Available phosphorus

Available phosphorus (P) content in the soil samples was determined by the method described by Hunter (1984). The extracting agent used was monocalcium phosphate [Ca

$H_2(PO_4)_2.H_2O$] solution and colour was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelengths.

3.17 Methods for plant analysis

For determination of N and B content in plants, the samples were first digested with acid and determination of elements in the digest was performed either by titration (for N) or by colorimetric methods (for B). For N, digestion was done with conc. H_2SO_4 and digest was distilled over following the procedure outlined under soil analysis section (3.15). While for P, digestion was performed by diacid mixture of HNO_3 and $HClO_4$ at the ratio of 2: 1. The amount of these elements in the digest was estimated following the procedure described under soil analysis section (3.15).

3.18 Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan`s Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

This chapter includes the experimental results along with discussions. Individual and combined effects of N and P on flower bud emergence, days of first flower opening, first fruit set, plant height at first flowering, plant height at first harvest, plant height at final harvest, number of branches per plant at first flowering, number of branches per plant at first harvest, number of branches per plant at final harvest, length of capsicum, breadth of capsicum, number of fruit per plant, average fruit weight, fruit yield per hectare, thickness of pericarp, dry matter percentage of fruit. The nutritional value of *Capsicum frutescens* or *Capsicum annum* is presented in tables as follows:

The results of *Capsicum annum* presented in tables are discussed character wise under the following heads:

4.1 Days to flower bud emergence

4.1.1 Influence of nitrogen

Days to flower bud emergence 0f capsicum was significantly increased by different level of nitrogen (Table 3). The highest flower bud emergence (30.43) was found with 150 kg N ha^{-1} which was statistically similar with that of 100 kg N ha^{-1} and the lowest flower bud emergence (29.12) was observed in control treatment. It was observed that flower bud emergence increased gradually with the increment of nitrogen dose. This might be due to higher availability of N and their uptake that progressively enhance the flower bud emergence.

4.1.2 Influence of phosphorus

A positive and significant difference was observed among the different levels of phosphorus in respect of flower bud emergence (Table 4). Flower bud emergence increased with increasing level of phosphorus. The higher flower bud emergence (30.84) was produced with 60 kg/ha and the lowest emergence (29.27) was found in control treatment.

4.1.3 Combined effect of nitrogen and phosphorus

The treatment combination of nitrogen and phosphorus had significant effect on days to flower bud emergence (Table 5). The highest days to flower bud emergence (32.28) was found in N_2P_2 treatment which was followed by N_3P_0. The lowest days to flower bud emergence (27.17) was observed in control treatment (N_0P_0) which was statistically similar with N_3P_0 treatment. The second highest result (31.52) was found in N_2P_0 which was statistically similar to N_0P_2. These results revealed that higher dose of phosphorus and medium dose of nitrogen were influential nutrients for flower bud emergence.

4.2 Days to first flower opening

4.2.1 Effect of nitrogen

The influence of nitrogen showed significant variation in days of first flower opening (Table 3). The highest days to first flower opening (32.21) were found with 150 kg N ha^{-1} which was statistically similar with that of 100 kg N ha^{-1} and the lowest days of first flower opening (31.03) was observed in control treatment which was statistically similar to 50kg N ha^{-1}. It was observed that days to first flower opening increased gradually with the increment of nitrogen dose. These results do not support by Gill *et al.* (1974). They reported that number of days required for flowering of sweet pepper was found to increase with high dose of nitrogen application.

4.2.2 Effect of phosphorus

Phosphorus fertilizer had no significant effect on the days to first flower opening (Table 4). Days to first flower opening increased with increasing level of phosphorus. The most delayed flower bud emergence (31.74) was produced with 60 kg P ha^{-1}. Similar results were found by Alabi (2006). He stated that phosphorus levels significantly increased early flowering, maturity and yield (ton ha^{-1}) of the treated plants.

4.2.3 Combined effect of nitrogen and phosphorus

The combined effect of nitrogen and phosphorus had significant effect on days to first flower opening (Table 5). The highest days to first flower opening (33.34) was found in N_2P_2 treatment which is followed by N_2P_1. The lowest days to first flower opening (29.85) was observed in control treatment (N_0P_0) which is similar to N_1P_0. These results stated that higher dose of phosphorus and medium dose of nitrogen were markable nutrients for delaying first flower opening. Shrivastava *et al.* (1996) concluded that first flowering and 50% flowering were delayed by 4 and 4-6 days, respectively in plants receiving the highest rate of fertilizers.

4.3 Days to first fruit set

4.3.1 Influence of nitrogen

Days to first fruit set increased with increasing level of nitrogen, but insignificantly (Table 3). The highest days to first fruit set (33.03) was found with 150 kg N ha^{-1}. Actually nitrogen had no significant difference on days to first fruit set.

4.3.2 Influence of phosphorus

Days to first fruit set was progressively increased with increasing level of phosphorus (Table 4). However, the effect was non significant. The higher time required for first fruit set (32.89) was produced with 60 kg P ha^{-1} and the lowest (31.77) was found in control treatment.

4.3.3 Combined effect of nitrogen and phosphorus

The treatment combination of nitrogen and phosphorus had significant effect on days to first fruit set (Table 5). The highest days to first fruit set (34.28) was found in N_2P_2 treatment which is followed by N_1P_2. The lowest days to first fruit set (31.22) was observed in control treatment (N_0P_0) which was statistically similar to N_1P_0, N_3P_0 and N_3P_2 treatments. From these results, it was calculated that higher dose of phosphorus and medium dose of nitrogen were influential for the days to first fruit set.

Table 3. Effect of nitrogen on growth and yield character of *Capsicum*

Treatment	Days to flower bud emergence	Days to first flower opening	Days to first fruit set
N_0	29.12b	31.03 b	31.88
N_1	29.33 b	30.91 b	32.27
N_2	29.87 ab	32.15 a	32.74
N_3	**30.43 a**	**32.21 a**	**33.03**
$LSD_{0.05}$	0.96	0.93	NS
CV (%)	7.26	5.01	8.42

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0 = Control (without N), N_1 = 50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3 = 150 kg N ha^{-1}

Table 4. Influence of phosphorus on growth and yield character of *Capsicum*

Treatment	Days to flower bud emergence	Days of first flower opening	Days to first fruit set
P_0	29.27 b	31.14	31.77
P_1	30.81 a	31.45	32.78
P_2	**30.84 a**	**31.74**	**32.89**
$LSD_{0.05}$	0.83	NS	NS
CV (%)	7.26	5.01	8.42

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 5. Interaction effect of nitrogen and phosphorus on growth and yield character of *Capsicum*

Treatment	Flower bud emergence day	Days to first flower opening	Days to first fruit set
N_0P_0	**27.17 f**	**29.85 c**	**31.22 c**
N_0P_1	29.90 bcde	31.57 abc	32.15 abc
N_0P_2	31.50 ab	31.28 abc	31.95 bc
N_1P_0	29.50 cde	**29.97 c**	**31.55 c**
N_1P_1	29.67 bcde	31.30 abc	33.28 abc
N_1P_2	28.83 def	31.45 abc	34.03 ab
N_2P_0	31.52 ab	31.81 abc	32.30 abc
N_2P_1	30.42 bcd	32.31 a	32.55 abc
N_2P_2	**32.28 a**	**33.34 a**	**34.28 a**
N_3P_0	**27.66 f**	31.11 abc	**31.63 c**
N_3P_1	30.83 abc	31.63 abc	33.14 abc
N_3P_2	28.17 ef	31.89 ab	**31.68 c**
$LSD_{0.05}$	1.66	1.61	1.88
CV (%)	7.26	5.01	8.42

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

4.4 Plant height at first flowering

4.4.1 Effect of nitrogen

Plant height at first flowering of *Capsicum* was significantly increased by increasing different level of nitrogen (Table 6). The highest plant height at first flowering (17.14 cm) was found with 150kg N ha^{-1} which was statistically similar with that of 100kg N ha^{-1} and the lowest plant height at first flowering (14.97 cm) was observed in control treatment which was statistically similar to 50kg N ha^{-1}. It was observed that plant height at first flowering stage increased gradually with the increment of nitrogen dose. This could be due to higher availability of N and their uptake that progressively enhanced the plant height at first flowering. This result is supported by Aliyu *et al.* (1991). They stated that, greatest plant height, leaf numbers were obtained with 180 kg ha^{-1}. Plants reached 70-80% of their total height in the first 60 days of growth, being tallest with the highest N rate. This result was found by Chailloux *et al.* (1992).

4.4.2 Effect of phosphorus

There was a significant effect among the different levels of phosphorus in respect of plant height at first flowering (Table 7). Plant height at first flowering increased with increasing level of phosphorus. The highest plant height at first flowering (16.63 cm) was observed with 60 kg ha^{-1} and the lowest plant height at first flowering (15.18 cm) was found in control treatment. . Similar results were found by Akinrinde *et al.* (2005). They carried on an experiment on crop growth and found that the 150 mg P_2O_5 kg^{-1} level produced the tallest plants (40.0 cm) at the 6th week.

4.4.3 Combined effect of nitrogen and phosphorus

The treatment combination of nitrogen and phosphorus had significant effect on plant height at first flowering (Table 8). The highest plant height at first flowering (17.76 cm) was found in N_3P_2 treatment. The lowest plant height at first flowering (14.49 cm) was observed in control treatment (N_0P_0). These results showed that higher dose of phosphorus and higher dose of nitrogen were influential nutrients for plant height at first flowering. Similar results were found by Sarma *et al.* (2004). They stated that plant height (27.25 cm) increased significantly with 150:75:75 kg NPK ha^{-1}.

4.5 Plant height at first harvest

4.5.1 Effect of nitrogen

With the increase of nitrogen level plant height at first harvesting stage of *Capsicum* was significantly increased (Table 6). The highest plant height at first harvesting stage (24.29 cm) was found with 150kg N ha^{-1} which was statistically similar with 100 kg N ha^{-1} and the lowest plant height at first harvesting stage (22.05 cm) was obtained in the control. It was observed that plant height at first harvesting stage increased gradually with the increment of nitrogen dose. This must be due to higher availability of N and their uptake that gradually enhance the plant height at first harvesting stage.

4.5.2 Effect of phosphorus

With the increase of phosphorus level plant height at first harvesting stage of *Capsicum* was not significantly increased (Table 7). The highest plant height at first harvesting stage (24.01 cm) was observed with 60 kg ha^{-1}. Similar result was found by Alabi (2006). He stated phosphorus levels significantly increased pepper plant height, number of leaves per plant up to 125 kg P ha^{-1}.

4.5.3 Combined effect of nitrogen and phosphorus

Combined treatment of nitrogen and phosphorus had significant effect on plant height at first harvesting stage (Table 8). The highest plant height at first harvesting stage (25.00 cm) was found in N_3P_2 treatment. The lowest plant height at first harvesting stage (21.12 cm) was observed in control treatment (N_0P_0).

4.6 Plant height at final harvest

4.6.1 Effect of nitrogen

Plant height at final harvesting stage of *Capsicum* was significantly increased with the increase of nitrogen level (Table 6). The highest plant height at final harvesting stage

(31.62 cm) was found with 150 kg N ha^{-1} and the lowest plant height at final harvesting stage (26.59 cm) was found in the control. Plant height at final harvesting stage increased sequentially with the augment of nitrogen dose. Because to higher availability of N and their uptake that gradually enhance the plant height at final harvesting stage.

4.6.2 Effect of phosphorus

With the increase of phosphorus level, plant height at final harvesting stage of *Capsicum* was significantly increased (Table 7). Plant height at final harvesting stage increased with increasing level of phosphorus. The highest plant height at final harvesting stage (30.17 cm) was observed with 60 kg ha^{-1} and it was found that the lowest result (27.86 cm) was identified in the control treatment of phosphorus fertilizer.

4.6.3 Combined effect of nitrogen and phosphorus

Plant height at final harvesting stage with combined treatment of nitrogen and phosphorus had significant effect (Table 8). The highest plant height at final harvesting stage (32.00 cm) was found in N_2P_2 treatment. The lowest plant height final harvesting stage (25.38 cm) was observed in control treatment (N_0P_0). 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), number of leaves per plant. Similar results were also found by Sarma *et al.* (2004). They stated that plant height (27.25 cm), fruit number per plant (64.33), fruit weight (3.33 g) and yield (27.99 q ha^{-1}) of chilli increased significantly with 150:75:75 kg NPK ha^{-1}.

Table 6. Effect of nitrogen on yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height final harvest (cm)
N_0	14.97 b	22.05 c	26.59 c
N_1	15.66 b	23.53 b	27.44 c
N_2	16.57 a	23.87 ab	29.73 b
N_3	**17. 14 a**	**24. 29 a**	**31. 62 a**
$LSD_{0.05}$	0.90	0.56	1.28
CV (%)	5.69	6.50	7.55

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0=Control (without N), N_1 = 50 kg N ha^{-1}, N_2=100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 7. Effect of phosphorus on yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height final harvest (cm)
P_0	15.18 b	23.14	27.86 b
P_1	16.44 a	23.15	28.49 b
P_2	**16. 63 a**	24. 01	**30. 17 a**
$LSD_{0.05}$	0.78	NS	1.11
CV (%)	5.69	6.50	7.55

P_0= Control (without P), P_1 = 30 kg P ha^{-1}, P_2= 60 kg P ha^{-1}

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

Table 8. Interaction effect N and P on yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height at final harvest (cm)
N_0P_0	**14.49 d**	**21.12 c**	**25.38 e**
N_0P_1	14.73 cd	21.79 bc	26.39 de
N_0P_2	15.69 bcd	23.23 abc	27.99 cd
N_1P_0	14.76 cd	22.78 abc	27.64 cde
N_1P_1	16.44 abc	23.69 abc	29.37 bc
N_1P_2	15.77 bcd	23.93 abc	28.91 bc
N_2P_0	14.69 d	22.98 abc	27.94 cd
N_2P_1	17.37 ab	24.00 abc	31.87 a
N_2P_2	17.60 a	24.11 abc	**32. 00 a**
N_3P_0	16.78 ab	23.87 abc	25.77 de
N_3P_1	17.33 ab	24.85 ab	30.92 ab
N_3P_2	**17. 76 a**	**25. 00 a**	31.93 a
$LSD_{0.05}$	1.55	2.58	2.22
CV (%)	5.69	6.50	7.55

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

4.7 Number of branches per plant at first flowering stage

4.7.1 Effect of nitrogen

Number of branches per plant at first flowering stage of *Capsicum* was significantly increased with the increase of nitrogen level (Table 9). The highest number of branches per plant at first flowering stage (6.85) was found with 150 kg N ha^{-1} which was followed by (6.41) that of 100 kg N ha^{-1} and the lowest number of branches per plant at first flowering stage (4.42) was observed with control. Number of branches per plant at first flowering stage increased sequentially with the augment of nitrogen dose. So, because of higher availability of N and their uptake that gradually enhances the number of branches per plant at first flowering stage. Similar result was found by Aliyu *et al.* (1991). They carried out a field trial with respect to N fertilizer application and greatest branches number was obtained with 180 kg ha^{-1}.

4.7.2 Effect of phosphorus

No significant differences were recorded for different level of phosphorus in terms of number of branches per plant at first flowering of *Capsicum* (Table10). The number of branches per plant at first flowering stage (5.86) was the highest at the highest dose of P and the lowest result (5.61) was found in control treatment. Similar results were found by Alabi (2006). He found that number of branches per plant significantly increased with the increased of phosphorus levels up to 125 kg P ha^{-1}.

4.7.3 Combined effect of nitrogen and phosphorus

The combined treatment of nitrogen and phosphorus had significant effect in terms of number of branches per plant at first flowering stage (Table 11). The greatest umber of branches per plant at first flowering stage (7.00) was found in N_3P_1 treatment The lowest number of branches per plant at first flowering stage (4.31) was observed in control treatment (N_0P_0).

4.8 Number of branches per plant at first harvest

4.8.1 Effect of nitrogen

Number of branches per plant at first harvesting stage of *Capsicum* was significantly increased with the increase of nitrogen level (Table 9). The highest number of branches per plant at first harvesting stage (11.69) was found with 150 kg N ha^{-1} and the lowest number of branches per plant at first harvesting stage (7.95) was found under control. Number of branches per plant at first harvesting stage increased gradually with the augment of nitrogen dose.

4.8.2 Effect of phosphorus

Number of branches per plant at first harvesting stage increased with the increase of phosphorus of *Capsicum* significantly (Table 10). Number of branches per plant at first harvesting stage increased with increasing level of phosphorus. The greatest number of branches per plant at first harvesting stage (9.97) was observed with 60 kg P ha^{-1} followed by 30 kg ha^{-1} (9.79). It was found that the lowest result (8.89) was identified in the control treatment of phosphorus fertilizer.

4.8.3 Combined effect of nitrogen and phosphorus

In case of number of branches per plant at first harvesting stage the combined treatment of nitrogen and phosphorus had significant effect (Table 11). The highest number of branches per plant at first harvesting stage (12.00) was found in N_3P_0 treatment and the lowest number of branches per plant at first harvesting stage (7.00) was observed in control treatment (N_0P_0). These results explained that higher dose of nitrogen and phosphorus was influential nutrients for increasing number of branches per plant at first harvesting stage.

4.9 Number of branches per plant at final harvest

4.9.1 Effect of nitrogen

Number of branches per plant at final harvesting stage of *Capsicum annum* was significantly increased with the increase of nitrogen level (Table 9). The highest number of branches per plant at final harvesting stage (17.98) was found with 150 kg N ha^{-1} and the lowest number of branches per plant at final harvesting stage (14.21) was found under control. Number of branches per plant at final harvesting stage increased gradually with the increase of nitrogen doses. For the reason of higher availability of nitrogen and their uptake that by turn increase the number of branches per plant at final harvesting stage.

4.9.2 Effect of phosphorus

Number of branches per plant at final harvesting stage of *Capsicum* increased significantly with the increase of phosphorus (Table 10). The highest number of branches per plant at final harvesting stage (16.41) was observed with 60 kg P ha^{-1}. The lowest result (15.60) was identified in the control treatment of phosphorus fertilizer.

4.9.3 Combined effect of nitrogen and phosphorus

Number of branches per plant at final harvesting stage showed significant effect due to combined treatment of nitrogen and phosphorus (Table 11). Number of branches per plant at final harvesting stage (18.50) was the highest in N_3P_0 treatment The lowest number of branches per plant at final harvesting stage (13.93) was observed in control treatment (N_0P_0). 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 *et al.* (2002). They stated that plant height, numbers of branches per plant, yield and N and P uptake were recorded higher for 100% recommended N: P: K as fertigation and 70% N + 80% P and K.

Table 9. Effect of nitrogen on yield attributes of *Capsicum*

Treatment	Number of branches /plant at first flowering stage	Number of branches/plant at first harvest	Number of branches/plant at final harvest
N_0	4.42 c	7.95 c	14.21 d
N_1	5.27 b	8.35 c	15.20 c
N_2	6.41 a	10.22 b	16.48 b
N_3	**6. 85 a**	**11. 69 a**	**17. 98 a**
$LSD_{0.05}$	0.49	0.63	0.52
CV (%)	8.82	6.78	7.32

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0=Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 10. Influence of phosphorus on yield attributes of *Capsicum*

Treatment	Number of branches /plant at first flowering stage	Number of branches/plant at first harvest	Number of branches/plant at final harvest
P_0	5. 61	8.89 b	15.60 b
P_1	5.75	9.79 a	15.89 b
P_2	5. 86	**9. 97 a**	**16. 41 a**
$LSD_{0.05}$	NS	0.55	0.45
CV (%)	8.82	6.78	7.32

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 11. Interaction effect of nitrogen and phosphorus on yield attributes of *Capsicum*

Treatment	Number of branches/plant at first flowering stage	Number of branches/plant at first harvesting stage	Number of branches/plant at final harvesting stage
N_0P_0	**4.31 f**	8.97 bcd	**13.93 f**
N_0P_1	4.57 ef	**7.00 e**	14.12 ef
N_0P_2	4.39 f	7.87 de	14.57 ef
N_1P_0	5.43 de	9.12 bc	15.00 de
N_1P_1	5.65 cd	8.00 cde	14.97 de
N_1P_2	4.73 ef	7.93 cde	15.63 cd
N_2P_0	6.00 bcd	9.78 b	15.93 cd
N_2P_1	6.51 abc	9.00 bcd	16.00 c
N_2P_2	6.71 ab	11.87 a	17.50 b
N_3P_0	6.95 a	**12. 00 a**	**18. 50 a**
N_3P_1	**7. 00 a**	11.57 a	17.50 b
N_3P_2	6.50 ab	11.50 a	17.93 ab
$LSD_{0.05}$	0.86	1.10	0.90
CV (%)	8.82	6.78	7.32

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

4.10 Length of *Capsicum*

4.10.1 Effect of nitrogen

It was found that the length of *Capsicum* significantly increased with the increase of nitrogen level (Table 12). The highest length of *Capsicum* (7.63 cm) was found with 150 kg N ha^{-1} and which was statistically similar (7.41 cm) with 100 kg N ha^{-1} and the lowest length of *Capsicum* (5.83 cm) was found in control treatment. Length of *Capsicum* increased gradually with the increase of nitrogen dose. For the reason of higher availability of nitrogen and their uptake by plant that sequentially increased the length of *Capsicum*.

4.10.2 Effect of phosphorus

Length of *Capsicum* was increased significantly with the increment of phosphorus (Table 13). The highest length of *Capsicum* (7.38 cm) was observed with 60 kg ha^{-1} of phosphorus fertilizer which was followed by 30 kg ha^{-1} (6.80 cm). The lowest result (6.51 cm) was identified in the control treatment.

4.10.3 Combined effect of nitrogen and phosphorus

Combined treatment of nitrogen and phosphorus had significant effect (Table 14) on length of *Capsicum*. Length of *Capsicum* had the highest value (8.00 cm) in N_3P_1 treatment, The lowest length of *Capsicum* (5.05 cm) was observed in control treatment (N_0P_0). From these results it was observed that higher dose of nitrogen and phosphorus was influential nutrients for length of *Capsicum* up to a certain limit. Gowda *et al.* (2002) reported increased fruit length with 75 percent nitrogen, phosphorus plus 100 percent potassium in addition to the inoculation of *Azotobacter*, *Azospirillum*, PSB and VAM.

4.11 Breadth of *Capsicum*

4.11.1 Effect of nitrogen

Breadth of *Capsicum* was found to be significantly increased with the increase of nitrogen level up to a certain limit (Table 12). The highest breadth of *Capsicum* (4.86 cm) was found with 100 kg N ha^{-1} and the lowest breadth of *Capsicum* (2.97 cm) was found in control treatment. Mary *et al.* (1990) found that the greatest fruit length and girth obtained from plants receiving the highest NK rates (N - 87.5 kg ha^{-1} and K_2O-52.5 kg ha^{-1}) and irrigated at 0.75 IW: CPE ratio.

4.11.2 Effect of phosphorus

Breadth of *Capsicum* did not increase with the increment of phosphorus of *Capsicum* significantly (Table 13). The greatest breadth of *Capsicum* (3.92 cm) was observed with 30 kg ha^{-1} of phosphorus fertilizer. The lowest result (3.74 cm) was observed in the control treatment.

4.11.3 Combined effect of nitrogen and phosphorus

Combined treatment of nitrogen and phosphorus had significant effect (Table 14) on breadth of *Capsicum*. Highest breadth of *Capsicum* was observed in N_3P_1 treatment (5.00 cm). The lowest breadth of *Capsicum* (2.59 cm) was observed in control treatment (N_0P_0). From these results, it was observed that higher dose of nitrogen and phosphorus was influential nutrients for breadth of *Capsicum* up to a certain limit.

Table 12. Influence of nitrogen on length of *Capsicum* and breadth of *Capsicum*

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
N_0	5.86 c	2.97 c
N_1	6.68 b	3.21 c
N_2	7.41 a	**4.86 a**
N_3	**7.63 a**	4.23 b
$LSD_{0.05}$	0.72	0.31
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0=Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 13. Influence of phosphorus on length of *Capsicum* and breadth of *Capsicum*

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
P_0	6.51 b	3.74
P_1	6.79 ab	3.91
P_2	**7.38 a**	3.80
$LSD_{0.05}$	0.62	NS
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 14. Interaction effect of nitrogen and phosphorus on length and breadth of *Capsicum*

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
N_0P_0	5.05 d	2.59 e
N_0P_1	5.52 cd	3.21 d
N_0P_2	7.02 ab	3.11 de
N_1P_0	6.21 bcd	3.07 de
N_1P_1	6.73 abc	3.35 d
N_1P_2	7.11 ab	3.20 d
N_2P_0	6.93 ab	4.00 c
N_2P_1	7.41 ab	4.20 bc
N_2P_2	7.90 a	4.50 abc
N_3P_0	7.39 ab	4.69 ab
N_3P_1	**8. 00 a**	**5. 00 a**
N_3P_2	7.50 ab	4.90 a
$LSD_{0.05}$	1.24	0.54
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant

4.12 Number of fruits per plant

4.12.1 Effect of nitrogen

The number of fruit per plant increased significantly with the increase of nitrogen level (Table 15). The highest number of fruits per plant (8.61) was found with 150 kg N ha^{-1} and the lowest number of fruits per plant (4.32) was found in control treatment. Number of fruits per plant increased gradually with the increase of nitrogen dose. Application of 100 kg N in combination with 25 kg P ha^{-1}recorded the highest number of fruits $plant^{-1}$ (Pundir *et al.,* 1999). Nitrogen fertilization improved plant growth, but did not influence fruiting time. Moderate nitrogen applications (150 kg N ha^{-1}) gave best yields in most field trials (Vos *et al.,* 1997). This investigation was supported by Sharma *et al.* (1996); Das *et al.* (1992); Mishriky *et al.* (1994); Ingle *et al.* (1992); Shrivastava *et al.* (1996). Nitrogen at 240 kg ha^{-1} + P at 180 kg ha^{-1} produced the highest mean number of fruits per plant (7.51) (Srinivasan *et al.*, 1997).

4.12.2 Effect of phosphorus

Number of fruit per plant increased with the increment of phosphorus of *capsicum* significantly (Table 16). The highest number of fruit per plant (7.44) was observed with 60 kg ha^{-1} of phosphorus fertilizer. It was found that the lowest number of fruit (6.17) per plant was identified in the control treatment.

4.12.3 Combined effect of nitrogen and phosphorus

Combined treatment of nitrogen and phosphorus had significant effect (Table 17) on number of fruit per plant. Number of fruit per plant (9.50) was the highest in N_3P_1 treatment. The lowest number of fruit per plant (3.50) was observed in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for number of fruit per plant. Srinivasan *et al.* (1997) reported that N at 240 kg ha^{-1} + P at 180 kg ha^{-1} produced the highest mean number of fruits per plant (7.51). Shrivastava *et al.* (1996) found that the highest number of fruits/plant (10.66) were observed in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}.

4.13 Average fruit weight

4.13.1 Effect of nitrogen

Average fruit weight per plant was measured and found significant increased with the increase of nitrogen level (Table 15). The highest average fruit weight per plant (99.80) was found with 150 kg N ha^{-1} and at the same time the lowest number of fruit per plant (84.47) was observed in control treatment. Average fruit weight per plant increased gradually with the increase of nitrogen dose. The result is in agreement with Mishriky *et al.*, (1994) who reported that increasing the nitrogen rate significantly increased number and weight of fruits per plant.

4.13.2 Effect of phosphorus

Average fruit weight per plant increased with the increase of phosphorus of *capsicum* significantly (Table 16). Average fruit weight per plant (91.51) was the highest with 60 kg ha^{-1} of phosphorus fertilizer the lowest (89.74) with in the control treatment.

4.13.3 Combined effect of nitrogen and phosphorus

The interaction effect of nitrogen and phosphorus for average fruit weight was significant (Table 17). Average fruit weight per plant (102.50) was the highest in N_3P_1 treatment and the lowest (83.50) in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for increasing average fruit weight per plant. Similar results were found by Shrivastava *et al.* (1996). They reported that the highest fresh weight/fruit (128) were in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}.

4.14 Yield (t ha^{-1})

4.14.1 Effect of nitrogen

Analysis of variance showed that the yield was significantly increased with the increase of nitrogen level (Table 15). The highest amount of marketable fruit yield of *capsicum* (8.34 t ha^{-1}) was found with 150 kg N ha $^{-1}$ and at the same time the lowest amount of yield (4.94 t ha^{-1}) was observed in control treatment. Yield gradually increased with the increase of nitrogen dose. Finally availability of nitrogen and their uptake by plant sequentially increased the amount of yield. Application of 150 kg N ha^{-1} in equal splits, at planting, 30 days and 60 days after planting gave higher yield of sweet pepper cv. 'California Wonder.' This result was found by Hasanuzzaman (1999). With the increase of nitrogen fertilization the fruit yield increased up to a certain level (Hasan, 1978). The N and P treatment, showed that 120 kg N + 60 kg P ha^{-1}gave significantly higher yield than the other combinations (Srivastava *et al.*, 2003). The yield of chilli fruits increased with increasing nitrogen levels and the highest fruit yield was recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}, (Singh *et al.*, 2004) . Aliyu (2002) found that significant increases in the yield both per plant and per hectare were obtained up to 240 kg N ha^{-1}. Balakrishnan (1999) reported that plant growth and fruit yield were reduced considerably in nitrogen deficient treatment but was only slightly affected by calcium deficiency. With regard to N application rate, the greatest vegetative growth and fruit yield (5.49 t ha^{-1}) were observed at 120 kg N ha^{-1} (Singh *et al.* 2000). The dry chilli yield increased significantly with increasing N and N at 120 kg ha^{-1}gave 313.8, 103.9 and 24.8% increases in yield, respectively, over 0, 60 and 90 kg ha^{-1} (Das *et al.* 1992).

4.14.2 Effect of phosphorus

Yield of chilli (*Capsicum annum*) increased with the increase of phosphorus level significantly (Table 16). The highest yield of chilli (7.18 t ha^{-1}) was observed with 60 kg ha^{-1} of phosphorus fertilizer. It was found that the lowest yield of chilli (6.27 t ha^{-1}) was observed in the control treatment Singh *et al.* (2004) reported that the highest fruit yield of *Capsicum* recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}. However, P at 60 kg ha^{-1}gave higher yields than 120 kg P ha^{-1} (Srivastava *et al.*, 2003). The application of phosphorus increased early and total yields of sweet peppers (Ozaki and Hortenstine, 1963).

4.14.3 Combined effect of nitrogen and phosphorus

The interaction effect of nitrogen and phosphorus on yield was significant (Table 17). Yield of *capsicum* (8.51 t ha^{-1}) was the highest in N_3P_1 treatment. The lowest yield of *capsicum* (4.57 t ha^{-1}) was observed in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for increasing yield of *capsicum*. Among the various N and P combinations, 120 kg N + 60 kg P ha^{-1} recorded the greatest fruit yield (262.30 q ha^{-1}). (Chauhan *et al.*, 2005). Such type of results was found by Chaudhary *et al.* 2007. They stated that maximum fruit yield was obtained with N at 250 kg ha^{-1}, while P application increased yield by increasing fruit number and fruit yield/plant at concentrations up to 150 kg ha^{-1}. Raj-Narayan *et al.* (2004) stated that the maximum N, P and K uptake (134.56, 14.91 and 104.46 kg ha^{-1}, respectively), fruit yield (296.63 q ha^{-1}), ascorbic acid content (114.26 mg/100 g) and chlorophyll content (6.50 mg/g) were recorded in 50% poultry manure (PM) +50% NPK application. Singh *et al.* (2004) found that the highest fruit yield was recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}, followed by 120 kg N ha^{-1} + 30 kg P ha^{-1}. And the lowest fruit yield was recorded in the control treatment where only 60 kg K ha^{-1} was applied as a basal dressing. Sharma *et al.* (1996) concluded that the best treatment to promote yield and profitability was 120 kg N + 30 kg P_2O_5 ha^{-1}. Shrivastava *et al.* (1996) found that the highest yield/plant (637.5 g) and yield ha^{-1} (92.95 q ha^{-1}) were in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}.

Table 15. Influence of nitrogen on number of fruits per plant, average fruit weight/ plant (gm) and yield (t ha^{-1}) of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant	Yield (t ha^{-1})
N_0	4.32 c	84.47 d	4.94 d
N_1	6.02 b	86.78 c	6.46 c
N_2	8.23 a	93.28 b	7.57 b
N_3	**8.61 a**	**99.80 a**	**8.34 a**
$LSD_{0.05}$	0.61	0.98	0.56
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0 =Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 16. Influence of phosphorus on number of fruit per plant, average fruit weight/ plant (gm) and yield (t ha^{-1}) of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant	Yield (t ha^{-1})
P_0	6.17 c	89.74 b	6.27b
P_1	6.78 b	92.00 a	7.03 a
P_2	**7.44 a**	**91.51 a**	**7.18 a**
$LSD_{0.05}$	0.53	0.85	0.49
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 17. Interaction effect of nitrogen and phosphorus on number of fruits per plant, average fruit weight and yield (t ha^{-1}) of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant	Yield (t/ha)
N_0P_0	3.50 g	83.50 h	4.57 d
N_0P_1	4.95 f	85.00 gh	4.93 d
N_0P_2	4.50 fg	84.90 gh	5.32 d
N_1P_0	5.12 ef	85.01 gh	5.50 d
N_1P_1	6.12 de	86.62 g	6.79 c
N_1P_2	6.82 cd	88.70 f	7.10 bc
N_2P_0	7.40 bc	91.57 e	6.70 c
N_2P_1	8.00 b	95.36 d	7.90 ab
N_2P_2	9.30 a	92.92 e	8.10 ab
N_3P_0	7.20 bcd	97.37 c	8.30 a
N_3P_1	**9.50 a**	**102.5 a**	**8.51 a**
N_3P_2	9.12 a	99.50 b	8.21 a
$LSD_{0.05}$	1.05	1.70	0.97
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant

4.15 Thickness of pericarp

4.15.1 Effect of nitrogen

Thickness of pericarp of fruit was measured and found significantly influenced by the nitrogen levels (Table 18). The highest thickness of pericarp of fruit (2.74) was found with 150 kg N ha^{-1} and in the mean time the lowest (1.33 mm) was observed in control treatment. Thickness of pericarp increased gradually with the increase of nitrogen dose.

4.15.2 Effect of phosphorus

Thickness of pericarp increased with the increase of phosphorus levels significantly (Table19). The highest thickness of pericarp (2.20 mm) was observed with 60 kg ha $^{-1}$ of phosphorus fertilizer followed by 30 kg ha $^{-1}$. The lowest thickness of pericarp (1.82 mm) was identified in the control treatment.

4.15.3 Combined effect of nitrogen and phosphorus

The combined effect of nitrogen and phosphorus on the thickness of pericarp was significant (Table 20). Thickness of pericarp (2.90 mm) was the highest in N_3P_2 treatment which was statistically similar to N_3P_1 and N_2P_2. The lowest thickness of pericarp (1.20 mm) was observed in control treatment (N_0P_0).

4.16 Dry matter of fruit

4.16.1 Effect of nitrogen

Dry matter percent of fruit increased significantly with the increase of nitrogen level (Table 18). The highest dry matter of fruit (5.63 %) was found with 150 kg N ha $^{-1}$ and the lowest (1.33%) in control treatment. Thickness of pericarp increased gradually with the increase of nitrogen dose.

4.16.2 Effect of phosphorus

Dry matter percentage of fruit increased with the increase of phosphorus levels significantly (Table19). The highest dry matter percentage (4.50%) was observed with 60 kg ha^{-1} of phosphorus fertilizer which was followed by 30 kg ha^{-1}. The lowest dry matter percentage was identified in the control treatment.

4.16.3 Combined effect of nitrogen and phosphorus

The interaction effect of N and P on dry matter percentage was significant (Table 20). The highest dry matter percentage (6.00%) was found in N_3P_2. Similar result was found by Sajan *et al.* (2002).They stated that the maximum plant height (100.03 cm), leaf area (28.79 dm^2/plant), and dry matter (187.36 g/plant) were recorded in the plants inoculated with *Azotobacter, Azospirillum*, PSB, and VAM in combination with 75% NPK+100% K compared to the control (NPK fertilizer 75 or 100%) .They also stated that the plants also produced 36% more fruits per plant (111.38) and 45% more dry fruit yield (2.27 t ha^{-1}) compared to the control (81.68 and 1.56 t ha^{-1}, respectively). Gowda *et al.* (2002) found that he maximum plant height, number of branches per plant, leaf area and dry matter production per plant were recorded in plant supplied with 75 per cent nitrogen, phosphorus plus 100 per cent potassium in addition to the inoculation of *Azotobacter, Azospirillum*, PSB and VAM.

Table 18. Influence of nitrogen on thickness of pericarp (mm) and dry matter of fruit (%) of *Capsicum*

Treatment	Thickness of pericarp (mm)	Dry matter of fruit (%)
N_0	1.33 d	2.75 d
N_1	1.75 c	3.93 c
N_2	2.22 b	4.93 b
N_3	**2.74 a**	**5.63 a**
$LSD_{0.05}$	0.23	0.23
CV (%)	11.89	5.44

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

N_0=Control (without N), N_1=50 kg N ha^{-1}, N_2=100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 19. Influence of phosphorus on thickness of pericarp (mm) and dry matter of fruit (%) of *Capsicum*

Treatment	Thickness of pericarp (mm)	Dry matter of fruit (%)
P_0	1.82 b	4.00 b
P_1	2.03 a	4.44 a
P_2	**2.20 a**	**4.50 a**
$LSD_{0.05}$	0.20	0.20
CV (%)	11.89	5.44

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 20. Interaction effect of nitrogen and phosphorus on thickness of pericarp (mm) and dry matter of fruit (%) of *Capsicum*

Treatment	Thickness of pericarp (mm)	Dry matter of fruit (%)
N_0P_0	1.20 f	2.75 gh
N_0P_1	1.50 ef	2.50 h
N_0P_2	1.30 ef	3.01 fg
N_1P_0	1.59 def	3.35 f
N_1P_1	1.67 cde	3.95 e
N_1P_2	2.00 cd	4.50 d
N_2P_0	1.97 cd	4.60 d
N_2P_1	2.10 bc	5.29 bc
N_2P_2	2.60 a	4.90 cd
N_3P_0	2.50 ab	5.30 bc
N_3P_1	2.83 a	**6.00 a**
N_3P_2	**2.90 a**	5.60 b
$LSD_{0.05}$	0.40	0.40
CV (%)	11.89	5.44

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS= Non significant

4.17 Effect of nitrogen and phosphorus on nutrient content in *Capsicum* plants and in post harvest soil

4.17.1. Nitrogen content in plants

Nitrogen content in plants was influenced significantly by nitrogen fertilization (Figure 3). The highest N content in plant was 1.71%, which was observed in N_{100} treatment and it was statistically similar with N_{150} treatment. The lowest N content in plants (0.95%) was found in N_0 treatment. The result revealed that nitrogen content in plant was increased with increasing rate of nitrogen up to 100 kg N ha^{-1}. Nitrogen content in plant was not significantly affected by different P level (Figure 4). The N content in plant ranged from 1.24% observed in control to 1.51% recorded in P_0 treatment.

The combined effect of N and P on N content in plant was significant (Table 21). The N content in plant ranged from 0.87% observed in control to 1.89% in $N_{150}P_{60}$ treatment. The highest concentration of N obtained with $N_{150}P_{60}$ treatment. The minimum plant-N content was found in control, which was statistically similar with N_0P_{30}, N_0P_{60} and $N_{150}P_0$ treatment.

4.17.2. Phosphorus content in plants

There was no significant difference among the different treatments of N in respect of P content in plants (Figure 3). Maximum P content of 0.04% was found in N_{150} treatment and the minimum P content in plants (0.03%) was recorded in N_0 treatment. There was significant difference among the different treatments of P in respect of P content in plants (Figure 4). The P content in plants ranged from 0.03% observed in control to 0.04% in P_{60}. The highest P concentration (0.04%) was observed in P_{60}, which was significantly different from P_{30} and P_0. The result showed that plants-P content was increased with increasing rate of phosphorus.

The combined effect of Nitrogen and phosphorus on P content in plants was significant (Table 21). Phosphorus content in plants was ranged from 0.03% to 0.04%. The maximum phosphorus content in plants was found in $N_{150}P_{60}$ treatment, which was significantly identical with $N_{150}P_{30}$, $N_{100}P_{60}$ and the minimum P-content (0.03%) was found in control.

4.17.3 Nitrogen content in post harvest soil

There was significant difference among the different treatments of N in respect of N content in post harvest soil (Table 21). The highest N content in post harvest soil was 0.08%, which was observed in N_{150} treatment and it was statistically similar with N_{100} and N_{50} treatments. The lowest N content in post harvest soil (0.06%) was found in N_0. The result revealed that nitrogen content in post harvest soil was increased with increasing rate of nitrogen up to higher dose (150 kg N ha^{-1}).

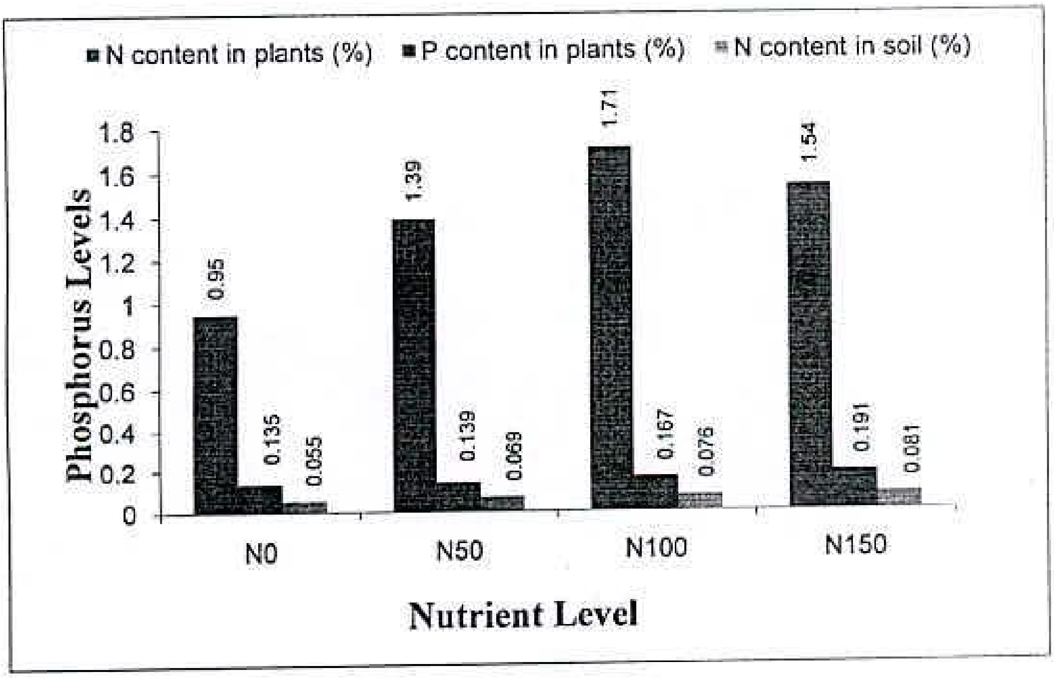

Fig. 3 Effect of nitrogen on nutrient content in plants of *Capsicum* and nitrogen content in post harvest soil

Figure in column, having same letter(s) do not differ significantly at 5% level.

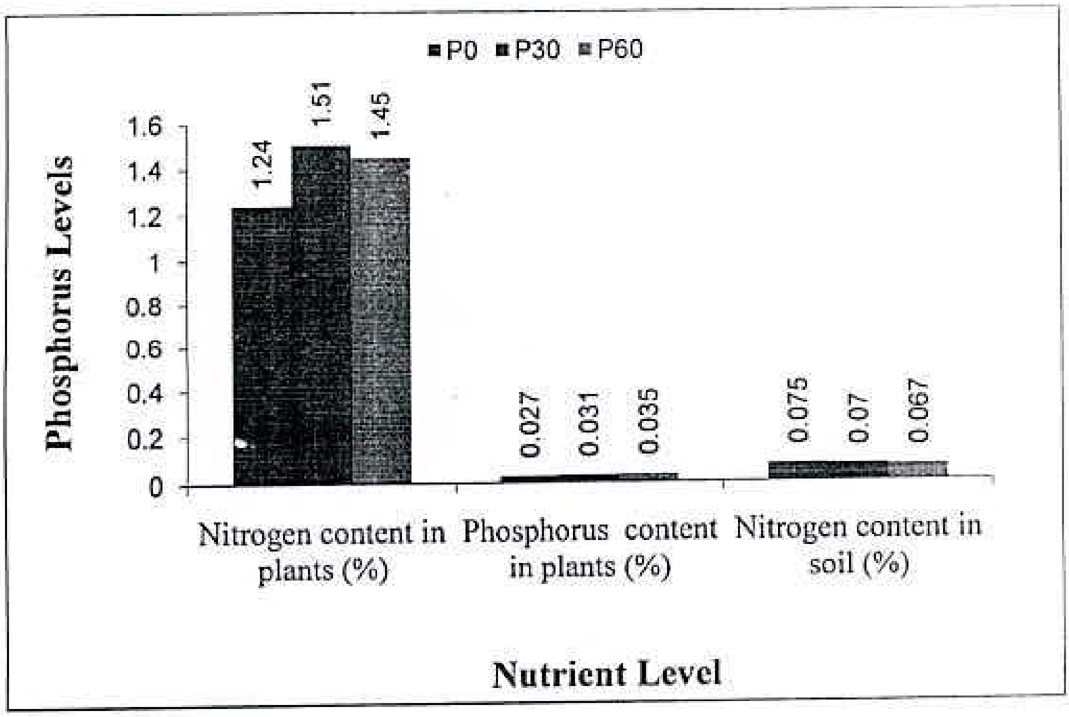

Fig. 4 Effect of phosphorus on nutrient content in plants of *Capsicum* and nitrogen content in post harvest soil

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

Table 21. Interaction effect of nitrogen and phosphorus on nutrient content in plants of *Capsicum* and post harvest soil

Treatments	Nutrient content in plants (%)		Nitrogen content in soil (%)
	Nitrogen	Phosphorous	
N_0P_0	0.87 f	19.33 j	0.06 cd
N_0P_{30}	0.96 f	23.67 i	0.05 d
N_0P_{60}	0.98 f	26.67 g	0.06 cd
$N_{50}P_0$	1.26 de	25.00 h	0.07 bcd
$N_{50}P_{30}$	1.44 cd	27.33 f	0.07 bcd
$N_{50}P_{60}$	1.47 cd	29.00 d	0.07 abc
$N_{100}P_0$	1.61 bc	28.33 ef	**0.09 a**
$N_{100}P_{30}$	1.71 ab	29.67 c	0.07 abc
$N_{100}P_{60}$	1.82 ab	31.23 ab	0.07 abc
$N_{150}P_0$	1.08 ef	28.67 ef	0.08 ab
$N_{150}P_{30}$	1.65 bc	31.33 ab	0.08 ab
$N_{150}P_{60}$	**1.89 a**	**33.50 a**	0.08 ab
CV (%)	8.72	9.63	8.63
$LSD_{0.05}$	0.21	0.01	0.02

Figure in column, having same letter(s) do not differ significantly at 5% level.

NS = Non significant

Nitrogen content in post harvest soil was not significantly affected by different P level (Table 22). The N content in post harvest soil ranged from 0.07% observed in P_{30}treatment to 0.08% recorded in control. The results also showed that N content in post harvest soil decreased with increasing level of phosphorus.

The combined effect of N and P on N content in post harvest soil was significant (Table 23). The N content in post harvest soil ranged from 0.05% observed in N_0P_{30}, 0.88% in $N_{100}P_0$ treatment. The highest concentration of N obtained with $N_{100}P_0$ treatment combination, which was statistically similar with $N_{100}P_{30}$. The minimum post harvest soil N content was found in N_0P_0 treatment.

CHAPTER 5
SUMMARY AND CONCLUSION

A field experiment was conducted at the research Farm of Sher-e-Bangla Agricultural University, Dhaka during November 2006 to March 2007 to study the effect of nitrogen and phosphorus on growth, yield and quality of *Capsicum*. The experiment was conducted in a randomized complete block design with 3 replications. Fertilizer treatments were randomly distributed in each block. Each block consisted of 12 plots and individual plot was 2.2 m × 1.8 m i.e. 3.96 sq. m in size. The row-to-row and plant to plant distance were 55 and 27.5 cm respectively accommodating 12 plants in each plot. The adjacent block and neighboring plots were separated by 0.75 m and 0.5 m, respectively. There were 12 treatments combinations in the experiment comprising 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_{60}, respectively). The individual and combined effects of nitrogen (N) and phosphorus (P) on growth, yield and quality of *capsicum* were studied.

Nitrogen and phosphorus fertilization at different levels individually influenced plant characters. The individual and interaction effect of N and P on growth, yield and quality of *Capsicum* was found positive. Days to flower bud emergence (29.87), days to first flower opening (32.15), plant height at first flower (16.57 cm) and at first harvest (23.87), number of branches at first flowering (6.41), length (7.41 cm) and breadth (4.86 cm) of fruit and number of fruits per plant (8.23) increased significantly with increasing nitrogen doses up to 100 kg N ha^{-1}. However, plant height at final harvest (31.62 cm), number of branches per plant at first (11.69) and final harvest (17.98), average weight of fruit (99.80 gm), yield (8.34 t ha^{-1}), thickness of pericarp (2.74 mm) and dry matter content (5.63 %) increased significantly up to 150 kg N ha^{-1} (N_3 treatment).

On the other hand, days to flower bud emergence (30.81), plant height at first flowering (16.44 cm), number of branches at first harvest (9.79), average weight of fruit (92.00 gm), yield (7.03 t ha^{-1}), thickness of pericarp (2.03 mm) and dry matter content (4.44 %)

increased significantly with increasing levels of P up to the treatment P_1(30 kg P ha^{-1}), where as plant height (30.17 cm) and number of branches (16.41) at final harvest, length of *Capsicum* (7.38 cm), number of fruits per plant (7.44) enhanced significantly up to the treatment P_2 (60 kg P ha^{-1}).

Considering the combined effect of nitrogen and phosphorus, the maximum significant days to flower bud emergence (32.28), days to first flower opening (33.34), days to first fruit set (34.28) and plant height at final harvest (32.00 cm) were obtained with N_2P_2 (100 kg N + 60 kg P ha^{-1}). On the other hand maximum length of *Capsicum* (8.00 cm), breadth of *Capsicum* (5.00 mm), number of fruits per plant (9.50), average weight of fruit (102.5 gm), yield (8.51 t ha^{-1}) and dry matter content (6.00 %) were found with the treatment combination N_3P_1 (150 kg N + 30 kg P ha^{-1}).

From the present study, the following conclusion may be drawn –

- Individual effect of N and P on growth and yield of *Capsicum* was found positive and significant.
- The combined effect of N and P enhanced growth, yield and yield attributes of capsicum.
- Application of N @ 150 kg ha^{-1} and P @ 60 kg ha^{-1} was the most suitable combination to give the maximum significant yield of capsicum.

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

REFFERENCES

Aguilar-Acuna, J. L., Grageda-Cabrera, O. A., Vuelvas-Cisneros, M. A., Martinez-Hernandez, M., Solis-Moya, E., Medina-Cazares, T. and Ramirez-Ramirez, A (2005). Efficiency of fertilizers applied with fertigation in poblano chili pepper (*Capsicum annum* L.). Programa de Fertirrigacion y Nutricion Vegetal, Campo Experimental Bajio, INIFAP, Km 6.5 carretera Celaya - San Miguel de Allende, Apartado Postal 112, 38010 Celaya, Guanajuato, Mexico. *Agricultura Tecnica en Mexico.* **31** (2): 177-189.

Akinrinde, E. A. and Adigun, I. O. (2005). Phosphorus use efficiency by pepper (*Capsicum frutescens*) and okra (*Abelmoschus esculentus*) at different phosphorus fertilizer application levels on two tropical soils. Department of Agronomy, University of Ibadan, Ibadan, Nigeria. *Journal of Applied Sciences.* **5** (10): 1785-1791.

Alabi, D. A. (2006). Effects of fertilizer phosphorus and poultry droppings treatments on growth and nutrient components of pepper (*Capsicum annuum* L). Department of Plant Science and Applied Zoology, Olabisi Onabanjo University, Ago-Iwoye, Nigeria. *African Journal of Biotechnology.* **5** (8): 6716.

Aliyu, L. and Yusuf, Y. (1991). Response of two chilli pepper (*Capsicum frutescens*) varieties to intra-row spacing and nitrogen levels. Department of Agronomy, Ahmadu Bello University, Samaru Zaria, Nigeria. Capsicum Newsletter. **10**: 43-44.

Aliyu, L. (2000) Effect of organic and mineral fertilizers on growth, yield and composition of pepper (*Capsicum annum* L.). Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria. **18** (1): 29-36.

Aliyu, L. (2002) Growth and yield of pepper (*Capsicum annum* L.) as affected by nitrogen and phosphorus application and plant density. Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria. *Crop Research Hisar.* **23** (3): 467-475.

Aloni, B., Karni, L., Rylski, I. and Zaidman, Z. (1994). The effect of nitrogen fertilization and shading on the incidence of "colour spots" in sweet pepper (*Capsicum annum*) fruit. Department of Vegetable Crops, Institute of Field and Garden Crops, Volcani Center, ARO, Bet Dagan 50250, Israel. *Journal of Horticultural Science.* **69** (4): 767-773.

Anez, B. and Tavira, E. (1993). Growth and yields of capsicum in response to different planting distances and nitrogen rates. Instituto de Investigaciones Agropecuarias, Universidad de los Andes, Apartado 220, Merida 5101, Venezuela. Revista de la Facultad de Agronomia, Universidad del Zulia. **10** (1): 1-21.

AVRDC. (1989). Tomato and Pepper production in the tropics. AVRDC, Taiwan, P. 585.

Azofeifa, A. and Moreira, M. A. (2005). Nutrient uptake and partitioning of sweet pepper plants (*Capsicum annum* cv. UCR 589) in Alajuela, Costa Rica. Estacion Experimental Fabio Baudrit, Universidad de Costa Rica, Alajuela, Costa Rica. *Agronomia Costarricense.* **29** (1): 77-81.

Baghour, M., Ruiz, J. M., Moreno, D. A., Villora, G., Hernandez, J. and Romero, L., (2000). Forms of sulfur in mature leaves of Capsicum (*Capsicum annum* L.) as affected by supplies of ammonium nitrate and potassium sulfate. Departmento de Biologia Vegetal, Facultad de Ciencias, Universidad de Granada, Fuentenueva S/N, 18071-Granada, Spain. **31** (11/14): 2329-2334.

Balakrishnan, K. (1999). Studies on nutrients deficiency symptoms in chilli (*Capsicum annum* L.). Dept. of Crop Physiology, Horticultural College and Research Institute (TNAU), Periyakulam-625604, India. *Indian Journal of Plant Physiology.* **4** (3): 229-231.

Balliu, A., Bani, A. and Sulce, S. (2007). Nitrogen effects on the relative growth rate and its components of pepper (*Capsicum annum*) and eggplant (*Solanum melongena*) seedlings. Agricultural University of Tirana, Tirana, Albania. Acta Horticulturae. **7** (7): 257-262.

Basavaraj, N. and Naik, C. I. (2000). Some production aspects of Capsicum (*Capsicum annum* L.) under plains. Division of Horticulture, University of Agril. Sciences, Dharwad, Karnataka, India. **3** (4) 181-183.

Chailloux, M., Treto, E. and Cardoza, H. (1992). Effect of nitrogen on capsicum growth in Red Ferralitic soils. Instituto de Investigaciones Horticolas Liliana Dimitrova, La Habana, Cuba. Agrotecnia-de-Cuba. **24** (3-4): 61-66.

Chaudhary, A. S., Sachan, S. K. and Singh, R. L. (2007) .Effect of spacing, nitrogen and phosphorus on growth and yield of capsicum hybrid.S.V.B.P.Ag.& Tech., Krishi Gyan Kendra, Izatnagar, Bareilly (U.P.), India. *International Journal of Agricultural Sciences.* **3** (1): 12-14.

Chauhan, V. L., Singh, R. V. and Raghav, M. (2005). Optimum nitrogen and phosphorus fertilization in hybrid capsicum. Department of Vegetable Science, GBPUAT Hill Campus, Ranichauri 249 199 (Uttaranchal), India. Vegetable Science. **32** (2): 200-202.

XinNian, C. and YunXiang, H. (2000). Experiment of a new compound flower fertilizer applied on Solanum pseudo-capsicum. General Affairs Section, HNAU, Changsha 410128, China. *Journal of Hunan Agricultural University.* **26** (3): 214-215.

Cochran, H. L. (1936). Some factors influencing growth and fruit setting in the pepper. Cornell Agr. Expt. Sta. Memoir. No. 190. P.36.

Das, T. K. and Rath, B. S. (1992). Effect of different levels of N and P on the yield of transplanted (irrigated) chili (*Capsicum annum* L.). Vegetable Improvement Project, Research Wing, O.U.A.T., Bhubaneswar, India. *Orissa Journal of Agricultural Research.* **5** (3/4): 194-196.

Deanon, J. R. (1967). Egg plant, Tomato and pepper. In: Vegetable production in Southeast Asia (Ed. Knott, J. E. and Deanon, J. R.), Laguna. Univ. of Philippines. P. 120.

Demirovska, V., Trpevski, V., Ognenovski, V., Stojanova, M., Agic, R. and Simonov, D. (1992). The effect of different nitrogen rates on the yield and quality of some capsicum cultivars Zemjodelski Institut, Skopje, Macedonia. *Savremena Poljoprivreda.* **40** (1-2): 45-50.

Eissa, A. M., Salman, S. R. and Abou-Hadid, A. F. (2005). Effect of the interactions between different levels of soil moisture, phosphorus and iron on the growth and nutritional status of pepper (*Capsicum annum* L.) plants grown on a calcareous soil.Soils, Water & Environmental Res. Inst., ARC., Ain Shams Univ., Cairo, Egypt. *Egyptian Journal of Horticulture.* **30** (3/4): 291-299.

Elia, A. and Santamaria, P. (1995). Effects of the form of nitrogen on sweet pepper (*Capsicum annum* L.). II. N, oxalate and anion and cation content. Istituto sull'Orticolltura Industriale, Bari, Italy. *Rivista di Agronomia.* **29** (3): 234-241.

Farris, N. P. (1988). Perfect pepper. Horticulture, USA Horticultural limited Partnership. P. 60-62.

Gezerel, O. and Donmez, F. (1988). The effect of slow release fertilizers on the yield and fruit quality of vegetable crops growing in the Mediterranean areas of Turkey. *Acta Horticulturae.* **272**: 63-69.

Ghoname, A. and Shafeek, M. R. (2005). Growth and productivity of sweet pepper (*Capsicum annum* L.) grown in plastic house as affected by organic, mineral and bio-N fertilizers. National Research Centre, Department of Vegetable Research, El-Tahrir St., Dokki, Cairo, Egypt. *Journal of Agronomy.* **4** (4): 369-372.

Gill, M. J. (1974). Nitrogen effect on flowering and fruit set of sweet pepper. *Indian J. Agric.Sci.* **62** (2): 42-44.

Gowda, K. K., Sajjan, M. and Sreeramu, B. S. (2002). Effect of bio-fertilizers with graded levels of nitrogen and phosphorus on growth, yield and quality of chillies (*Capsicum annum* L.) cv. Byadagi Dabba. Division of Horticulture, University of Agricultural Sciences, GKVK, Bangalore - 65, India. Proceedings of the 15th Plantation Crops Symposium Placrosym-XV, Mysore, India. **5** (3): 304-309.

Grazia, J de., Tittonell, P. A. and Chiesa, A. (2007). The effect of substrates with compost and nitrogenous fertilization on photosynthesis, precocity and pepper (*Capsicum annum*) yield.Catedras de Edafologia y Horticultura, respectivamente, Facultad de Ciencias Agrarias, Universidad Nacional de Lomas de Zamora, Ruta Provincial no 4 km 2, Llavallol (1836), Buenos Aires, Argentina. *Ciencia-e-Investigacion Agraria.* **34** (3): 195-204.

Gulati, J. M. L., Mishra, M. M., Paul, J. C. and Sahu, G. S. (1995). Production potential of chilli (*Capsicum annum*) under levels of irrigation and nitrogen. Water Management Project, Regional Research Station, Orissa University of Agriculture and Technology, Chiplima 768 025, India. *Indian Journal of Agronomy*. **40** (1): 145-146.

Hari, G. S., Rao, P. V., Reddy, Y. N. and Reddy, M. S. (2006). Effect of organic manures in combination with nitrogenous fertilizer on yield and nutrient uptake in paprika (*Capsicum annum* L.) under irrigated conditions of northern Telangana Zone of Andhra Pradesh. Jannareddy Venkat Reddy Horticultural Research Station, Malyal, District Warangal - 506 101 (A. P.), India. **31** (2): 230-233.

Hasan, H. R. (1978). Effect of nitrogenous fertilizer on yield and nutrient uptake in *Capsicum annum*L. Ph.D. Thesis, IARI, New Delhi, India.

Hassanuzzaman, S. M. (1999). Effect of hormone on yield of bell pepper (*Capsicum annum* L.) M. S. Thesis, Submitted to the Department of Horticulture, Bangladesh Agricultural University, Mymensingh.

Ingle, H. V., Gulandhe, S. S. and Allurwar, M. W. (1992) . Effect of split application of nitrogen on growth and yield of chilli (*Capsicum annum* L.) var. CA-960. Regional Fruit Research Station, Katol, Nagpur, Maharashtra, India. *Journal of Soils and Crops*. **2** (1): 102-103.

Jaggi, R. C., Suri, V. K. and Dixit, S. P. (2003). Comparative performance of sulphur-containing and non-containing phosphorus fertilizers on dry chilli (*Capsicum annum*) in acid Alfisol. Department of Soil Science, Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyala, Palampur 176 062, India. *Indian Journal of Agricultural Sciences*. **73** (1): 49-50.

Javior, E. Q. (1992). Fore word. In: Vegetable production and marketing. Proc. Nat. Rev. Pln. Workshop. AVRDC/ BARI/ BARC/ USAID, ARP-ii Supplment. P.21-30.

Kacha, R. P., Sadhu, A. C., Tank, D. A., Gediya, K. M. and Patel, M. V. (2007) .Effect of spacing, castor cake and nitrogen levels on green fruit yield of chillies (*Capsicum annum* L.). Department of Agronomy, Anand Agricultural University, Anand - 388 110 (Gujarat), India. *Research on Crops*. **8** (2): 431-434.

Kappel, N., Terbe, I. and Szabo, Z. J. (2006). Specific nutrient requirements of green pepper (*Capsicum annum* L.). Department of Vegetable and Mushroom Growing, Faculty of Horticultural Science, Corvinus University of Budapest, Budapest, Hungary. *Kertgazdasag Horticulture.* **38** (1): 3-12.

Kato, T. and Tanaka, M. (1971). Studies on fruit setting and development of sweet pepper. Fruiting behaviour. *Jap. J. Hort. Sci.* **40**: 359-366.

Katwale, T. R. and Saraf, R. K. (1990) . Effect of growth regulators and urea spray on the growth and yield of chillies (*Capsicum annum* L.). JNKVV, Zonal Agricultural Research Station, Chhindwara 480 001, India. *Orissa Journal of Horticulture.* **18** (1-2): 52-56.

Knott, J. E. and Deanon, J. R. (1967). Eggplant, Tomato and Pepper. Vegetable production in Southeast Asia, Laguna, Philippines. Univ. of Philip. Press. P.99-109.

Kumar, A. K., Sreehari, G. and Reddy, A. V. (2006). Integrated nutrient management in chilli (*Capsicum annum* L.) under irrigated conditions in N. T. zone of Andhra Pradesh. ANGRAU J. V. R. Horticultural Research Station, Malyal, Warangal - 506 101 (A. P.), India. *Research on Crops.* **7** (2): 526-528.

WeiLi, L. and Sung Yu (2007). Influence of nitrogen concentration on plant growth and fruit pungency of 'Beauty Zest' and 'Hungariana' pepper (*Capsicum annum* var. *annum*). Department of Horticulture, National Chung Hsing University, Taichung, Taiwan. *Journal of the Taiwan Society for Horticultural Science.* **53** (2): 205-213.

JianLing, L., RenGang, L., WenHua, L. Ke, J., Meng Na and Zhe, C. (2005). The yield response of vegetable to phosphate fertilizer and soil phosphorus accumulation in a Chinese cabbage - Capsicum rotation. College of Resource and Environmental Sciences, Hebei Agriculture University, Baoding 071001, China. *Scientia Agricultura Sinica.* **38** (8): 1616-1620.

Lovelook, Y. (1973). Various herbs species and condiments. The Vegetable Book. New York, St. Martin Press. P. 343.

Maheswari, T. U., Haripriya, K. and Kamalakannan, S. (2003). Impact of foliar organic nutrients on nutrient uptake pattern of chilli (*Capsicum annum* L.). Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar - 608 002, India. *South Indian Horticulture.* **51** (1/6): 168-172.

Maheswari, T. U., Haripriya, K., Poonkodi, P. and Kamalakannan, S. (2004). Effect of foliar application of organic nutrients on some quality indices and economics of chilli (*Capsicum annum* L.) Faculty of Agriculture, Annamalai University, Annamalainagar - 608 002, India. *Advances in Plant Sciences.* **17** (1): 259-262.

Mallangouda, B., Sulikeri, G. S., Murthy, B. G. and Prathibha, N.C. (1995). Effect of NPK FYM and companion crops on growth, yield and yield components of chilli (*Capsicum annum* L.). University of Agriculture Sciences, Dharwad, Karnataka, India. *Advances in Agricultural Research in India.* **5** (3): 58-69.

Martinez, Y., Diaz, L. and Manzano, J. (2003). Influences of nitrogen and potassium fertilizer on the quality of 'Jupiter' pepper (*Capsicum annum*) under storage. P.O. Box 3301, Universidad Centroccidental, Lisandro, Alvarado, Barquisimeto, Lara, Venezuela. *Acta Horticulturae.* **628** (1): 135-140.

Mary, S. S. and Balakrishnan, R. (1990). Effect of irrigation, nitrogen and potassium on pod characters and quality in chilli (*Capsicum annum* L.) cv. K.2. Department of Horticulture, Agricultural College & Research Institute, Madurai 625 104, India. *South Indian Horticulture.* **38** (2): 86-89.

Mishriky, J. F. and Alphonse, M. (1994). Effect of nitrogen and plant spacing on growth, yield and fruit mineral composition of pepper (*Capsicum annum* L.). Department of Vegetable Crops, Faculty of Agriculture, Cairo University, Egypt. Bulletin of Faculty of Agriculture, University of Cairo. **45** (2): 413-431.

Moreno, D. A., Pulgar, G., Villora, G. and Romero, L. (1996). Effect of N and K on fruit production and leaf levels of Fe, Mn, and Zn, Cu and B and their biochemical indicators in capsicum plants. Departamento de Biologia Vegetal, Facultad de Ciencias, Universidad de Granada, Fuentenueva Campus, 18071 Granada, Spain. *Phyton Buenos Aires.* **59** (1/2): 1-12.

Murugan, M. (2001). Quality of chilli (*Capsicum annum* L.) variety Co-3 as influenced by levels and sources of phosphorus and levels of nitrogen. Cardamom Research Station, Kerala Agricultural University, Pampadumpara - 685 556, Kerala, India. *Journal of Spices and Aromatic Crops.* **10** (1): 1-5

Murugan, M., Backyiarani, S., Kumar, A. J. and Subbiah, A. (2002).Yield and nutrient content of chilli (*Capsicum annum* L.) in response to sources of P and levels of P and N. Cardamom Research Station, Kerala Agricultural University, Pampadampara - 685 556, Kerala, India. *Journal of Spices and Aromatic Crops.* **11** (1): 13-17.

Natarajan, S. (1990). Standardisation of nitrogen application for chilli (*Capsicum annum* L.) grown under semi-dry condition. Agricultural Research Station, Paramakudi 623 007, India. *South Indian Horticulture.* **38** (6): 315-318.

Olsen, J. K. and Lyons, D. J. (1994). Petiole sap nitrate is better than total nitrogen in dried leaf for indicating nitrogen status and yield responsiveness of capsicum in subtropical. Australia. Queensland Department of Primary Industries, Bundaberg Research Station, MS 108 Ashfield Road, Bundaberg, Qld 4670, Australia. *Australian Journal of Experimental Agriculture.* **34** (6): 835-843.

Owusu, E. O., Nkansah, G. O. and Dennis, E. A. (2000). Effect of sources of nitrogen on growth and yield of hot pepper (*Capsicum frutescens*). Crops Research Institute, PO Box 3785, Kumasi, Ghana. **40** (2): 58-62.

Ozaki, K. and Hortenstine, S. (1963). Effect of phosphorus on yield and quality in chilli (*Capsicum annum* L.). Department of Agronomy, College of Agriculture, Dimlau,Argentina. *Vegetable Science.* **25** (2): 144-145.

Pulgar, G., Villora, G., Moreno, D. A., Ruiz, J. M., Hernandez, J., Lopez, Cantarero, I. and Romero, L. (2000). Effect of nitrogen and potassium on the ionic balance in Capsicum plants (*Capsicum annum* L. cv. Lamuyo). Dpto. Biologia Vegetal, Facultad de Ciencias, Universidad de Granada, Fuentenueva S/N, 18071-Granada, Spain. **31** (11/14): 2321-2328.

Pundir, J. P. S. and Porwal, R. (1999). Effect of spacings and fertilizers on growth, yield and physical fruit quality of chilli (*Capsicum annum* L.) cultivars. Rajasthan Agricultural University, Bikaner - 334 006, Rajasthan, India. *Journal of Spices and Aromatic Crops*. **8** (1): 23-27.

Narayan, R., Magray, G. H., Ahmed, N. and Samanta, A. (2004). Effect of organic manures on nutrient uptake and quality of capsicum (*Capsicum annum* var. *grossum* L.). Division of Olericulture, S. K. University of Agricultural Sciences & Technology of Kashmir, Shalimar 191 121, Srinagar, India. *Horticultural Journal.* **17** (2): 141-144.

Rashid, M. M. (1999). Sabjee Biggan (In Bengali). Rashid Publishing House, 94, Puratan DOHS, Dhaka-1206.

Reddy, K. C., Ahmed, S. R. and Moula, S. P. (1999). Soil test based fertilizer prescription for specific yield target of chilli (*Capsicum annum* L.) grown in vertisols of Guntur in Andhra Pradesh. Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad - 500 030, Andhra Pradesh, India. *South Indian Horticulture.* **47** (1/6): 247-249.

Rocha, M. C., Gedda, A. E-di-C., Manera, T. C., Silva, D. A. G-da., Carmo, M. G. F-do., Polidoro, J. C. and Fernandes, M-do. C. A. (2003). Discente do Curso de Pos Graduacao em Fitotecnia Universidae Federal Rural do Rio de Janeiro, Brazil. Agronomia. **37** (1): 42-45.

Ruiz, J. M., Moreno, D. A., Villora, G., Olivares, J. Garcia, P. C., Hernandez, J. and Romero, L. (2000). Nitrogen and phosphorus metabolism and yield of capsicum plant (*Capsicum annum* L. cv. Lamuyo) in response to increases in NK fertilization. Department of Plant Biology, Faculty of Science, University of Granada, E-18071, Granada, Spain. *Communications in Soil Science and Plant Analysis.* **31** (11/14): 2345-2357.

Sajan, K. M., Gowda, K. K., Kumar, S. N. and Sreeramu, B. S. (2002). Effect of bio-fertilizers on growth and yield of chilli (*Capsicum annum* L.) cv Byadagi Dabba at different levels of nitrogen and phosphorus. Division of Horticulture, University of Agricultural Science, Bangalore - 560 065, Karnataka, India. *Journal of Spices and Aromatic Crops.* **11** (1): 58-61.

Santamaria, P. and Elia, A. (1995). Effect of the form of nitrogen on sweet pepper (*Capsicum annum* L.). I. Growth and water uptake. Istituto sull'Orticoltura Industriale, Bari, Italy. *Rivista di Agronomia.* **29** (3): 228-233.

Sarma, U. J., Baruah, J. P., Suhrawardy, J., Narzary, B. D. and Chakravarty, M. (2004). Effect of various NPK levels on yield and capsaicin content in direct seeded chilli (*Capsicum annum*). Regional Agricultural Research Station, Assam Agricultural University, Gossaigaon - 783 360 (Assam), India. *Indian Journal of Hill Farming.* **17** (1/2): 15-18.

Sharma, B. R., Chadha, A. P. S. and Bajpai, H. K. (1996). Response of chilli (*Capsicum annum* Lin.) to nitrogen and phosphorus levels under irrigated condition. Department of Vegetable Crops & Floriculture, Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur - 482 004 (M.P.), India. *Advances in Plant Sciences.* **9** (2): 213-214.

Sharu, S. R. and Meerabai, M. (2001). Effect of integrated nutrient management on yield and quality in chilli (*Capsicum annum* L.). Department of Agronomy, College of Agriculture, Vellayani, Thiruvanthapuram, Kerala, India. *Vegetable Science.* **28** (2): 184-185.

Shehata, S. A., Behairy, A. G. and Fawzy, Z. F. (2004). Effect of some organic manures on growth and chemical composition of sweet pepper (*Capsicum annum*, L) grown in a sandy soil. Faculty of Agriculture, Cairo University, Cairo,Egypt. *Egyptian Journa of Agricultural Research.* **2** (2) (Special Issue): 57-71.

Shoemaker, J. S. and Teskey, B. J. E. (1955). Practical Horticulture, John Wiley and Sons. Inc. New York.

Shrivastava, A. K. (1996). Effect of fertilizer levels and spacings on flowering, fruit set and yield of sweet pepper (*Capsicum annum* var. *grossum* L.) cv. Hybrid Bharat. Department of Floriculture and Olericulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalya, Jabalpur - 482004, India. *Advances in Plant Sciences.* **9** (2): 171-175.

Singh, D. K. and Jain, S. K. (2004). Interaction effect of nitrogen and phosphorus on yield and economics of chilli (*Capsicum annum* L.), cv. Pant C-1. Department of Vegetable Science, College of Agriculture, G. B. Pant University of Agriculture & Technology, Pantnagar - 263 148, India. *Scientific Horticulture*. **9**: 97-100.

Singh, D. N., Sahu, A. and Parida, A. K. (1999). Response of chilli (*Capsicum annum*) to applied nitrogen and potassium in clay loam soils of Orissa. Orissa University of Agriculture and Technology, Keonjhar, Orissa 758 002, India. *Indian Journal of Agricultural Sciences*. **69** (4): 287-288.

Singh, G. B. and Yadav, D. V. (1992). Integrated plant nutrition system in sugarcane. *Fertilizer News*. **37**: 15-22.

Singh, S. K., Rai, B., Srivastava, J. P., Singh, M. B. and Rai, R. (2000). Nitrogen nutrition and plant population management on dwarf chilli (*Capsicum annum* L.). Vegetable Research Station, Kalyanpur, Kanpur-208024, India. P. 184-185.

Hassan, S. Ramlan, Z. A. and Inon, S. (1994). Influence of potassium fertiliser and mulching on growth and yield of chilli (*Capsicum annum* L.). Department of Agronomy and Horticulture, University of Agriculture Malaysia, 43400 UPM Serdang, Selangor, Malaysia. *Acta Horticulturae*. (369): 311-317.

Somos, A. (1984). The Paprika. Budapest, Adademiai Kiado.

Sontakke, M.B., Pardeshi, P. P., Mandge, A. S., and Shinde, N. N. (1995). Effect of graded levels of nitrogen and spacing on growth and yield of two cultivars of chillies (*Capsicum annum* L). College of Horticulture, Marathwada Agricultural University, Parbhani 431 402, Maharashtra, India. : *Journal of Research*-APAU. **23** (2): 8-9.

Srinivasan, K., Veeraragavathatham, D., Kanthaswamy, V. and Thiruvudainambi, S. (1997). Effect of nitrogen and phosphorous on the yield and economics of hybrid capsicum. Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, India. *South Indian Horticulture*. **47** (1/6): 57-60.

Shrivastava, A. K. (1996) Effect of fertilizer levels and spacings on flowering, fruit set and yield of sweet pepper (*Capsicum annum* var. *grossum* L.) cv. Hybrid Bharat. Department of Floriculture and Olericulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalya, Jabalpur - 482004, India. *Advances in Plant Sciences.* **9** (2): 171-175.

Srivastava, B. K., Singh, M. P. and Kamal-Joshi. (2003). Standardization of nitrogen and phosphorus requirement for capsicum hybrid.Department of Vegetable Science, G. B. Pant University of Agriculture and Technology, Pantnagar - 263 145 (Uttaranchal), India. **35**(2): 202-204.

Tumbare, A. D. and Bhoite, S. U. (2002). Effect of solid soluble fertilizer applied through fertigation on growth and yield of chilli (*Capsicum annum*). Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra 413 722, India. *Indian Journal of Agricultural Sciences.* **72** (2): 109-111.

Uddin, M. K. and Khalequzzaman, K. M. (2003). Yield and yield component of winter chilli (*Capsicum annum* L.) as affected by different levels of nitrogen and boron. *Pakistan J. Bio. Sci.* **6** (6): 605-609.

Uribe, S. J. N., Gamero, S. J., Rivas, A. S. and Garcia, S. M. E. (2002). Adaptation of a regression model for the fertilization of pepper *Capsicum annum* L. tipe "Ancho San Luis" in the experimental field of the CIIDIR-IPN Unidad Durango. CIIDIR-IPN Unidad Durango, Durango, Mexico. 10-12-November 2002; P. 1-2.

Viloria-de-Z, A., Arteaga-de-R. L. and Diaz-Torrealba, L. T. (2005). Growth of pepper (*Capsicum annum* L.) in response to different levels of NPK and sowing density. Growth of pepper (*Capsicum annum* L.) in response to different levels of NPK and sowing density. Universidad Centroccidental Lisandro Alvarado, Apartado 400, Barquisimeto, Lara, Venezuela. **43**: 24-29.

Vos, J. G. M. and Frinking, H. D. (1997) Nitrogen fertilization as a component of integrated crop management of hot pepper (*Capsicum spp.*) under tropical lowland conditions. Department of Phytopathology, Wageningen Agricultural University, P.O. Box 8025, 6700 EE Wageningen, Netherlands. *International Journal of Pest Management.* **43** (1): 1-10.

Wien, H. C. (1997). Peppers. In: The Physiology of Vegetable Crops (Ed. Wien, H. C.) CAB International. P. 259-293.

Yodpetch, C. (1997). Study on the optimum fertilizer rates on yield and quality of three long cayene peppers (*Capsicum annum* L.). Rajamangala Institute of Technology, Faculty of Agriculture, Bang Phra, Chonburi 20210, Thailand. 32 (5 Suppl.): 37-45.

Zhu, J. H., Li, X. L., Christie, P. and Li, J. L. (2005). Environmental implications of low nitrogen use efficiency in excessively fertilized hot pepper (*Capsicum frutescens* L.) cropping systems. Key Laboratory of Plant Nutrition, Ministry of Agriculture, Key Laboratory of Plant-Soil Interactions, Ministry of Education, Department of Plant Nutrition, China Agricultural University, Beijing 100094, China. *Agriculture, Ecosystems and Environment.* **111** (1/4): 70-80.

APPENDICES

Appendix 1. Monthly records of meteorological observation at the period of experiment (November, 2006 to March, 2007)

Month	Temperature (Maximum, ^{0}C)	Temperature (Minimum, ^{0}C)	Humidity (%)	Precipitation (mm)
November	30.20	20.13	68.00	31
December	26.60	13.5	52.7	9
January	25.40	12.93	48.3	7
February	25.30	14.2	55.8	7
March	28.3	17.2	72.30	15

Source : Weather Yard, Bangladesh Metrological Department, Dhaka.