EFFECT OF DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF GARDEN PEA (*Pisum sativum* L.)

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By

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CERTIFICATE

This is to certify that thesis entitled, "*EFFECT OF DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF GARDEN PEA*" 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 result of a piece of *bonafide* research work carried out by *BORHAN UDDIN* Registration No. ***03-1204*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated....June, 2010..

Place: Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka during December 2007 to February 2008 to study the effects of different levels of nitrogen and phosphorus on the growth and yield of garden pea. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 2.4 m^2 (1.6 m x 1.5 m). There were 12 treatment combinations in the experiment comprising 4 levels of N (0, 30, 60 and 90 kg/ha designated as N_0, N_{30}, N_{60} and N_{90}, respectively) and 3 levels of P (0, 50 and 75 kg P_2O_5/ha designated as P_0, P_{50} & P_{75}, respectively). The individual and combined effects of nitrogen (N) and phosphorus (P) on growth and yield of garden pea were studied. The individual and interaction effects of N and P on growth and yield was found significant.

Nitrogen @ 90 kg/ha gave the highest plant height, root length, highest number of branches per plant, highest pod length, highest number of seed per pods, 1000-seed weight, highest green pod yield and seed yield per hectare. The highest plant height, highest root length, highest green pod yield was recorded in 75 kg P_2O_5/ha. Phosphorus @ 50 kg/ha gave the highest number of branches per plant, highest length of pods and seed yield per hectare. The treatment combination of $N_{90}P_{50}$ produced the maximum plant height, root length, highest green pod yield and highest seed yield per hectare but the treatment combination of N_{90} P_{75} gave the maximum plant height at vegetative stage, highest number of pods per plant, highest length of pod and maximum N, P, K and S content in plants. Lowest N, P, K and S contents were found in control (N_0P_0) treatment. From the present findings it can be concluded that combined application of N @ 90 kg/ha and P @ 50 kg/ha is the most suitable combination to achieve the maximum return from garden pea plants.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter 1
Introduction

INTRODUCTION

Garden pea *(Pisum sativum L.)* is a widely spread legume crop belonging to the subfamily Papilionoideae under the family Leguminosae. It is a highly self pollinated cold climate crop and can also be grown in tropical countries in the winter season. The crop is reported to perform better in sub tropical areas having cold period of five month duration (Makasheva, 1983). Rice-wheat combinations have always pre-dominated the traditional diets of Bangladesh. Rice and wheat are grown on the more productive lands, leaving the pulses to the marginal land. However, emphasis on cereal production in official food policies has led to the negligence of production of pulses in recent years. It has reduced the per capita availability of protein.

Pea can be grown in all types of soil. The sandy loams with clay sub-soil are generally preferred for earliness. It grows best in the soils having pH 5.5 to 6.7. People in Bangladesh consume 23 g vegetables per head per day but the minimum requirement is 200 g per head per day (Rashid, 1993). As the nation with an acute shortage of vegetables, its production should be increased to meet the shortage. Among the pulse crops in Bangladesh, pea ranks sixth in yield and area (Anonymous, 1998). At present, pea is being cultivated in an area of 7468 hectares in Bangladesh, with a total production of 13540 metric tons (Anonymous, 2000). The average yield is only 0.77 ton per hectare, which is much lower as compare to other pea growing countries such as USA 3.94 t/ha and France 3.23 t/ha, (Makasheva,1983). The low yield is mainly due to the use of low yielding cultivars and lack of balanced fertilization.

The crop has the capacity of fixing atmospheric nitrogen to the soil. Inclusion of peas in crop rotation helps in improvement of soil fertility and yield of the succeeding crops (Rana and Sharma, 1993). If the garden pea is grown as vegetables, it would fit well into the existing cropping system and can be grown successfully after the harvest of transplanted aman or jute crops. The biomass of garden pea can be used as cattle feeds or can be incorporated into the soil for supplementing nitrogen for the next crop and increasing organic matter content of the soil. Chilli, mungbean and any other late *rabi* crops or boro rice can be grown after the harvest of garden pea.

Cultivation of this crop is highly profitable and attractive to the farmers for its short du*rabi*lity. It takes about 45 to 50 days from sowing for its green pod harvest and 55 to 60 days for matured seed harvest. The garden pea is grown mainly for green pods and seeds are used as vegetables. The matured seeds can be used for preparing 'dal' or 'chatpati' and other delicious foods. For its high nutritive value and sumptuous taste, it has gained popularity. Green pea is rich in vitamin and protein. Matured seed contains 9-15% water, 18-35% protein, 4-10% sugar, 0.6-1.5% fat, 2-10% cellulose and 2-4% minerals (Makasheva, 1983). Green peas are rich in vitamins. Pea contains all the amino acids. After the main produce is used, the waste material of pea, still reach in protein, can serve as a reserve for improving the quality of feeds.

Nitrogen constitutes a part of the proteins, the basis of life the nucleic acids (RNA, DNA), Chlorophyll, phosphamide and other organic compounds. Deficiency of N results in poor growth and stunting of the plants. Higher N supply favours a higher rate of protein synthesis, growth of the leaves and formation of greater assimilation surface. Pea responds greatly to major essential nutrient elements like nitrogen, phosphorous and potassium in respect of its growth and yield. On the other hand, manure like cow dung when applied helps maintain good soil structure besides being a continuous source of nutrient. However, in soils having low organic matter and N content, the addition of fertilizer at the rate of 15-30 kg N/ha has been found to be beneficial. The green pod yield increases with the increase N rates up to 40 kg N /ha (Bhopal and Singh, 1990). Significant yield response to the addition of 36 to 90 kg P_2O_5 /ha were reported (Sen and Kavitkar, 1958).

Phosphorus is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plant and various forms of ribonucleic acid (RNA) are needed for protein synthesis. It is also a component of two compounds involved in the most significant energy transformations in plants, adenosine diphosphate (ADP) and adenosine triphosphate (ATP) associated with the uptake of some nutrients and their transport within the plants and as well as the synthesis of different molecules. Phosphorus plays a vital role in cell division in plants, flowering and fruiting, including seed formation, crop maturation, root development, improvement of crop quality and so on.

The soil should therefore contain an optimum level of P for assuring higher yield of pea. Most of the P present in the soils is not readily available to plants. Pea research in Bangladesh has been neglected. So it has now become necessary to undertake research programmes to develop some cultivation technology for approaching the highest yield potential of garden peas.

Therefore, it is imperative that an optimum dose of nitrogen and phosphorus in the form of fertilizer should be determined for the cultivation of pea and the optimum sowing time for the better production of pea. This experiment was therefore, undertaken with the following objectives,

- To know the growth and yield performance of pea by using individual and combined applications of nitrogen and phosphorus fertilizers.
- To know the individual and interaction effects of nitrogen and phosphorus on nutrient contents and uptake by pea.
- To determine the N and P requirements for approaching the maximum yield potential of garden pea.

Chapter 2
Review of literature

REVIEW OF LITERATURE

Among the pulse crops, garden pea occupies the greater position in Bangladesh. Pea being a leguminous vegetable having high yield potential would require an ample supply of plant nutrients to ensure proper growth, development and satisfactory yield. The crop has many similarities with other leguminous crops. Hence a brief review of available literature with regards to the influence of nitrogen and Phosphorus fertilizers on this crop are presented in this Chapter

2.1 Effect of nitrogen on the growth and yield attributes of garden pea

Brkic *et al.* (2004) conducted an experiment by using different rates of N (0, 40, 80, 120 kg N/ha) during 1999-2000 on two soils (Mollic Gleysols and Eutric cambiosls) in Croatia; They reported that the highest seed yield, nodule dry matter and seed protein content obtained from plants fertilized with 40 kg N/ha on Mollic Gleysols (3.96% humus) were 4.02 t/ha, 0.482 g/plant, and 26.91%, respectively. The highest seed yield, nodule dry matter and seed protein content observed from plants grown on Eutric Cambisols (1.07% humus) with 80 kg N/ha were 3.65 t/ha, 0.456 g/plant and 26.48%, respectively.

Clayton *et al.* (2004) reported that the close proximity of a highly concentrated band of N fertilizer had a greater impact on nodulation and subsequent N_2 fixation than the residual soil N level under field conditions. Soil applied inoculants improved N nutrition of field pea compared to seed applied inoculation with or without applied urea-N.

Nasreen and Farid (2003) conducted a field experiment during the winter (*rabi*) seasons of 2000-01 and 2001-02 on a Grey Terrace Soil in Bangladesh to study the effect of different nutrients on yield, yield components and nutrient uptake by garden pea cv. BARI Motorsuti-1 grown in Grey Terrace soil. Application of different nutrients caused significant increase in yield and nutrient uptake. The highest fresh pod yield and protein content were achieved by the treatment of N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 and it was not significantly different from the N_{30} P_{50} K_{40} S_{20}, N_{30} P_{50} K_{40} S_{20} Mo_1 and N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 Zn_1 treatments. Uptake of N, P, K, S, and Zn by shoot and seed was also highest under the treatment N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 and not significantly different from N_{30} P_{50} K_{40} S_{20} Mo_1 and N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 Zn_1. Addition of Mo, B and Zn with NPKS did not show any significant change in pod yield. Application of N_{30} P_{50} K_{40} S_{20} Mo_1, N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 and N_{30} P_{50} K_{40} S_{20} Mo_1 B_1 Zn1 kg/ha were not economical, but treatment N_{30} P_{50} K_{40} S_{20} kg/ha proved to be the most economically profitable for garden pea production.

Mishra, *et al*. (2002) carried out a field experiment and reported that the higher mean seed yield (3354 kg/ha) was obtained with 20 kg N/ha. The application of 40 kg N/ha under moisture stress at branching and flowering stages and no moisture stress treatments increased the yield by 29, 18 and 30%, respectively.

Voisin *et al*. (2002) investigated the effect of mineral N availability on nitrogen nutrition and biomass partitioning between shoot and roots of pea (*Pisum sativum*, cv. Baccara) under adequately irrigated conditions in the field, using five levels of fertilizer N application at sowing (0, 50, 100, 200 and 400 kg N/ha). Although the presence of mineral N in the soil stimulated vegetative growth, resulting in a higher biomass accumulation in shoots in the fertilized treatments, neither seed yield nor seed nitrogen concentration were affected by soil mineral N availability. However, biomass partitioning within the nodulated roots was changed. Root biomass was greater when soil mineral N availability was increased: root growth was greater and began earlier for plants that received mineral N at sowing.

Kushwaha *et al*. (2001) conducted a field study involving four rates of N (0, 30, 60 and 90 kg/ha) and reported the nitrogen use efficiency of 20.23 kg/ha grain found with application of 90 kg N.

Uddin *et al*. (2001) conducted an experiment at BSMRAU farm in Bangladesh, from November 1997 to January 1998, and reported that the highest amount of crude protein of green seed was recorded under 40 kg N/ha. A row spacing of 30 cm along with the application of 60 kg N/ha was found to be the best combination for achieving the highest yield and quality of garden pea in Salna Soil Services under Madhupur Soil Tract of Bangladesh.

Solaiman *et al.* (1999a) conducted an experiment to investigate the effect of NPK fertilizers and *Rhizonium* inoculant on nodulation, growth and yield of chickpea. They found that application of phosphorus and potassium along with *Rhizobium* inoculant significantly increased plant height and dry matter of chickpea. Eusuf Zai *et al.* (1999) further reported that *Rhizobium* inoculant significantly increased growth and dry matter production of chickpea. Similar result were obtained by Mahmud *et al.* (1997) in lentil. Essa and Al-Dulaimi (1985) got same result in soybean.

Gangwar *et al.* (1998) conducted a field study at Pantnagar in *rabi* [winter] 1994/95, and observed that the requirements of N, P and K for the production of 0.1 t of vegetables pea seed were 8.25, 1.03 and 5.65 kg, respectively. The percentage utilization of soil available N (organic carbon), P_20_5 (Olsen-P) and K_20 (ammonium acetate-K) was 36.59, 13.83 and 11.81, respectively. The contribution from fertilizer as a percentage of its nutrient content was 188.82, 20.79 and 46.57 for N, P and K, respectively.

Michalojc *et al.* (1997) found in trials at Lublin, Poland, in 1980-81, peas cv. Rarytas with 0, 20 or 40 kg N/ha, 60 kg P_2O_5/ha and 0, 150 or 300 kg K_2O/ha. The highest seed yield and best seed quality (as determined by vitamin C, saccharose and macro-and microelements contents) were obtained by applying 40 kg N.

Jeuffroy *et al.* (1997) found in greenhouse pot experiments with non-nodulated peas cv. solara which were given a nutrient solution without N for part or all of the growing season or for 4 or 5 days/week throughout the growing season. The final number of flowering nodes varied according to the N starvation season. The final number of flowering nodes varied according to the N starvation period: early and prolonged N starvation prematurely halted the progression of flowering. The effect was similar on main stems and branches. The date of commencement of flowering and the rate of progression along the stem were similar for the different treatments. For all treatments, the end of flowering resulted from the non-development and non-growth of initiated nodes in the apex of the stems.

El-Beheidi *et al.* (1995) conducted an experiment in 1991-92 at El-kassasien Horticulture Research Station, Egypt with peas cv. Little Marvel which were given 40 kg N/feddan as ammonium nitrate, calcium nitrate, ammonium sulphate or urea and foliar application of vitamin B_1 at 0 or 50 ppm. applied at 18, 25 and 32 d after sowing. Leaf chlorophyll content and seed yield/feddan were highest with urea and vitamin B_1 applications.

Singh and Nair (1995) conducted an experiment on the performance of 29 cowpea (*Vigna unguiculata*) genotypes, grown under zero and 120 kg N/ha applied in two equal splits, was evaluated with respect to their nodulation and nitrogen assimilating characteristics. Nitrogenous fertilization treatments, in general, inhibited not only nodulation capacity but also nodule growth. There was an increase in the nodule and root nitrate reductase activity in fertilizer-treated plants. However, in general, no nitrite accumulation was observed. Varieties EC240890 and EC170606, which exhibited good nodulation and desirable metabolic characters under the fertilizer treatment, are recommended for use in cereal-based intercropping systems.

Kaushik *et al.* (1995) investigate a pot experiment that the effect of fertilizer N as urea on the early growth of *Cajanus cajan* cv. UPAS120 and Manak, with or without *Bradyrhizobium* inoculantion of the seeds. They obtained that high N rates decreased nodule number, dry weight and ARA compared with 20 kg N/ha.

Pkalita *et al.* (1994) reported that foliar spray of 2% N at first flowering and post flowering stages of pea produced significantly higher yield in the treated plot compared with the control. They also concluded that N stress both at flowering and pod filling stages was likely responsible for decline in yield performance of pea.

Agarwala and Kumar (1993) reported that lentil plants inoculated with *Rhizobium* fixed more atmospheric N and produced significantly higher yield attributes and grain yield than in uninoculated plant. They also obtained significantly higher grain yield at the rate of 20 kg N/ha compared with that in the control.

Conner *et al.* (1993) reported that earlier sowing increased N_2 fixation by as much as 96 kg N/ha compared with late sowing. They also concluded that early sowing improved the probability of peas contributing to soil total N.

Rana and Sharma (1993) conducted a field experiment on sandy loam soil with direct seeded upland rice (cv. Govind) in *Kharif* season on the same plots where chickpea (cv. Pg-114), field Pea (cv. Azad P-1), lentil (cv. PL 406) and wheat (cv. HD 2329) were grown in previous winter. Rice was given 0, 40, 80 or 120 kg N/ha. The highest rice equivalent yield obtained in the field pea rice cropping system.

Azad *et al.* (1992) conducted an experiment with field pea cv. PG-3 on soils having organic matter contents of 0.19, 0.38 or 0.44% with varying N levels of 0, 15, 30, 37 or 45 kg/ha. Yields without N were 1.97, 1.28 and 1.35 kg seed/ha on the 3 soils respectively, while yields at the highest N rates were 2.94, 2.05 and 2.09 t/ha. Response to applied N decreased with increasing soil carbon.

Sati *et al.* (1991) conducted an experiment in loam soils having pH-7.4 by using N fertilizer in different ways as (a) 25 kg/ha as basal dressing, (b) 15 kg/ha as basal application + 10 kg/ha as top dressing, (c) 15 kg/ha as basal + 10 kg/ha as a foliar spray and (d) only seed inoculation. They did not find any significant variation on yield and yield attributes of pea (cv. Arkel) by imposing the different treatments. However, inoculation increased the nodulation significantly, but did not favour the growth or yield of pea.

Bhopal and Singh (1990) conducted an experiment with the semi dwarf garden pea cv. Lincoln that received N at the rate of 0, 20, 40 and 60 kg/ha and P_2O_5 at 0, 30, 60 and 90 kg/ha with K_2O at 30 kg/ha. They concluded that the mean green pod yield increased with increasing N rates up to 40 kg/ha (1.57 t/ha) and then decreased at 60 kg/ha (1.47 t/ha). Vigorous vegetative growth was attributed at the highest N rates. Yield in the control treatment was 1.02-1.03 t/ha.

Simon (1990) in a pot trial used 5 *Rhizobium* strains on 3 new and one local varieties of garden pea. Inoculation with selected strains in most cases increased seed yield as compared to the use of unselected native Rhizobia. There were significant differences between different variety and Rhizobial strain combinations. High TNA (total nitrogenase activity) was accompanied by high plant biomass but not improved seed yield.

Vijai *et al.* (1990) carried out an experiment with garden pea cv. Bonneville shoed that increasing rates of N or P application significantly increased growth and pod yield. At the highest rates of N and P_2O_5 application (45 and 80 kg/ha, respectively) the number of pods/plant, seed/pod, pod length and green pod yield were greatest.

Deschamps and Wery (1989) concluded that irrigation and or N application increased DM production more markedly in chickpea than in peas. Both chickpea and Pea received 40 kg N/ha which were applied in 3 split doses.

Saimbhi and Grewal (1989) conducted a field experiment with a new pea cultivar (Harabonna) by applying N at the rates of 0, 25 and 50 kg/ha from three sources (viz. calcium ammonium nitrate, urea and ammonium sulphate), P_2O_5 at 30 and 60 kg/ha in all possible combinations with N. they observed that the sources of N had no appreciable effect on the indices studied but the rate of N and P at 50:30 kg/ha gave the highest yield of 70 q/ha compared with 33.3 q/ha in the non fertilized control.

2.2 Effect of phosphorus on the yield and yield attributes of garden pea

Manga *et al.* (1999) reported that the growth and yield of French bean were influenced by phosphorus and molybdenum fertilization. In their trail, the crop received 0, 13 or 26 kg P and 0, 0.5 or 1.0 kg ammonium molybdate/ha. Phosphorus application significantly increased the number of pods per plant, number of seeds per pod and shelling percentage. The seed yield was increased by 43.2 and 73.32% (averaged over years) when 13 and 26 kg P/ha were applied, respectively.

Solaiman (1999b) conducted an experiment to study the effect of *Bradirhizobium* sp. (*Vigna*) inoculants, P and K fertilization. Plant receiving inoculant along with 25.8 kg P/ha and 33 kg k/ha performed best in all parameters including seed yield.

Srivastava *et al.* (1998) conducted an experiment during the winter seasons of 1991-92 and 1992-93 in New delhi, India. Peas cv. Arkel were given 0, 12.9 or 25.8 kg P/ha; 0 or 0.5 kg Mo/ha and no biofertilizer or seed inoculation with *Rhizobium leguminosarum*. Application of 25.8 kg P/ha, Mo and seed inoculation resulted in significant increases growth and yield.

Kanaujia *et al.* (1998) conducted an experiment in 1994-1996 in Himachal Pradesh, peas were inoculated with *Rhizobium* or not inoculated and given 0-38.7 kg/ha each of P and 0-75 kg K/ha. Seed inoculation plus the application of 25.8 kg P and 50 kg K gave the highest pod yield of 13.17 t/ha.

Mohan and Rao (1997) observed that seed yield and number of pods/plant generally increased with increasing rate of P (90 kg P_2O_5/ha) and Mo (0.50 kg Mo/ha).

Bhuiyan *et al.* (1996) reported that *Rhizonium* inoculant of groundnut in presence of P, K, Mo and B fertilizer resulted significant increase in shoot dry weight during the three consecutive *rabi* season. They also found that shoot weight of groundnut increased due to *Rhizonium* inoculants in association with Mo and B.

Naik (1995) carried out an experiment in 1983-84 at Ranchi, Bihar with garden pea with the cultivar Bonneville, spaced at 30x5, 30x10 or 30x15 cm and given 25-75 kg N, 11-43 kg P and 21-42 kg K/ha. Pod yield was not significantly affected by N or K rate, and was highest with 43 kg P (1.30 t/ha).

Rahman *et al.* (1994) carried out an experiment in1989-90 at RARS, Jamalpur and observed that chickpea produced significantly higher grain yield in association with *Rhizobium* inoculant alone or in presence of P and K fertilizer. The grain yield increase was from 37% to 119%.

Rathi *et al.* (1993) carried out an experiment with the effect of irrigation and phosphorus levels on protein content and uptake of nutrients in field pea at Jabalpur, Madhyapradesh in the *rabi* seasons of 1988-90. Peas, cv. JP-885 were grown in sandy loam soil and given no irrigation, 1 irrigation at branching (B) or flowering (F) or pod development (P), 2 irrigation at B + F, B + P or F + P, or 3 irrigation at B+ F + P and given 0, 20, 40 or 60 kg P_2O_5/ha. N and P content in the seed were highest with irrigation at B in both years and protein content was highest with irrigation at B or F in 1989 and at B in 1990. N content in the seeds was highest with 40 and 60 kg P_2O_5/ha in 1989 and 1990, respectively. P content was highest at 40 kg P_2O_5/ha and protein content at 60 kg P_2O_5/ha.

Naik *et al.* (1993) studied the response of pea to different levels of P (40, 80 and 120 kg P_2O_5/ha) and the sources in sandy loam soil of New Delhi. P sources used in the trial were SSP powder and granular forms, Mussorie rock phosphate (MRP) alone or MRP + seed inoculation with Pseudomonas strain. SSP in powder and granular forms produced similar D and seed yields, which were greater than applying MRP with or without seed inoculation. Seed yields with SSP were 30% higher than that with MRP. There was no impact of different rates of P application on yield of pea.

Yadav *et al.* (1993) conducted an experiment with pea at Morna, Madhyapradesh in the winter seasons of 1984-1986. Peas were grown at 25 or 50 cm spacing under non-irrigated or irrigated conditions at 50 and/ or 70 days after sowing and given 0, 25 or 75 kg P_2O_5 /ha. Seed yield was highest with single irrigation at 50 DAS coupled with P application at the rate of 25 kg P_2O_5/ha and keeping the minimum plant spacing of 25 cm. At higher rates of P application the yield increase was not significant.

Singh *et al.* (1992) reported that field pea cv. Rachna, receiving N, P, K, Zn at the rate of 18, 46, 40, 25 kg/ha gave the highest grain yield of 2.97 t/ha in 1983-84 and 3.16 t/ha in 1984-85. The highest net return was obtained with application of 46 kg P_2O_2/ha. In another field trial with field pea cv. Rachna, given 0-3 kg N and 0-25 kg P_2O_5/ha, seed yield increased with up to 30 kg N and 50 kg P_2O_5/ha.

Shukla and Kohli (1992) conducted an experiment with response to phosphorus fertilization of early cultivars of garden pea grown in the summer at kalpa and in the winter at Solan. P was applied at 45, 60 or 75 kg P_2O_5/ha. At Kalpa, the highest yield, economic values of yield and net income/ha were obtained with cv. PH1 at 60 kg P_2O_5/ha. At Solan, the highest returns were obtained with cv. Hara Bona at 60-75 kg P_2O_5/ha.

Kohli *et al.* (1992) conducted an experiment and studied the effect of different levels of P and K fertilizer on the response of pea's cv. Arkel. Three levels of P (0, 13 and 26 kg/ha) and two levels of K (0 and 33 kg/ha) were applied. P significantly increased number of pod/plant and total green pod yield from 4.49 with no P to 5.12 t/ha at the highest P rate.

Negi (1992) carried out an experiment in sandy loam soil of Kukumseri, Himachalpradesh and found the maximum seed yield of pea (1.73 t/ha in 1989 and 3.28 t/ha in 1990) with application of 60 kg P_2O_5/ha as against 1.04 and 2.08 t/ha, respectively under control conditions.

Naik *et at.* (1991) conducted an experiment with P utilization in pea (*Pisum sativum L.)* influenced by time of sampling. In field trials in the *Rabi* (winter) seasons of 1987-89 on sandy loam soil the effects of 0, 40, 80, 120 kg P_2O_5/ha on DM yield and P uptake of peas were studied at flowering and maturity. P application increased total DM yield, although the increase was significant only at maturity in 1987-88. P uptake at maturity increased with P application in both the years. Percentage of P derived from fertilizer increased with P application and was higher at maturity than flowering. Percentage utilization of applied P decreased with increasing P application rate.

Sharma *et al.*, (1991) carried out a pot experiment with mustard (*Brassica juncea* L) and pea (*Pisum sativum* L.) in green house to determine the effects of 0, 45 or 90 kg each of P_2O_5, Ca and S/ha on DM yield, uptake and S utilization in mustard and peas. S uptake from the soil and from fertilizer in both crops increased with up to 90 kg S, 90 kg P_2O_5 and 45 kg Ca/ha. S utilization decreased from 15.6-12.2% in mustard and 4.4 to 2.8% in peas when S application was increased from 45 to 90 kg/ha. Interactions between S and P, S and Ca and P and Ca were significant for S utilization by both crops.

Dravid (1991) conducted an experiment to demonstrated the effect of pea's cv. KPSD-5 and pusa-10 and lentils cv. PL-639 and PL-406 with saline irrigation water 0, 13, 26 or 39 kg P/ha and inoculated with *Rhizonium* inoculant or not inoculated. Dry matter yield increased with upto 30 kg P in both crops.

Prasad and Maurya (1989) carried out an experiment in 1983-84 during the *rabi* season to observe the effect of application of P at 0, 17.2, 34.4 or 51.6 kg/ha with or without *Rhizobium* inoculation of seeds. P application and *Rhizobium* inoculant alone or in combination resulted significant increase in yield compared with control. The highest yield was obtained with combination of 51.6 kg P and *Rhizobium* inoculant.

2.3 Combined effect of nitrogen and phosphorus on the yield and yield attributes of garden pea

Lal (2004) conducted an experiment in Uttar Pradesh, India during 2002-03 to observe the effects of N (at 0, 20, 40 and 60 kg/ha) and P (at 0, 30, 60 and 90 kg/ha) on the seed yield of pea cv. Arkel and French bean [phaseolus vulgaris]. N at 40 kg/ha was optimum for the maximum pea and bean seed yields. Seed yield of both crops increased with increasing P rates up to 60 kg/ha.

Patel *et al.* (1998) conducted an experiment at Indore, Madhya Pradesh with peas cv Arkel with 20 kg N + 34.4 kg P + 33.3 kg K/ha, 33.3 kg K/ha, *Rhizobium* inoculant, 3 kg phosphate solubilizing microorganisms (PSM)/ha, *Rhizobium* + PSM. Application of 50% NP significantly compared with recommended level of nutrients (20 kg N + 34.4 kg P + 33.3 kg K/ha) applied through chemical fertilizers.

Verma *et al.* (1997) conducted a field experiment at Nauri, Soaln, on a sandy soil to evaluate the effect of N (0, 15, 30 or 45 kg N/ha and P (0, 13, 26 or 39 kg P/ha) levels on the yield and macronutrient concertrations of peas. They concluded that 15 kg N and 26 kg P/ha were the optimum doses for maximum yield and high nutrient concentrations in peas.

Verma *et al.* (1996) reported Nutrient uptake was determined in peas cv. Lincoln, grown at Solan, Himachal Pradesh in *rabi* [winter] 1987/88 and given 0-45 kg N and 0-90 kg P_20_5/ha. Mineral concentrations in seeds generally increased with up to 15 kg N and 60 kg P_20_5/ha.

Saini and Thakur (1996) conducted a field experiment during summer season of 1990-91 at Leo. where pea's cv. Lincoln were given 0-60 kg N and 0-66 kg P/ha. Mean green pod yield increased with upto 30 kg N (17.4 t/ha) and was highest with upto 52.8 kg P (20.9 t/ha).

Yadav *et al.* (1996) found in a field trial in 1982-84 at Solan, Himachal Pradesh on peas cv. Lincoln, Bonneville, GC 141 and Kinnari with 0-40 kg N and 0-90 kg P/ha. N application increased the number of days to flowering and marketable maturity but did not consistently affect the pod yield/plot, whereas P application increased pod yield/pod at the highest application rate only in 1982/83. There was a significant interaction between cultivar, N and P for most characters studied.

Saini *et al.* (1996) found in a field experiment conducted during the summer seasons of 1990-91, at Leo on peas cv. Lincoin with 0-60 kg N and 0-66 kg P/ha. Mean green pod yield increased with up to 30 kg N (17.4 t/ha) and was highest with up to 52.8 kg P (20.9 t).

Bail *et al.* (1995) conducted an experiment in 1982-86 on peas cv. PG 3 with 0-60 kg N and 0-60 kg P_20_5/ha. Application of 40 kg N and 30 kg P_20_5/ha was optimum for seed yield and N and P uptake. Nitrogenase activity was decreased by 40 and 60 kg N/ha, particularly at 0 and 30 kg P_20_5/ha.

Nagaraju *et al.* (1995) carried out an experiment on an Ultisol (pH 5.6) at Bangalore during *kharif* 1990 and 1991. Seed yield and 4 component trails were evaluated in pigeon pea cv. TTB-7 grown under 4 levels of phosphorus (0, 23, 46, 69 kg/ha) and nitrogen (0, 9, 18 and 27 kg/ha) and 4 weed control treatments. Application of 69 kg P + 27 kg N/ha significantly improved pigeon pea seed yield 2 folds (1331 kg/ha). Application of alachlor was superior over hand weeding 30 DAS in controlling weed, dry weight as well as improving yield and its components.

Billore *et al.* (1993) carried out an experiment with pea on Vertisol during the rainy seasons of 1987-89 at Sehore, Madhya Pradesh . The highest land equivalent ratio at 1.45 and net return were obtained where pigeon peas were given the recommended fertilizer rate 20 kg N + 26 kg P/ha. The respective pigeon pea mean seed yields were 1.13 t/ha.

Hussain *et al.* (1992) carried out an experiment with pea cultivars P-8. Investigations were undertaken to study the effect of various levels of nitrogen and phosphorus, each (40-80 kg/acre) alone and in combination on growth, fruit set, maturity and yield of pea. Maximum height (202.91 cm) of the plants were obtained by the application of N + P each at 80 kg N/A. Highest fruit set (84.76 %) was on plants that received 40 kg N/A as compared to 64.62 % by application of 40 kg P. Significantly least days (94.25) were taken to first picking by the application of 80 kg P/A as compared to106.3 days by 80 kg N/A. The highest number of pickings (6) were taken by highest dose of N, while highest yield/picking (1.4 kg), per plot (8.38 kg) and per hectare (13.95 t) was obtained by application of N and P each at the rate of 40 kg /ha. Maximum number of pods/plant (39.75) was obtained from plots that received the highest dose of P. Size and weight of a nodule was significantly highest by the application of 60 kg N + 80kg P/A.

Negi (1992) carried out an experiment with vegetable pea at 4 levels of N (10, 20, 40, 60 kg/ha) and 3 of P (0, 60, 120 kg P_2O_5/ha). He reported that highest green pod yield could be obtained at the N rate of 20 kg/ha. A combination of 20 kg N and 60 kg P_2O_5/ha produced yield up to 1.72 t/ha.

Tripathi *et al.* (1991) conducted an experiment on the effect of N and P (untreated control, 25 kg N/ha, 50 kg P_2O_5/ha or 25 kg N + 50 kg P_2O_5/ha) and weed control on growth and yield of vegetable pea. Plant height, number of pods/plant, number of grains/pod, shelling percentage, pod yield/ha and net profit/ha were highest with 25 kg N + 50 kg P_2O_5/ha and hand weeding.

Vijai Bahadur *et al.,* (1990) conducted an experiment with garden pea (cv. Bonneville for over 2 growing seasons. Increasing rates of N or P application significantly increased growth and pod yield. At the highest rate of application i.e. 45 kg/ha N and 80 kg/ha P_2O_5 plant height, number of branches, nodules, flowers and pods/plant, seeds/pod, pod length and green pod yield were highest.

Naik (1989) carried out an experiment with garden pea (*Pisum sativum* L) in two winter seasons with the cultivar Bonneville, spaced at 30 x 5, 20 x 10 or 30 x 15 cm with N at 25-75, P_2O_5 at 25-100 and K_2O at 25 or 50 kg/ha. Data on plant height, pod length girth, shelling %, average pod weight, number and weight of pods/plant and pod yield were recorded. The closest spacing coupled with the highest rates of N and P application resulted in the highest yields but no appreciable response to K was observed.

Pachauri *et al*. (1988) in a 2 years trial with garden pea cv. Lincoln applied N at 0, 37.5 or 75 kg/ha, P_2O_5 at 0, 75 and 150 kg/ha and K_2O at 0, 50 and 100 kg/ha. A basal dose of FYM was applied at 5 q/ha. The highest seed yield was obtained on plots receiving N: P_2O_5:K_2O at 75: 150:50 kg/ha, respectively.

Srivastava and Varma (1985) carried out an experiment in 1976-78 on a sandy loam soil. Effect of 0-40 kg N, 0-38 kg P and 0 or 0.5 kg Sodium molybdate/ha in different combinations increases the growth. The interaction of nitrogen and phosphorus markedly increased dry matter production of field pea.

Chapter 3
Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at the research field in Sher-e- Bangla Agricultural University, Dhaka- 1207, during the period from December 2007 to February 2008 to find out the effect of different levels of N and P on the growth and yield of garden pea (*Pisum sativum* L.)

3.1 Experimental site

The experimental site was under the Agro Ecological Zone of Madhupur Tract (AEZ 28) and located at $23^{0}774^{/}$ N latitude and $90^{0}335^{/}$ E longitude with an elevation of one meter above from sea level (Fig. 1).

3.2 Soil

The soil of the experimental field belongs to the Tejgaon soil series of the Madhupur Tract (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 (1.34 %) and soil pH varies from 5.8 – 6.00. The land is above flood level and well drained. The initial morphological, physical and chemical characteristics of soil are presented in Table 1 and 2.

3.3 Climate

The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297mm. The average maximum temperature is 30.34 ^{0}C and average minimum temperature is 21.21^{0}C. The average mean temperature is 25.17 ^{0}C. The experiment was done during the *rabi* season. Temperature during the cropping period was ranged between 12.20 ^{0}C to 29.2 ^{0}C. The humidity varies from 73.52 % to 81.2 5% (Appendix I). The day length was reduced to 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting. The monthly average temperature, humidity, bright sunshine, solar radiation, precipitation and potential evapotranspiration pattern of the site during the experimental work are presented in appendix -I.

Fig.1. Map showing the experimental site under study.

Table 1. Morphological characteristics of experimental field

Morphological Features	**Characteristics**
Location	Sher-e Bangla Agril. 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 of soil.	
% Sand	29.00
% Silt	41.90
% Clay	29.10
2. Soil texture	Silty Clay Loam
B. Chemical properties	
1. Soil pH	5.6
2. Organic carbon (%)	0.78
3. Organic matter (%)	1.34
4. Total N (%)	0.08
5. C : N ratio	9.75 : 1
6. Available P (ppm)	31.15
7.Exchangeable K (m.e./100g soil)	0.18
8. Available S (ppm)	34.55

3.4 Collection of seed

IPSA 1, a short duration and high yielding variety of pea, was used as a test crop. The variety was developed by the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur.

3.5 Experimental treatment

The experiment was undertaken to study the effect of 4 levels of Nitrogen and 3 levels of Phosphorus on the growth and yield of garden pea.

The study comprised the following treatments:

A. Nitrogen level: 4

1) N_0 : Control
2) N_{30} : 30 kg N/ha
3) N_{60} : 60 kg N /ha
4) N_{90} : 90 kg N / ha

B. Phosphorus level: 3

1) P_0 : Control
2) P_{50} : 50 kg P_2O_5/ha
3) P_{75} : 75 kg P_2O_5/ha

There were 12 treatment combinations of nitrogen and phosphorus levels used in the experiment the treatment combinations are as follows:

$T_1 = N_0 P_0$ (Control)

$T_2 = N_0 P_{50}$ kg ha^{-1}

$T_3 = N_0 P_{75}$ kg ha^{-1}

$T_4 = N_{30} P_0$ kg ha^{-1}

$T_5 = N_{30} P_{50}$ kg ha^{-1}

$T_6 = N_{30} P_{75}$ kg ha^{-1}

$T_7 = N_{60} P_0$ kg ha^{-1}

$T_8 = N_{60} P_{50}$ kg ha^{-1}

$T_9 = N_{60} P_{75}$ kg ha^{-1}

$T_{10} = N_{90} P_0$ kg ha^{-1}

$T_{11} = N_{90} P_{50}$ kg ha^{-1}

$T_{12} = N_{90} P_{75}$ kg ha^{-1}

3.6 Design and layout of the experiment

The experiment was laid out with randomized completely block design (RCBD) with three replications. The experimental plot was first divided into three blocks. Each block consisted of 12 units of plots. Different combination of N and P were assigned randomly to each block as per design of the experiment.

Total number of plot	= 36
Individual plot size	= 1.6 m × 1.5 m (2.4 m^2)
Block to block distance	= 1.0 m
Plot to Plot distance	= 0.5 m
Row to row distance	= 0.5 m
Plant to plant distance	= 5 cm

3.7 Land preparation

The land was first opened on 8 December, 2007 with the help of a power tiller. Later the land was prepared by deep and cross ploughing with the tractor followed by harrowing and alternate laddering up to a good tilth. Weeds, stubbles and crop residues were removed from the field. Field layout was done on 11 December, 2007 according to the design adopted. Finally, individual plots were prepared with spade on 13 December, 2007. Drains were made around each plot and the excavated soil was used for raising the plots to about 5 cm high from the soil surface.

3. 8 Collection of initial soil sample

Initial soil sample were collected before land preparation by means of an auger from different locations of the field at 0-15 cm soil depth. The soil was air dried and mixed thoroughly to make a composite sample. After collection of the soil samples the plant roots, leaves etc were picked up and removed. Then the sample was sieved through a 10–mesh sieve and stored in a clean plastic container for physical and chemical analysis.

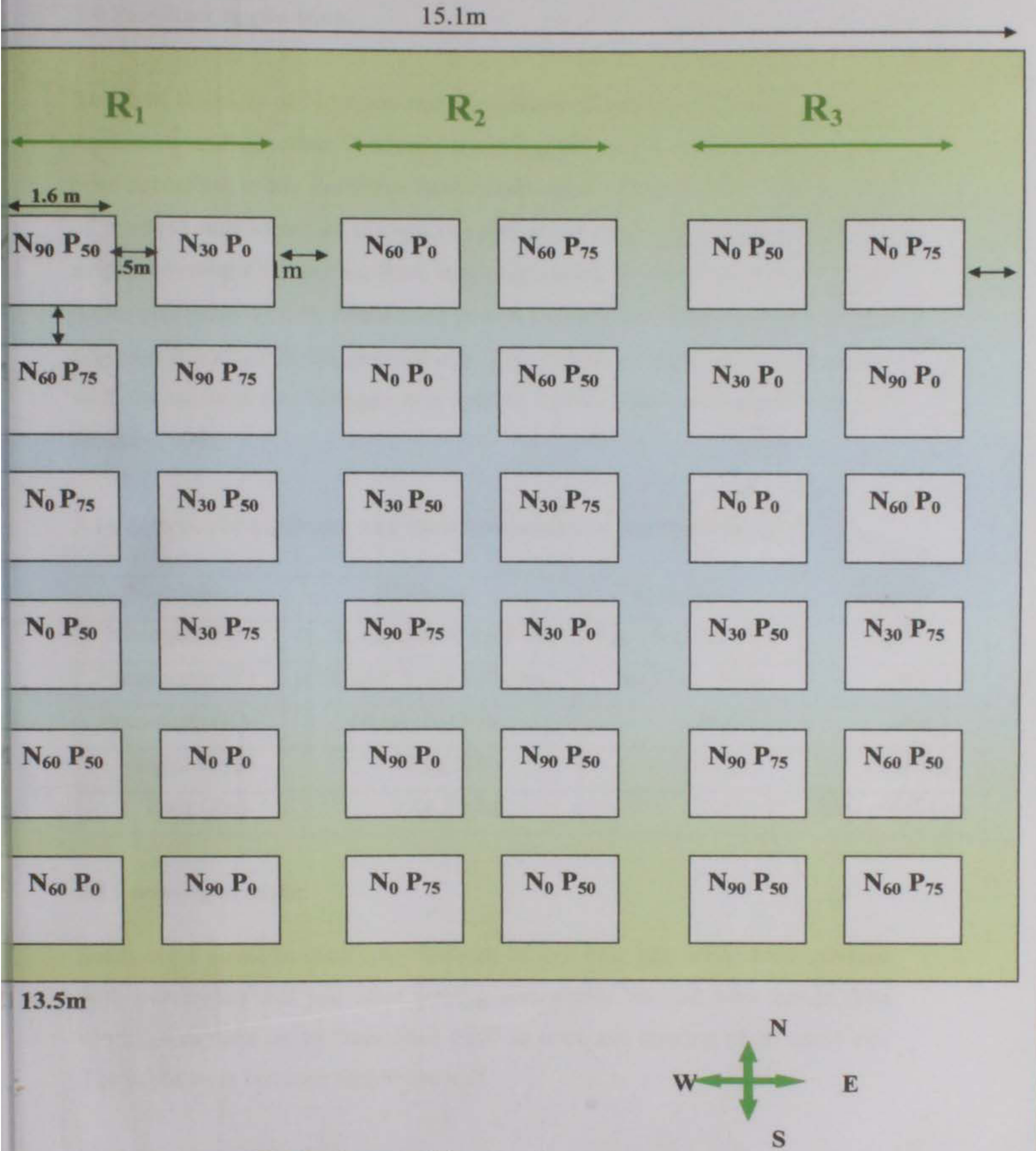

Fig. 2 Layout of the experimental plot

3.9 Fertilizer application

Required amounts of Nitrogen and Phosphorus fertilizers were applied as per treatments and all other fertilizers were applied in the whole plots as basal dose according to the Fertilizer Recommendation Guide (BARC, 2005). Half of nitrogen and whole of phosphorus and basal dose of potassium, zinc and sulphur were applied during final land preparation in the form of Urea, Triple super phosphate (TSP), Muriate of potash (MP), Zinc Sulphate ($ZnSO_4$) and Gypsum ($CaSO_4.2\ H_2O$), respectively. The fertilizers were mixed thoroughly with the soil and rest nitrogen was applied in two equal splits on 5th and 25th January, 2008.

3.10 Sources of nutrients and their levels used in the experiment

Nutrient	Dose/ha	Dose/plot	Source
Nitrogen (N)	0, 30, 60 and 90 kg N/ha	0 g, 16 g and 48 g	Urea
Phosphorus (P)	0, 50 and 75 kg P_2O_5/ha	0 g, 27g, 40 g	TSP
Potassium (K)	60 kg K_2O/ha	24 g	MP
Sulphur (S)	10 kg S/ha	20 g	Gypsum
Zinc (Zn)	2 kg Zn/ha	1 g	Zinc sulphate

3.11 Sowing of seeds

Seeds were sown in each row at depth of 2-3 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands .The sowing was done on 14 December, 2007 in rows and spacing of 20 cm×5 cm. The seeds were covered with loose soil.

3.12 Intercultural operations

3.12.1 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedlings of about 5 cm height were transplanted from border rows with roots plunged 3 cm below the soil in the hills in the evening and watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.12.2 Weeding

The experimental plots were kept weed free by hand weeding. Weeding was done three times as and when necessary and soil surface crusts were broken. It helped to increase soil moisture conservation.

3.12.3 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation was given five times at an interval of 7 days depending on soil moisture content.

3.12.4 Urea top dressing

The rest of urea was applied in two equal splits on 5 January, 2008 after 20 days of seed sowing and 25 January, 2008 after 40 days of seed sowing.

3.12.5 Plant protection

At the early stage of growth, some plants were attacked by insect pests. Malathion 57 EC and Nuvacrone were sprayed at the rate of 2 ml/liter at an interval of 15 days. Protection measures were taken to protect the matured seeds against the attack of pigeon and rat.

3.13 Harvesting

Harvesting was done at two times. Green pods were harvested at tender stage on 17 February, 2007 from three rows of each plot. Second harvest was done at 28 February, 2007 when the pods become yellow and fully dry from rest four rows of each plot. After harvest pods were separated from plants. Then plants and pods were weighed.

3.14 Collection of data

Five plants were selected at random in such a way that the border effect could be avoided. For this reason, the outer two lines and the outer plants of the middle lines in each unit plot were avoided. Data were recorded under the following parameters at harvesting stage:

i. Plant height (cm)
ii. Root length (cm)
iii. Number of branches/plant
iv. Number of pods/plant
v. Pod length (cm)
vi. 1000 seed weight (g)
vii. Number of seeds per pod
viii. Green pod yield (t/ha)
ix. Mature seed yield (t/ha)

Post harvest soils and plant samples were analyzed chemically for the following datas:

i. Totla Nitrogen
ii. Avialable Phosphorus
iii. Exchangeable Potassium
iv. Avialable Sulphur

3.15 Chemical analysis of soil samples

Soil samples collected before starting the research (Initial soil samples) and after harvest of the crop, were analyzed for both physical and chemical properties. The analysis was done at the Division of Soil Science, Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. The properties studied included soil texture, pH, organic matter, total N, available P, exchangeable K and available S. The physical and chemical properties of the initial soils have been presented in Table 2. The soil was analyzed following standard methods:

3.15.1 Particle size analysis of soil

Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using Marshsll's Triangular co-ordinate as designated by USDA.

3.15.2 Soil pH

The glass electrode pH meter was used to determine the pH of the soil samples. The ratio of soil and water in the solution was maintained 1: 2.5 (Jackson, 1973).

3.15.3 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 1 N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution. The result was expressed in percentage.

3.15.4 C/N ratio

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

3.15.5 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).

$$\% \text{ organic matter} = \% \text{ organic carbon} \times 1.724$$

3.15.6 Total nitrogen (%)

Total nitrogen in the soil samples were determined by Micro Kjeldhal method (Page *et al.*, 1982). The procedure was – digestion of soil sample by conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 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).

3.15.7 Available phosphorus (ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black, 1965).

3.15.8 Exchangeable potassium (meq/100g soil)

Exchangeable potassium in the soil samples was extracted with the normal ammonium acetate at pH 7.0 (Black, 1965) and was determined by using a flame photometer.

3.15.9 Available sulphur (ppm)

Available S in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.*, 1982). The S content in the extract was determined turbidimetrically and the intensity of turbidity was measured by spectrophotometer at 420 nm wavelength.

3.16 Plant sample analysis

For chemical analysis of plant samples, randomly collected plant samples of each plot were oven dried at 72°C for 72 hours. Then dried plant sample were ground by grinding machine. The plant and seed samples of different treatments were analyzed for N, P, K and S. For determination of N, P, K and S content in seed, the samples were first digested with acid and determination of elements in the digest were performed. For N, digestion was done with conc. H_2SO_4 and digest was distilled following the procedure outlined under soil analysis section (3.16). The amount of these elements in the digest was estimated following the procedure described under soil analysis section (3.16).

3.17 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

RESULTS AND DISCUSSION

The depiction of experimental results along with discussion in response of garden pea to effects of nitrogen and phosphorus on the plant height, root length, yield and yield contributing characteristics, N and P contents in plants were shown in Tables 3 to 17 and figures 3 to 6

4.1 Effect of N and P on growth and yield of garden pea

4.1.1 Plant height

4.1.1.1 Effect of nitrogen

Plant height of garden pea was significantly influenced by different treatments of nitrogen at all the growth stages (Table 3). The plant height for vegetative, flowering and maturity stages ranged from 28.74 to 30.967, 34.689 to 44.98 and 49.859 to 67.37 cm respectively. The maximum plant height for vegetative (30.96 cm) was found in treatment N_{30}, flowering (44.98 cm) and maturity stages (67.369 cm) was attained in the treatment N_{90}. Higher nitrogen application to soil favoured in increasing vegetative growth of the crop which resulted in increasing plant height appreciably. Hussain *et al.* (1992) reported that maximum height of garden pea was obtained by the application of N @ 80 kg/ha which supports the present findings.

4.1.1.2 Effect of phosphorus

Plant height of garden pea influenced significantly by the application of different levels of phosphorus (Table 4). At vegetative stage, plant height of pea varied with the variation of treatments. Most of the treatments recorded significantly higher plant height over control. The plant heights at vegetative, flowering and maturity stages ranged from 29.35 to 30.74, 39.94 to 41.39 and

61.01 to 62.42 cm respectively. The highest plant height for vegetative (30.74 cm) and flowering stage (41.39 cm) was found in treatment P_{50}, and maturity stages (62.43 cm) was attained in the treatment P_{75}. Solaiman *et al.* (1999) reported that P and K application resulted significant increases of plant height.

4.1.1.3 Interaction effect of nitrogen and phosphorus

The effects of N and P on the height of pea plant were found to be positive and significant in case of flowering and maturity stages but it is insignificant during vegetative stage (Table 5). At vegetative stage, plant height of pea varied with the variation of treatments. Most of the treatments recorded significantly higher plant height over control. The highest plant height (31.88 cm) was recorded under the treatment combination of N_0P_{50}. The lowest Plant height 28.32 cm was found from the control applied with 60 kg of N and 75 kg of P/ha. More or less similar trend in plant height was observed at flowering stage of the crop. But at this stage Nitrogen alone or applied with Phosphorus recorded highest plant height from the treatments consisting of 90 kg of N/ha. At flowering stage all the treatments recorded significantly higher plant height over control. The highest plant height 46.33 cm was recorded from the treatment incorporated with 90 kg of N combined with 75 kg of P/ha, it was followed by the treatment applied with 90 kg N plus 50 kg of P/ha. The lowest plant height 34.23 cm was found from the control treatment applied with no fertilizer. At maturity stage of the crop treatment comprising of N_{90} produced the highest plant height of 68.94 cm which was statistically similar with treatment $N_{90}P_{75}$ (68.82 cm). At this stage, the lowest plant height 48.80 cm was found in the treatment applied with no fertilizer. The above findings indicate that chemical fertilizer N and P is dominating factor influencing the plant height.

4.1.2 Root length

4.1.2.1 Effect of nitrogen

The effects of nitrogen on root length of pea plant were found to be positive and significant (Table 3). Most of the treatments recorded significantly root length over control. The root length for vegetative, flowering and maturity stages ranged from 9.98 to 14.98, 11.11 to 15.14 and 11.21 to 15.48 cm respectively. The maximum root length for vegetative (14.98 cm), flowering (15.14 cm) and maturity stages (67.369 cm) was attained in the treatment N_{90}. Gosal *et al.* (2000) have also obtained the similar results. Rahman and Quasem (1982a) showed a similar result with 60 kg N/ha.

4.1.2.2 Effect of phosphorus

Root length of garden pea influenced significantly by the application of different levels of phosphorus (Table 4). The root length at vegetative, flowering and maturity stages ranged from 11.96 to 13.13, 12.81 to 13.56 and 13.33 to 14.48 cm respectively. The highest root length for flowering stage (13.67 cm) was found in treatment P_{50}, at vegetative stages (13.13 cm) and maturity stages (14.48 cm) was attained in the treatment P_{75}. Solaiman *et al.* (1999) reported that P and K application resulted significant increases of root length of mungbean. Similar result was found by Prasad and Maurya (1989) who reported that P application in association with *Rhizobium* inoculants resulted in significant increases of root length of garden pea.

4.1.2.3 Interaction effect of phosphorus

The combined effects of different levels of N and P on root length of pea were found significant at different growth stages (Table 5). The ranges of root length were 9.24 to15.36 cm, 10.26 to 15.50 cm and 10.86 to 15.70 cm at vegetative, flowering and maturity stages, respectively. At vegetative stage root length of pea varied with the variation of treatments. Plants received N @ 90 kg/ha alone or along with P fertilizer gave higher root length. Maximum root length 15.36 cm was recorded by N @ 90 kg/ha with P @ 50 kg/ha.

Root length of pea was found positive and significant due to the combined effect of different levels of N and P at flowering stage. All the treatments recorded significantly higher root length over control. The highest root length 15.50 cm was recorded under the combined treatment $N_{90}P_{50}$ which is statistically similar with the treatment $N_{90}P_{75}$ (15.30 cm). The lowest root length 10.26 cm was found by treatment with no fertilizer.

At maturity stage, the highest root length 15.70 cm was found under $N_{90}P_{75}$ treatment combination which was statistically similar to $N_{90}P_{50}$. All the treatments produced higher root length compared to control.

Table 3: Effect of nitrogen on plant height and root length at different growth stages of garden pea

Nitrogen (kg/ha)	Plant height (cm)			Root length (cm)		
	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)
N_0	30.820	34.689 d	49.859 d	9.982 d	11.111 d	11.211 c
N_{30}	30.967	39.361 c	61.691 c	12.089 c	13.122 c	13.911 b
N_{60}	28.740	43.597 b	65.198 b	13.622 b	14.022 b	15.100 a
N_{90}	30.505	44.980	67.369 a	14.978 a	15.144 a	15.478 a
CV%	9.40	0.55	0.29	2.16	1.81	2.01
LSD	9.40	0.25	0.55	0.87	0.85	0.94

Table 4: Effect of phosphorus on plant height and root length at different growth stages of garden pea

Phosphorus (kg/ha)	Plant height (cm)			Root length (cm)		
	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)
P_0	30.68	39.943 b	59.656 c	11.962 b	12.808 b	13.333 a
P_{50}	30.74	41.389 a	61.003 b	12.917 a	13.667 a	13.958 a
P_{75}	29.35	40.637 a	62.428 a	13.125 a	13.575 a	14.483 a
LSD	9.40	0.55	0.29	2.16	1.81	2.01
CV%	NS	0.77	0.36	0.55	0.49	1.76

Table 5: Combined effect of nitrogen and phosphorus on plant height and root length at different growth stages of garden pea

Treatment	Plant height (cm)			Root length (cm)		
	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)	Vegetative (30 DAS)	Flowering (45 DAS)	Maturity (60 DAS)
N_0P_0	29.38	34.23 h	48.80 i	9.24 i	10.26 h	10.86i
N_0P_{50}	31.88	34.93 g	49.93 h	10.23 h	11.53 g	11.96h
N_0P_{75}	29.20	34.90 g	50.84 g	10.46 gh	11.53 g	12.40g
$N_{30}P_0$	31.32	38.03 e	61.38 f	11.00 g	12.63 f	13.33f
$N_{30}P_{50}$	30.86	42.81 d	61.38 f	12.20 f	13.33 e	14.06e
$N_{30}P_{75}$	30.72	37.23 f	62.31 e	13.06 e	13.40 e	14.33de
$N_{60}P_0$	28.40	43.20 cd	64.10 cd	13.23 de	13.70 de	14.66 cd
$N_{60}P_{50}$	29.50	43.50 c	63.75 d	13.86 bc	14.30 bc	15.13 abc
$N_{60}P_{75}$	28.32	44.08 b	67.74 b	13.76 cd	14.06 cd	15.50 ab
$N_{90}P_0$	31.62	44.30 b	64.34 c	14.36 b	14.63 b	15.06 bc
$N_{90}P_{50}$	30.72	44.30 b	68.94 a	15.36 a	15.50 a	15.66 a
$N_{90}P_{75}$	29.17	46.33 a	68.82 a	15.20 a	15.30 a	15.70 a
LSD	NS	0.67	0.31	0.47	0.42	1.53
CV%	9.40	0.95	0.29	2.16	1.81	2.01

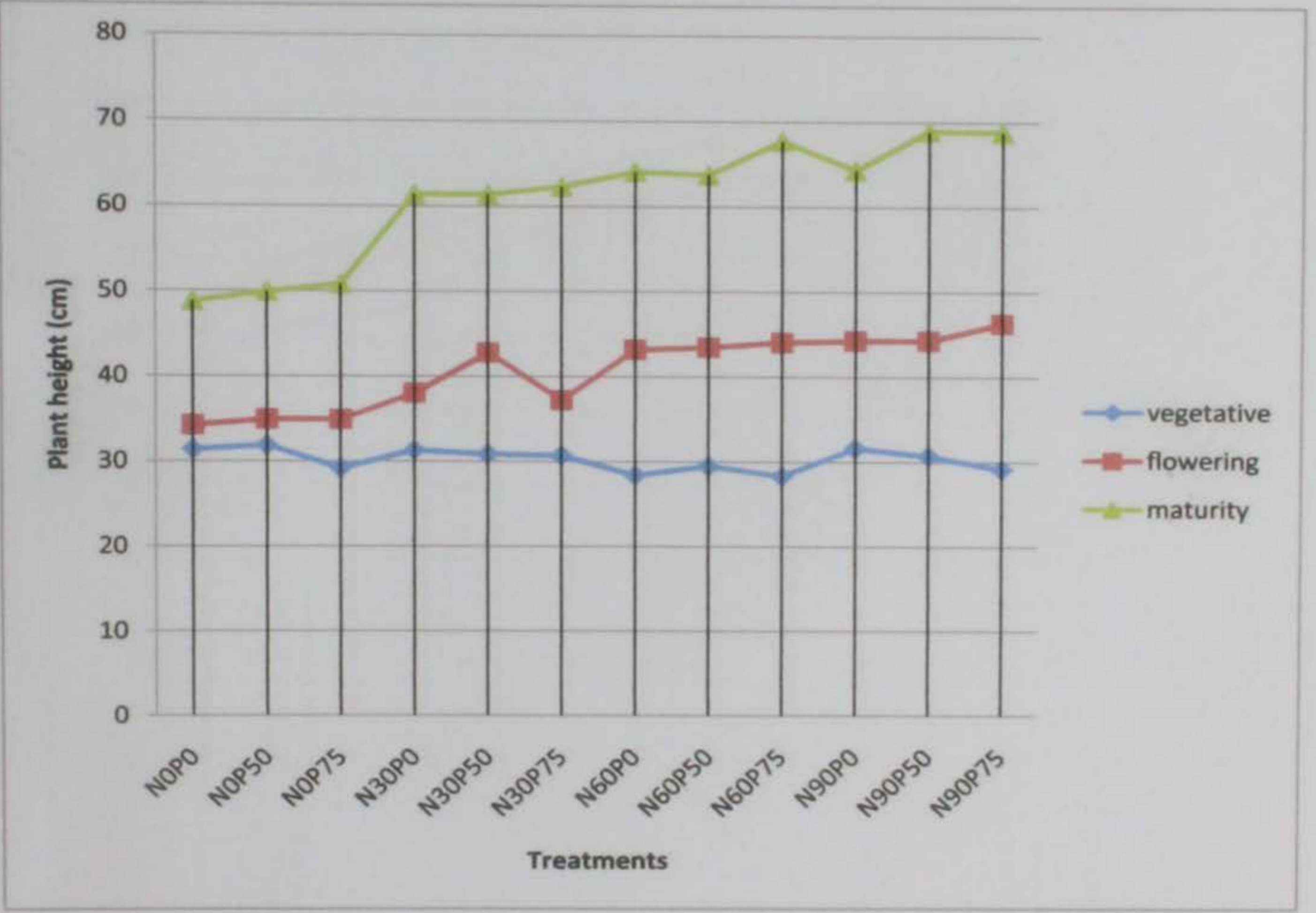

Fig 3: Interaction effect of nitrogen and phosphorus on plant height at different growth stages of garden pea

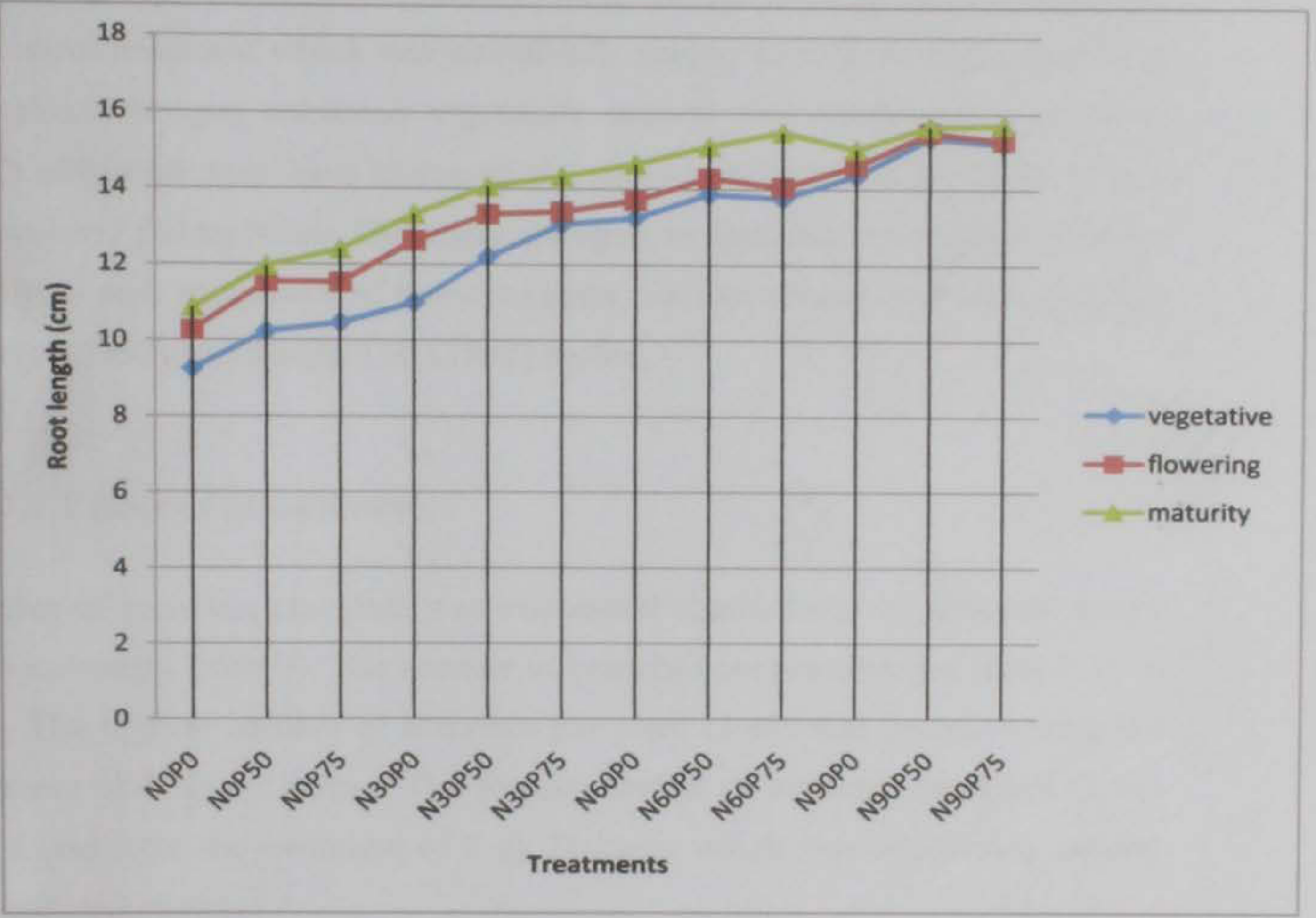

Fig 4: Interaction effect of nitrogen and phosphorus on root length at different growth stages of garden pea

4.1.3 Number of branches

4.1.3.1 Effect of nitrogen

The effect of N on number of branches per plant was influenced significantly (Table 6). The number of branches per plant ranged from 1.23 to 3.06 .The highest number of branches per plant (3.06) was recorded from the treatment of N @ 90 kg/ha. The lowest number of branches per plant (1.23) was found in the control treatment which was statistically similar to N @ 30 kg/ha and N @ 60 kg/ha. Nitrogen enhanced vegetative growth and development of plant, which ultimately may have increased the number of branches per plant up to a certain level (90 kg N/ha). Generally nitrogenous fertilizer increased vegetative growth as well as number of branches/plant. Similar results were also reported by Negi (1992) and Singh *et al*. (1992) earlier.

4.1.3.2 Effect of phosphorus

Number of branches per plant was influenced significantly by different levels of phosphorus (Table 7). The number of branches per plant ranged from 1.51 to 1.88. The highest number of branches per plant (1.88) was recorded from the treatment of P @ 50 kg/ha. The lowest number of branches per plant (1.51) was found from the treatment of P @ 75 kg/ha which was statistically similar to other treatments.

4.1.3.3 Interaction effect of nitrogen and phosphorus

Number of branches per plant was significantly influenced by the interaction effects of the nitrogen and phosphorus. The combined effect of nitrogen and phosphorus levels on the number of branches per plant was highly significant (Table 8). The number of branches per plant ranged from 1.03 to 3.71. The maximum number of branches per plant (3.71) was obtained under the treatment combination of 90 kg N/ha and 50 kg P/ha ($N_{90}P_{50}$), which was statistically similar with $N_{90}P_0$ treatment combination followed by $N_{90}P_{75}$ treatment. The rest of the treatments were statistically similar. Generally nitrogenous fertilizer increased vegetative growth as well as number of branches/plant. Similar results were also reported by Negi (1992) and Singh *et al*. (1992).

4.1.4 Number of pods/plant

4.1.4.1 Effect of nitrogen

Nitrogen had highly significant effect on the number of pods per plant (Table 6). The number of pods per plant ranged from 4.49 to 5.86. The highest number of pods per plant (5.86) was recorded in the treatment of 30 kg N /ha. The lowest number of pods per plant (4.49) was found in the control treatment (0 kg N/ha). Sing and Verma (2002), Tewari *et al*. (2000) also observed the similar results in bush bean.

4.1.4.2 Effect of phosphorus

The number of pods per plant was significantly influenced by different levels of phosphorus (Table 7). The number of pods per plant ranged from 4.79 to 5.44. The highest number of green pods per plant (5.44) was recorded from the treatment of 75 kg P/ha and the lowest number of pods per plant (4.79) was found in the control treatment.

4.1.4.3 Interaction effect of nitrogen and phosphorus

There was a significant variation in the number of pods per plant with the different treatments (Table 8). Plant receiving N @ 90 kg/ha along with 75 kg P/ha produced the highest number of pods per plant (6.58/plant). This treatment was followed by 5.6 pods/plant from the combined treatment of N @ 90 kg/ha and P @ 50 kg/ha. The lowest number of pods/plant 4.35 found in the combined treatment of N_0P_{75} which was statistically similar with control treatment combination. The contribution of N and P on increasing the pod number was remarkable. Results indicated that N addition favored vegetative growth and as well as formation of edible pods. Vijai *et al.* (1990) reported that the highest number of pods per plant of garden pea was obtained with higher doses of N and P application.

4.1.5 Pod length

4.1.5.1 Effect of nitrogen

The effect of different levels of N on the pod length was significant (Table 6). The length of pods ranged from 6.13 to 7.19 cm .The highest pod length (7.19 cm) was recorded under the treatment of 90 kg N /ha (N_{90}). The lowest pod length (6.13 cm) was found in the control treatment (0 kg N/ha). Similar results were also reported by Tewari *et al* (2000) and Naik *et al.*, (1989) recorded highest pod length with higher N rate.

4.1.5.2 Effect of phosphorus

The effect of different levels of P on pod length was statistically insignficant (Table 7). The length of green pods ranged from 6.33 to 6.60 cm. The highest pod length (6.60 cm) was recorded from the treatment of 75 kg P/ha and the lowest pod length (6.60 cm) was found in the control treatment (0 kg P/ha).

4.1.5.3 Interaction effect of nitrogen and phosphorus

The combined effect of different levels of N and P on the pod length was significant (Table 8). The length of pods ranged from 6.10 to 7.40 cm. The highest pod length (7.40 cm) was recorded from the combined treatment of 90 kg N /ha along with P @ 50 kg/ha which was statistically similar with that of 90 kg N/ha with 75 kg P/ha. The lowest pod length (6.10 cm) was found in the control treatment. Similar results were also reported by Tewari *et al* (2000) and Naik *et al.*, (1989) recorded highest pod length with higher N rate.

4.1.6 Number of seeds/pod

4.1.6.1 Effect of nitrogen

Significant differences were found on number of seeds per pod due to different levels of N (Table 6). It was observed that the number of seed per pod was increased with the increase of nitrogen level. The maximum number of seeds per pod (3.92) was found under 90 kg N/ha and the lowest number of seed per pod (3.24) was obtained in the control treatment (0 kg N/ha). Rahman and Quasem (1982) showed a similar result with 60 kg N/ha.

4.1.6.2 Effect of phosphorus

There were no significant differences on number of seeds per pod due to the application of different levels of P (Table 7). It was observed that the number of seed per pod was increased with the increase of phosphorus level. The maximum number of seeds per pod (3.64) was found under 75 kg P/ha and the lowest number of seed per pod (3.41) was obtained in the control treatment (0 kg P/ha).

4.1.6.3 Interaction effect of nitrogen and phosphorus

Combined effect of nitrogen and phosphorus played a significant role on the number of seeds per pod (Table 8). Treatment consisting of Nitrogen combined with Phosphorus at higher level was statistically similar and recorded higher number of seeds per pod compared to control. The maximum number of seeds per pod 4.01 was found in the treatment combination supplied with N @ 90 kg/ha with P @ 50 kg/ha which was statistically similar to the combined effect of N @ 90 kg/ha and P @ 75 kg/ha.

The lowest number of seeds per pod 3.06/pod was obtained under the treatment combined of N_0P_{75} which was statistically similar to control treatment. It was observed that combined effect of N and P exhibited a significant effect on the number of seeds per pod. These findings had the resemble with the results of Bhopal and Singh (1990) who concluded that seeds per pod increased significantly with the increase in the rates of nitrogenous fertilizer. It was also resemblance with the findings of Rahman *et al.* (1994) who reported that phosphorus fertilizer produced significantly highest number of seeds per pod in chickpea.

4.1.7 1000-seed weight

4.1.7.1 Effect of nitrogen

The effects of nitrogen were significant on 1000-seed weight of garden pea (Table 6). Due to the different levels of nitrogen varied the weight of green pea and matured seed varied significantly. Ranges of 1000-seed weight of garden pea was 208.36 to 236.90 g at green stage and 128.56 to 147.51 at mature stage. The highest weight of 1000-seed were found in the treatment of 90 kg N/ha and lowest weight of 1000-seed were found in the control treatment. This finding has the resemblance with the result of Solaiman (1999) who obtained the highest 1000-seed weight with the treatment comprising of *Rhizobium* inoculants, P and K.

4.1.7.2 Effect of phosphorus

The effect of different levels of P on 1000-seed weights both at green and matured stage was significant (Table 7). The weight found from 220.92 to 225.26 g at green stage and 136.97g to 140.23g at mature stage. The highest weight of 1000-seed were found in the treatment of 75 kg P/ha and lowest weight of 1000-seed were found (220.93) in the control treatment (0 kg N/ha) at green seed weight. The highest weight of 1000 matured seed was 136.97 g which was statistically similar to the control treatment.

4.1.7.3 Interaction effect of nitrogen and phosphorus

The combined effect of different levels of N and P on 1000-seed weight was significant at both stages. Different levels of nitrogen in association with different levels of phosphorus increased 1000-green seed weight as compare to control (Table 8). Treatment combinations of N @ 90 kg/ha combined with P @ 0, 50, 75 kg/ha recorded higher 1000-green seed weight in compare to other treatments. Similar trend was observed in 1000-matured seed weight of the crop. Result revealed that the interactions of N and P might have led to better assimilation of N for the plants that resulted better vegetative growth of pea plants and ultimately produced the larger seeds. This finding had the similarity with the result of Singh *et al.*, (1992) who conducted a field trial with field pea cv. Rachna, given 0-30 kg N and 0-25 kg P_2O_5/ha and got higher seed weight with 30 kg N and 50 kg P_2O_5/ha.

Table 6: Effect of nitrogen on yield contributing characteristics of garden pea

Nitrogen (kg/ha)	No. of branches	No. of pods/plant	Pod length (cm)	No. of seed/pod	1000-seed weight (g)	
					green	matured
N_0	1.233 b	4.493 b	6.133 b	3.241 b	208.36 d	128.56 c
N_{30}	1.156 b	5.861 a	6.344 b	3.391 b	218.42 c	135.57 b
N_{60}	1.328 b	4.981 b	6.456 b	3.527 ab	228.76 b	142.87 a
N_{90}	3.056 a	5.188 ab	7.189 a	3.917 a	236.90 a	147.50 a
CV%	17.16	9.33	3.76	8.81	0.39	1.23
LSD	0.72	1.10	0.68	0.63	2.5	5.12

Table 7: Effect of phosphorus on yield contributing characteristics of garden pea

Phosphorus (kg/ha)	No. of branches	No. of pods/plant	Pod length (cm)	No. of seed/pod	1000-seed weight (g)	
					Green	Matured
P_0	1.683 a	4.788 a	6.333	3.415	220.92 c	136.97 a
P_{50}	1.883 a	5.167 a	6.658	3.497	223.15 b	138.69 a
P_{75}	1.513 a	5.438 a	6.600	3.644	225.26 a	140.22 a
CV%	17.16	9.33	3.76	8.81	0.39	1.23
LSD	0.58	0.96	NS	NS	1.75	3.40

Table 8: Combined effect of nitrogen and phosphorus on yield contributing characteristics of garden pea

Treatment	No. of branches	No. of pods/plant	Pod length (cm)	No. of seed/pod	1000 seed weight (g)	
					Green	Matured
N_0P_0	1.25 c	4.41 de	6.10 d	3.28 cde	207.56 i	126.53 i
N_0P_{50}	1.33 c	4.71 cde	5.16 cd	3.38 cde	208.23 hi	128.45 hi
N_0P_{75}	1.11 c	4.35 e	6.13 d	3.06 e	209.28 h	130.70gh
$N_{30}P_0$	1.20 c	4.62 cde	6.13 d	3.48 b-e	213.64 g	132.51 fg
$N_{30}P_{50}$	1.03 c	5.39 bc	.46 bcd	3.67 a-d	217.27 f	135.69 ef
$N_{30}P_{75}$	1.23 c	5.60 b	.43 bcd	3.42 cde	224.35 e	138.53de
$N_{60}P_0$	1.03 c	5.14 b-e	5.26 cd	3.46 b-e	226.84 d	141.66cd
$N_{60}P_{50}$	1.45 c	5.22 bcd	5.60 bc	3.50 a-e	230.02 c	143.06 c
$N_{60}P_{75}$	1.50 c	4.57 cde	.50 bcd	3.20 de	229.43 c	143.88bc
$N_{90}P_0$	3.25 a	5.33 bc	6.83 b	3.76 abc	235.65 b	147.17ab
$N_{90}P_{50}$	3.71 a	5.60 b	7.40 a	4.01 a	237.09ab	147.57 a
$N_{90}P_{75}$	2.20 b	6.58 a	7.33 a	3.97 ab	237.97 a	147.78 a
CV%	17.16	9.33	3.76	8.81	0.39	1.23
lsd value	0.50	0.82	NS	NS	1.51	2.95

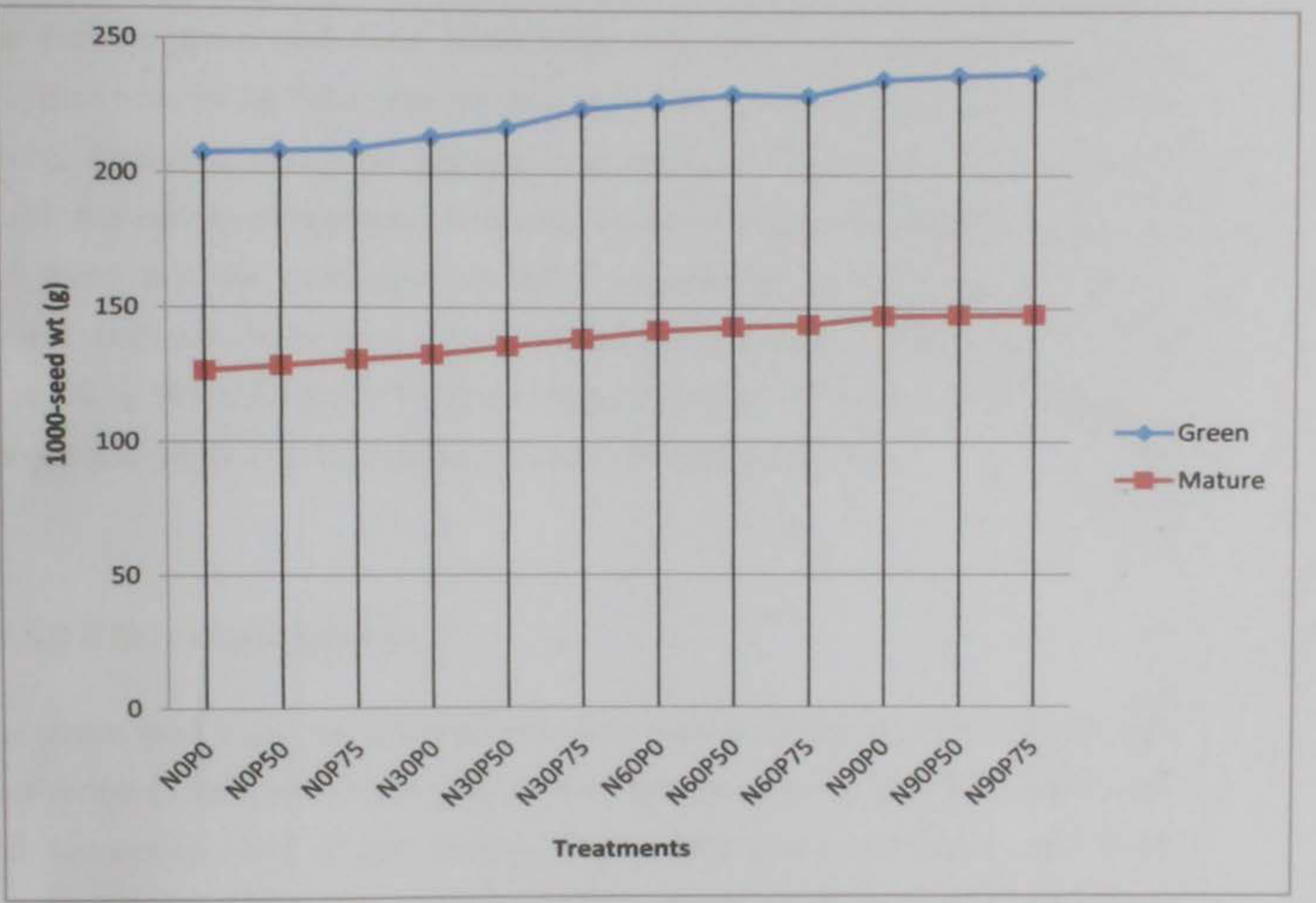

Fig 5: Interaction effect of nitrogen and phosphorus on 1000 seed weight at green and maturity stage of garden pea

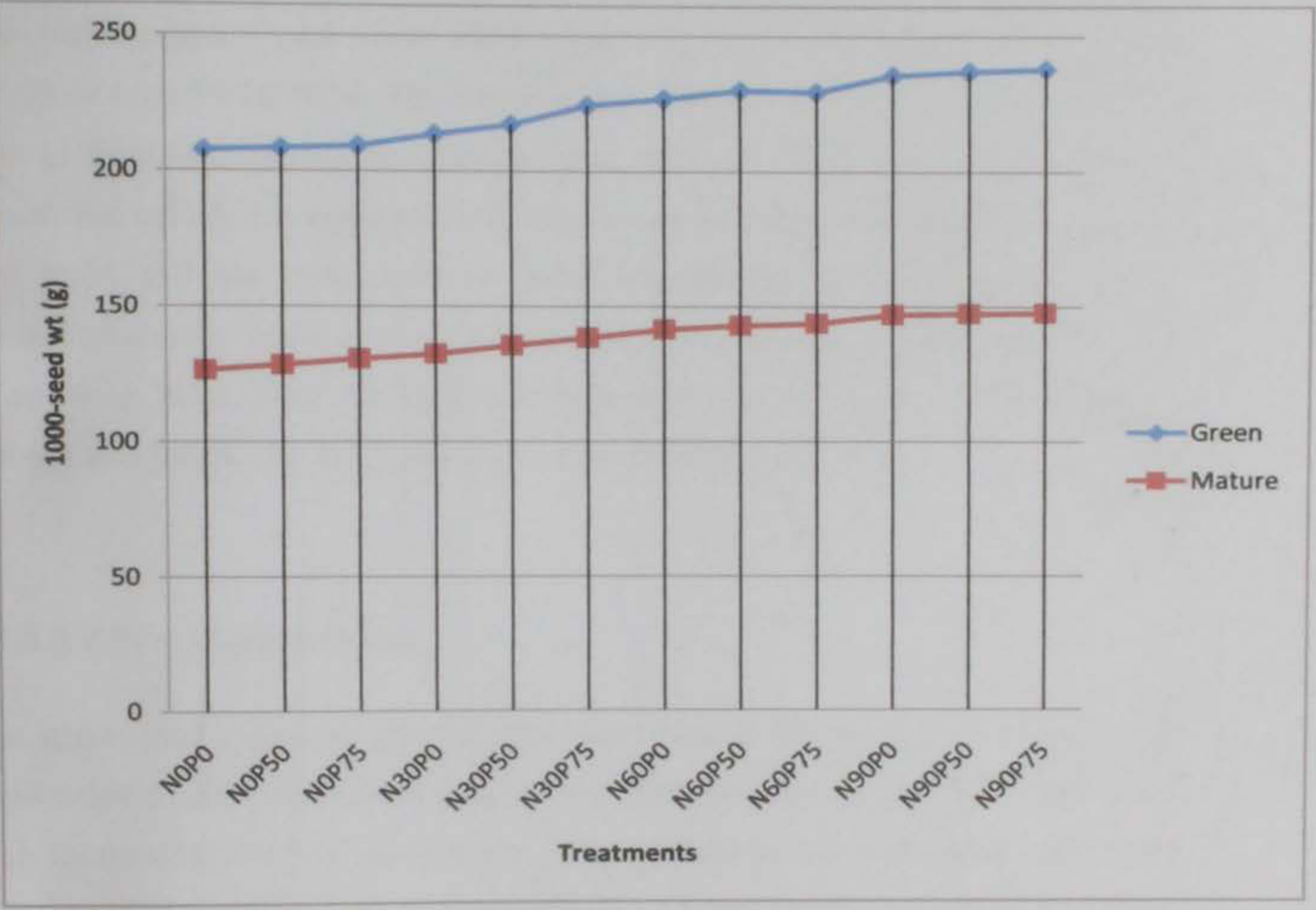

Fig 5: Interaction effect of nitrogen and phosphorus on 1000 seed weight at green and maturity stage of garden pea

4.1.8 Green pod yield (t/ha)

4.1.8.1 Effect of nitrogen

The green pod yield per hectare was significantly influenced by different levels of nitrogen (Table 9). The green pod yield ranged from 4.64 to 6.45 t/ha. The highest green pod yield (6.45 t/ha) was obtained when the crop was fertilized with 90 kg N/ha. The lowest green pod yield (4.64 t/ha) was found in control treatment where no nitrogen was applied. From these results it was found that mainly nitrogenous fertilizer increased vegetative growth as well as pod yield. All the treatments produced significantly higher pod yield over control treatment. Saini *et al*., (1996) stated that green pod yield increased with up to 30 kg N/ha. Negi (1992) found highest green pod yield with 20 kg N/ha. Bhopal and Singh (1990) found similar result with 40 kg N/ha.

4.1.8.2 Effect of phosphorus

The green pod yield per hectare was significantly influenced by phosphorus application (Table 10). Green pod yield of garden pea was gradually increased with increasing level of phosphorus. The highest green pod yield (4.10 t/ha) was recorded in 75 kg P/ha treated plot. The lowest green pod yield (3.67 t/ha) was recorded in control, which was statistically similar with the treatment of 50 kg P/ha. This finding have the resemblance with the result of Srivastava *et al.* (1998) who reported that application of 25.8 kg P/ha with *Rhizobium leguminosarum* gave maximum pod yield of pea. Kanaujia *et al.* (1998) also found similar result.

4.1.8.3 Interaction effect of nitrogen and phosphorus

There was a significant effect of different treatments in producing pod yield of pea (Table 11). The highest average green pod yield of 5 t/ha was found in the treatment combined with N @ 90 kg/ha and P @ 50 kg/ha. The effect of Nitrogen @ 90 kg/ha with 75 kg P/ha on green pod yield was however statistically similar to that of 50 kg P/ha but was superior to the rest of the treatments. The lowest yield of 3.26 t/ha was being noted under control. There was no significant yield variation among the rest treatments.

4.1.9 Seed yield (t/ha)

4.1.9.1 Effect of nitrogen

The seed yield per hectare was significantly influenced by different levels of nitrogen (Table 9). The highest seed yield (4.66 t/ha) was obtained in 90 kg N/ha treated plot and lowest (3.26 t/ha) was found in control plot. From these results it was found that mainly nitrogenous fertilizer increased vegetative growth as well as seed yield. Nitrogen @ 90 kg/ha produced higher number of pods per plant, so seed yield per hectare was higher with 90 kg N/ha. Saini *et al.*, (1996) stated that pod yield increased with up to 30 kg N/ha. Bhopal and Singh (1990) found similar result with 40 kg N/ha.

4.1.9.2 Effect of phosphorus

The seed yield per hectare was significantly influenced by different levels of phosphorus (Table 10). The highest seed yield (3.75 t/ha) was obtained in 75 kg P/ha treated plot and lowest (3.26 t/ha) was found in control plot. Increasing levels of phosphorus increased the seed yield of garden pea gradually. Solaiman *et al.* (1999) reported that the effect of *Bradirhizobium* sp. (*Vigna*) inoculants, P and K fertilization. Plant receiving inoculant along with 25.8 kg P/ha and 33 kg k/ha performed best in all parameters including seed yield.

4.1.9.3 Interaction effect of nitrogen and phosphorus

The combined effect of N and P on seed yield of garden pea was significant. Seed yield of pea varied significantly with the variation of different treatment combinations (Table 11). Seed yield of pea was significantly influenced due to N and P fertilizer application. All the treatment combinations produced significantly higher seed yield compared to control. The effect of N @ 90 kg/ha with different doses of P on seed yield was statistically similar and superior to other treatments. The treatment combination N @ 90 kg/ha and P @ 50kg/ha produced the maximum seed yield.

Mature seed yield of pea was significantly influenced due to different treatment combination. The effects of N @ 90 kg/ha with different levels of P were statistically similar and produced similar seed yield. Plants receiving N @ 90 kg/ha with P @ 50 kg/ha gave the highest mature seed yield.

Table 9: Effect of nitrogen on green pod yield and seed yield of garden pea

Nitrogen (kg/ha)	Green pod yield (t/ha)	Seed yield (t/ha)
N_0	4.642 c	3.360 b
N_{30}	5.110 bc	3.597 b
N_{60}	5.872 b	3.652 b
N_{90}	6.451 a	4.662 a
CV%	7.58	8.08
LSD	0.579	1.01

Table 10: Effect of phosphorus on green pod yield and seed yield of garden pea

Phosphorus (kg/ha)	Green pod yield (t/ha)	Seed yield (t/ha)
P_0	3.671 b	3.267 b
P_{50}	3.974 a	3.813 a
P_{75}	4.103 a	3.751 a
CV%	8.49	8.08
LSD	0.66	NS

Table 11: Combined effect of nitrogen and phosphorus on green pod yield and seed yield of garden pea

Treatment	Green pod yield (t/ha)	Seed yield (t/ha)
N_0P_0	3.26 d	3.06 e
N_0P_{50}	3.34 d	3.18 cde
N_0P_{75}	3.70 bcd	3.53 de
$N_{30}P_0$	3.48 cd	3.37 cde
$N_{30}P_{50}$	3.74 bcd	3.90 abc
$N_{30}P_{75}$	3.73 bcd	3.67 b-e
$N_{60}P_0$	3.56 cd	3.58 cde
$N_{60}P_{50}$	3.80 bcd	3.38 cde
$N_{60}P_{75}$	4.09 bc	3.83 a-d
$N_{90}P_0$	4.37 ab	3.85 a-d
$N_{90}P_{50}$	5.00 a	4.43 a
$N_{90}P_{75}$	4.88 a	4.31 ab
CV%	8.49	8.08
lsd value	NS	0.51

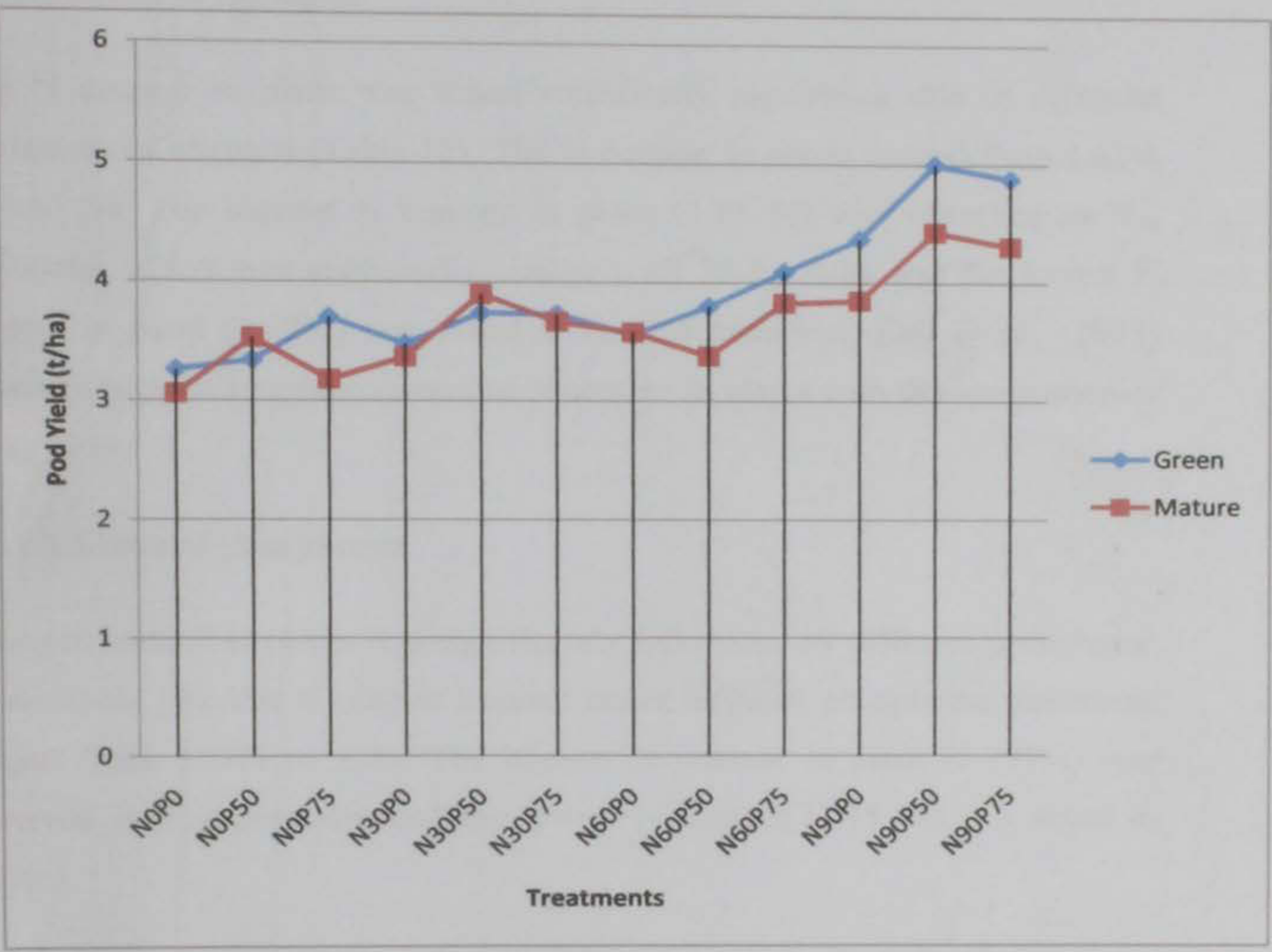

Fig 6: Interaction effect of nitrogen and phosphorus on pod yield at green and maturity stage of garden pea

4.2 Effect of N and P on nutrient content in Plant

4.2.1 N content in plant

4.2.1.1 Effect of nitrogen

The N content in plant was found statistically significant due to different treatments of nitrogen (Table 12). The N content in plants ranged from 1.62% to 1.81 %. The highest N content in plant (1.81 %) was observed in N_{90} treatment, which was statistically similar with 30 kg N/ha and the lowest N content in plant (1.62%) was noted in control treatment. Bail *et al*., (1995) observed highest N uptake as well as N content in plants with the application of 40 kg N/ha.

4.2.1.2 Effect of phosphorus

Nitrogen content in plants was significantly influenced by different phosphorus level (Table 13). The N content in plant under different phosphorus treatments ranged from 1.75% to 1.79. The highest N content in plant (1.797%) was observed in P_{75} treatment and the lowest N content (1.75 %) was noted in control.

4.2.1.3 Interaction effect of nitrogen and phosphorus

Table 14 shows nitrogen content in shoot at different growth stages as influenced by N and P fertilization. All the treatments significantly increased N accumulation. Nitrogen content in shoot varied from 1.43 to 1.96% of pea plant. Addition of nitrogen along with phosphorus favored N accumulation in plant. The highest N accumulation of 1.96% recorded with $N_{90}P_{75}$. The effect of this treatment was followed by the treatment $N_{90}P_{50}$. Generally N content in shoot was more or less higher in all the treatments at vegetative stage of the crop and later on declined markedly at maturity. This is because of anthesis of pea that needed more N. Amino acids were utilized at a higher rate of protein

4.2 Effect of N and P on nutrient content in Plant

4.2.1 N content in plant

4.2.1.1 Effect of nitrogen

The N content in plant was found statistically significant due to different treatments of nitrogen (Table 12). The N content in plants ranged from 1.62% to 1.81 %. The highest N content in plant (1.81 %) was observed in N_{90} treatment, which was statistically similar with 30 kg N/ha and the lowest N content in plant (1.62%) was noted in control treatment. Bail *et al.*, (1995) observed highest N uptake as well as N content in plants with the application of 40 kg N/ha.

4.2.1.2 Effect of phosphorus

Nitrogen content in plants was significantly influenced by different phosphorus level (Table 13). The N content in plant under different phosphorus treatments ranged from 1.75% to 1.79. The highest N content in plant (1.797%) was observed in P_{75} treatment and the lowest N content (1.75 %) was noted in control.

4.2.1.3 Interaction effect of nitrogen and phosphorus

Table 14 shows nitrogen content in shoot at different growth stages as influenced by N and P fertilization. All the treatments significantly increased N accumulation. Nitrogen content in shoot varied from 1.43 to 1.96% of pea plant. Addition of nitrogen along with phosphorus favored N accumulation in plant. The highest N accumulation of 1.96% recorded with $N_{90}P_{75}$. The effect of this treatment was followed by the treatment $N_{90}P_{50}$. Generally N content in shoot was more or less higher in all the treatments at vegetative stage of the crop and later on declined markedly at maturity. This is because of anthesis of pea that needed more N. Amino acids were utilized at a higher rate of protein synthesis for grain development. Most of the N demand for grain development was met through remobilization of N and assimilates from soil, leaves or other organs.

4.2.2 Phosphorus content in plant

4.2.2.1 Effect of nitrogen

P content in plants was significantly influenced by different nitrogen levels (Table 12). The highest P content (0.443 %) was obtained in N_{90} treatment. The minimum value (0.303 %) was obtained in control treatment, which was statistically similar with the treatment N_{30}. Bail *et al.*, (1995) found highest P uptake as well as P content in plants with the application of 40 kg N/ha.

4.2.2.2 Effect of phosphorus

Phosphorus content in plants was also influenced by different levels of P (Table 13). The highest Phosphorus content in plants (0.377 %) was found in P_{50} kg/ha, which was statistically significant with other treatments. The lowest Phosphorus content in plants (0.307 %) was found in control treatment. Above findings are in agreement with the result of Srivastava and Verma (1985) who carried out an experiment and observed that increasing the P rates markedly increased P contents in shoot of field pea.

4.2.2.3 Interaction effect of nitrogen and phosphorus

Treatment consisting of higher phosphorus in combination with nitrogen produced the highest P content. Phosphorus content in plants was ranged from 0.21% to 0.47%. The maximum Phosphorus content in plants (0.47%) was found in $N_{90}P_{75}$ combination. The minimum Phosphorus content in plants (0.21 %) was observed in N_0 P_0 treatment combination.

4.2.3 Potassium (K) content in plant

4.2.2.1 Effect of nitrogen

Different levels of nitrogen did not significantly influence the K content in plants (Table 12). But the highest K content in plants (0.574 %) was obtained in N_{90} treatment and the minimum value (0.445 %) was obtained in N_{60} treatment. Nasreen and Farid (2003) observed highest K uptake as well as K content in plants with the application of 30 kg N/ha.

4.2.3.2 Effect of phosphorus

Potassium content in plants was not significantly influenced by different levels of P (Table 13). The highest Potassium content in plants (0.582%) was found with the application of P @ 75 kg/ha. The lowest Potassium content in plants (0.445 %) was found in control treatment. It was observed that the K content increased with increasing level of P. Nasreen and Farid (2003) observed highest K uptake as well as K content in plants with the application of P in soil.

4.2.3.3 Interaction effect of nitrogen and phosphorus

Treatment consisting of higher phosphorus in combination with nitrogen produced the highest K content. Potassium content in plants was ranged from 0.335% to 0.692%. The maximum Potassium content in plants (0.692%) was found in $N_{90}P_{75}$ combination. The minimum Potassium content in plants (0.335 %) was observed in N_0 P_0 treatment combination.

4.2.4 Sulphur (S) content in plant

4.2.4.1 Effect of nitrogen

A significant effect in S content in plants was recorded due to different treatment levels of nitrogen (Table 12). The S content ranged from 0.303% to 0.446%. The highest S content in plants (0.446%) was obtained under N_{60}

treatment which was statistically similar with N_{90} treatments. The minimum value (0.303%) was obtained under control treatment. Nasreen and Farid (2003) observed highest S uptake as well as S content in plants with the application of 30 kg N/ha.

4.2.4.2 Effect of phosphorus

Sulphur content in plants was also influenced significantly by different levels of P (Table 13). The highest S content in plants (0.379%) was obtained in P @ 75 kg/ha. The lowest S content in plants (0.344%) was found in control treatment. Nasreen and Farid (2003) observed highest S uptake as well as S content in plants with the application of P.

4.2.4.3 Interaction effect of nitrogen and phosphorus

S content in plants was significantly influenced by the interaction of Nitrogen and phosphorus (Table 14). Sulphur content in plants was ranged from 0.362% to 0.496%. The maximum sulphur content (0.496%) in plants was found in $N_{90}P_{75}$ treatment combination and the minimum sulphur content (0.362%) was observed in N_0 P_0 treatment combination.

Table. 12. Effect of different levels of nitrogen on the N, P, K and S contents in garden pea plants

Nitrogen (kg/ha)	N in plants (%)	P in plants (%)	K in plants (%)	S in plants (%)
N_0	1.800 a	0.303 b	0.503	0.303 c
N_{30}	1.897 a	0.347 b	0.561	0.365 b
N_{60}	1.620 b	0.233 c	0.445	0.446 a
N_{90}	1.810 a	0.443 a	0.574	0.439 a
CV%	0.24	0.09	NS	0.019
LSD	0.18	0.1	9.77	3.38

In a column figures having similar letter(s) do not differ significantly.

Table. 13. Effect of different levels of phosphorus on the N, P, K and S contents in garden pea plants

Phosphorus (kg/ha)	N in plant (%)	P in plants (%)	K in plants (%)	S in plants (%)
P_0	1.758 a	0.307 b	0.445	0.344 b
P_{50}	1.790 a	0.377 a	0.513	0.378 a
P_{75}	1.797 a	0.310 ab	0.582	0.379 a
CV%	0.11	0.09	9.75	3.38
LSD	0.11	0.07	NS	0.0226

Table 14: Combined effect of nitrogen and phosphorus on N, P, K and S contents in shoot or plant at maturity of garden pea

Treatment	N in Plant (%)	P in Plant (%)	K in plant (%)	S in plant (%)
N_0P_0	1.43 c	0.21 g	0.335 c	0.362 f
N_0P_{50}	1.68 b	0.38 b-e	0.356 c	0.403 de
N_0P_{75}	1.68 b	0.32 def	0.379 c	0.453 b
$N_{30}P_0$	1.76 ab	0.30 ef	0.538 abc	0.396 e
$N_{30}P_{50}$	1.82 ab	0.34 c-f	0.499 abc	0.405 de
$N_{30}P_{75}$	1.75 ab	0.40 a-d	0.432 ab	0.423 c
$N_{60}P_0$	1.82 ab	0.26 fg	0.427 bc	0.334 g
$N_{60}P_{50}$	1.85 ab	0.26 fg	0.426 bc	0.452 b
$N_{60}P_{75}$	1.85 ab	0.42 abc	0.513 abc	0.455 b
$N_{90}P_0$	1.88 ab	0.18 g	0.531 abc	0.330 g
$N_{90}P_{50}$	1.90 ab	0.44 ab	0.531 abc	0.412 a
$N_{90}P_{75}$	1.96 a	0.47 a	0.692 a	0.496 a
CV%	0.24	0.09	0.205	0.017
lsd value	6.81	13.95	9.74	3.37

4.3 Effect of N and P on nutrient content in post harvest soil

4.3.1 Organic Carbon (OC) content in soil

4.3.1.1 Effect of nitrogen

A statistically non significant variation was observed in the organic carbon content in the post harvest soil (Table 15). The OC content of the post harvest soil ranged from 0.51 % to 0.56 %. The highest OC content (0.56 %) was observed in the treatment N_{90} and the minimum value (0.51 %) was found in N_0 treatments.

4.3.1.2 Effect of phosphorus

The effect of P on organic carbon content in the post harvest soil was not significant (Table 16). The OC content of the post harvest soil ranged from 0.50 % to 0.53 %. The highest OC content (0.53 %) was observed in the treatment combination of P_{75} and the minimum value (0.50 %) was found in P_{50} treatment combination.

4.3.1.3 Interaction effect of nitrogen and phosphorus

The effect of different treatments showed significant differences in OC content in post harvest soil (Table 17). The OC content of the post harvest soil ranged from 0.36 % to 0.60 %. The highest OC content (0.60 %) was observed in the treatment $N_{90}P_{50}$ and the minimum value (0.36 %) was found in $N_{30}P_{75}$ treatments.

4.3.2 Total nitrogen content in soil

4.3.2.1 Effect of nitrogen

A statistically significant variation was observed in the total N content in the post harvest soil (Table 15). The total N content in soil ranged from 0.078% to 0.087%. The highest N content in (0.87%) was found with N_{90} treatment and the minimum N content in post harvest soil (0.087%) was found in control treatment

4.3.2.2 Effect of phosphorus

A statistically non significant variation was observed in the total N content in the post harvest soil (Table 16). The total N content in soil ranged from 0.079% to 0.081%. The highest N content in (0.81%) was found with P_{50} treatment and the minimum N content in post harvest soil (0.079%) was found in control treatment

4.3.2.3 Interaction effect of nitrogen and phosphorus

The combined effect of N and P on N content in soil was not significant (Table 17). The total N content in soil ranged from 0.073% to 0.091%. The highest N content in (0.091%) was found with $N_{90}P_{75}$ treatment combination and the minimum N content in post harvest soil (0.073%) was found in control treatment N_0P_0.

4.3.3 Available phosphorus

4.3.3.1 Effect of nitrogen

The effect of different levels of N showed significant differences in P content in post harvest soil (Table 15). The highest P content (37.64 ppm) was recorded in control treatment and the lowest P content (27.39 ppm) was found in the treatment of 90 kg N/ha. Control or lowest dose of N decreased vegetative growth and as a result low P uptake from soil. Whereas higher N dose increased vegetative growth and uptake of P was more and residual available P was less in post harvest soil.

4.3.3.2 Effect of phosphorus

The effect of different levels of P showed significant differences in P content in post harvest soil (Table 16). The highest P content (43.22 ppm) was observed in the treatment of 75 kg P/ha and the minimum value (37.30 ppm) was found in the control treatment.

4.3.3.3 Interaction effect of nitrogen and phosphorus

The effect of combined application of nitrogen and phosphorus showed significant differences in P content in post harvest soil (Table 17). The P content in the post harvest soil ranged from 27.05 ppm to 41.33 ppm. The highest P content (41.33 ppm) was observed under the treatment of $N_{90}P_{75}$ and the minimum value (27.05 ppm) was found in the N_0P_0 treatment. Control or lowest dose of N and P decreased vegetative growth and as a result low P uptake from soil. Whereas higher N and P dose increased vegetative growth and uptake of P was more and residual available P was less in post harvest soil.

4.3.4 Exchangeable potassium

4.3.4.1 Effect of nitrogen

Different doses of nitrogen had significant effect in K content in post harvest soil (Table 15). The highest K content (0.389 m.e./100 g soil) was recorded in control treatment and the lowest K content (0.262 m.e./100 g soil) was found in the treatment of 90 kg N/ha. Control or lowest dose of N decreased vegetative growth and as a result low K uptake from soil. Whereas higher N dose increased vegetative growth and uptake of K was more and residual available K was less in post harvest soil.

4.3.4.2 Effect of phosphorus

Statistically significant variation was not observed in K content in post harvest soil with various levels of P (Table 16). But the highest K content in post harvest soil (0.314 m.e./100 g soil) was observed in P_{75} treatment and the minimum value (0.292 m.e./100 g soil) was found in the P_{50} treatment.

4.3.4.3 Interaction effect of Nitrogen and Phosphorus

The effect of combined application of nitrogen and phosphorus showed significant differences in respect of K content in post harvest soil (Table 17). The K content in the post harvest soil ranged from 0.198 m.e./100 g soil to 0.401 m.e./100 g soil. The highest K content (0.401 m.e./100 g soil) was observed in control treatment (N_0P_0) and the minimum value (0.198 m.e./100 g soil) was found in $N_{90}T_{75}$ treatment combination. Control or lowest dose of N and P decreased vegetative growth and as a result low K uptake from soil. Whereas higher N and P dose increased vegetative growth and uptake of K was more and residual available K was less in post harvest soil.

4.3.5 Available sulphur

4.3.5.1 Effect of nitrogen

The effect of different levels of N showed significant differences in S content in post harvest soil (Table 15). The highest S content (25.29 ppm) was recorded under control treatment and the lowest S content (15.07 ppm) was found under the treatment of 90 kg N/ha (N_{90}). Control or lowest dose of N decreased vegetative growth and as a result low S uptake from soil. Whereas higher N dose increased vegetative growth and uptake of S was more and residual available S was less in post harvest soil.

4.3.5.2 Effect of phosphorus

Statistically significant variation was observed in sulphur content in the post harvest soil due to different levels of P (Table 16). The highest S content (23.35 ppm) was observed in control treatment and the minimum value (16.69 ppm) was found in the treatment of 75 kg P/ha (P_{75}).

4.3.5.3 Interaction effect of nitrogen and phosphorus

The effect of combined application of nitrogen and phosphorus showed significant differences in S content of post harvest soil (Table 17). The S content of the post harvest soil ranged from 13.25 ppm to 27.47 ppm. The highest S content (27.47 ppm) was observed in control treatment and the minimum value (13.25 ppm) was found in the combined treatment of 90 kg N/ha + 75 kg P/ha ($N_{90}P_{75}$). Control or lowest dose of N and P decreased vegetative growth and as a result low S uptake from soil. Whereas higher N and P dose increased vegetative growth and uptake of S was more and residual available S was less in post harvest soil.

Table 15: Effect of different levels of nitrogen on the chemical characteristics in post harvest soil of garden pea

Nitrogen (kg/ha)	Nutrients in soil				
	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (m.e./100 g soil)	Available S (ppm)
N_0	0.507	0.078 c	37.64 a	0.389 a	25.29 a
N_{30}	0.515	0.080 bc	34.71 b	0.357 b	21.06 b
N_{60}	0.543	0.084 ab	31.25 c	0.302 c	19.10 c
N_{90}	0.557	0.087 a	27.39 d	0.262 d	15.07 d
CV%	3.16	5.28	3.41	5.09	4.64
LSD	NS	0.0031	2.192	0.0189	1.716

Table 16: Effect of different levels of phosphorus on the chemical characteristics in post harvest soil of garden pea

Nitrogen (kg/ha)	Nutrients in soil				
	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (m.e./100 g soil)	Available S (ppm)
P_0	0.512	0.079	37.30 c	0.302	23.35 a
P_{50}	0.503	0.081	41.05 b	0.292	18.87 b
P_{75}	0.532	0.080	43.22 a	0.314	16.69 c
CV%	3.16	5.28	5.40	5.09	4.64
LSD	NS	NS	2.176	NS	2.067

Table 17: Interaction effect of nitrogen and phosphorus on the chemical characteristics in post harvest soil of garden pea

Treatment	Nutrients in soil				
	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (m.e./100 g soil)	Available S (ppm)
N_0P_0	0.45 ef	0.073	27.10 g	0..401 a	27.47 a
N_0P_{50}	0.58 a	0.081	30.55 f	0.354 d	24.92 b
N_0P_{75}	0.49 d	0.087	32.00 def	0.302 f	26.18 ab
$N_{30}P_0$	0.37 g	0.083	31.17 ef	0.268 g	25.33 b
$N_{30}P_{50}$	0.43 f	0.074	32.75 de	0.215 i	21.05 de
$N_{30}P_{75}$	0.36 g	0.076	33.85 d	0.242 h	19.84 e
$N_{60}P_0$	0.58 a	0.074	36.45 c	0.333 e	14.45 ghi
$N_{60}P_{50}$	0.58 a	0.074	38.44 bc	0.390 ab	13.68 hi
$N_{60}P_{75}$	0.47 de	0.074	39.14 b	0.372 c	15.33 gh
$N_{90}P_0$	0.55 b	0.073	38.00bc	0.381 bc	17.17 f
$N_{90}P_{50}$	0.60 a	0.076	39.15 b	0.205 i	23.05 c
$N_{90}P_{75}$	0.52 c	0.091	41.33 a	0.198 i	13.25 i
CV%	3.16	5.28	3.41	5.09	4.64
LSD	0.022	NS	1.947	0.0167	1.525

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during December 2007 to February 2008 to study the effects of different levels of nitrogen and phosphorus on the growth and yield of garden pea. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 2.4 m^2 (1.6 m x 1.5 m). There were 12 treatment combinations in the experiment comprising 4 levels of N (0, 30, 60 and 90 kg/ha designated as N_0, N_{30}, N_{60} and N_{90}, respectively) and 3 levels of P (0, 50 and 75 kg/ha designated as P_0, P_{50} and P_{75}, respectively). The individual and combined effects of nitrogen (N) and phosphorus (P) on growth and yield of garden pea 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 was found significant.

Nitrogen @ 90 kg/ha gave the highest plant height at flowering stage (44.98 cm), at maturity stage (67.37) and root length at vegetative stage (14.98 cm), at flowering stage (15.14 cm), at maturity stage (15.47), highest number of branches (3.056), highest pod length (7.19 cm), maximum number of seeds per pod (3.92), highest 1000-seed weight at green stage (236.90 g) and at mature stage (147.50 g), highest green pod yield (6.45 t/ha), and highest matured seed yield (4.66 t/ha). Highest plant height at vegetative stage (30.97 cm), highest number of pods per plants (5.86) were obtained from the treatment of 30 kg N/ha. The lowest plant height at flowering stage (34.69 cm) and maturity stage (49.86 cm), lowest root length at vegetative stage (9.98 cm), at flowering stages (11.11 cm) and at maturity stage (11.21 cm), number of branches per plant (1.23), lowest number of pods per plant (4.49), lowest pod length (6.13 cm), lowest 1000-green seed weight (208.36 g), lowest matured 1000-seed weight

(128.56 g), lowest green pod yield (4.64 t/ha) and lowest matured seed yield (3.36 t/ha) was obtained from control treatment. Lowest plant height at vegetative stages (28.74 cm) was obtained from the treatment of 60 kg N/ha.

Phosphorus significantly influenced the growth and yield parameters of garden pea. The highest plant height at vegetative stage (30.74 cm), highest plant height at flowering stage (41.39 cm), highest root length at flowering (13.66 cm), highest number of branches per plant (1.88), highest pod length (6.66 cm), highest matured seed yield (3.81 t/ha) was recorded in 50 kg P/ha. Phosphorus @ 75 kg/ha gave highest plant height at maturity stage (62.42 cm), highest root length at vegetative stage (13.13 cm), highest root length at maturity stage (14.48 cm), highest green 1000-seed weight (225.26 g), highest matured 1000-seed weight (140.22 g), highest green pod yield (4.10 t/ha). The lowest plant height at flowering stage (39.94 cm), lowest plant height at maturity stage (59.66 cm), lowest root length at vegetative stage (11.96 cm), lowest root length at flowering stage (12.81 cm), lowest root length at maturity stage (13.33 cm), lowest number of branches per plant (1.68), lowest pod length (6.33 cm), lowest number of seed per pod (3.42), lowest green 1000-seed weight (220.92 g), lowest matured 1000-seed weight (136.97 g), lowest green pod yield (3.67 t/ha) and lowest matured seed yield (3.26 t/ha) were obtained from P control treatment. The lowest plant height at vegetative stage (29.35 cm) was obtained in the treatment 75 kg P/h.

The combined effect of nitrogen and phosphorus was significant on the growth and yield parameters of garden pea. At vegetative stage, the highest plant height of 31.88 cm was recorded with no N and 50 kg P/ha, the lowest plant height 28.32 cm was found with 60 kg of N and 75 kg of P/ha. At flowering stage, the highest plant height 46.33 cm was recorded from the treatment incorporated with 90 kg of N combined with 75 kg of P/ha. The lowest plant height 34.23 cm was found from the control treatment applied with no fertilizer. At maturity stage of the crop treatment comprising of

$N_{90}P_{50}$ produced the highest plant height of 68.94 cm, the lowest plant height 48.80 cm was found from the treatment applied with no fertilizer. At vegetative stage maximum root length 15.36 cm was recorded with N @ 90 kg/ha plus P @ 50 kg/ha and the lowest root length 9.24 cm was found from the treatment applied with no fertilizer. At flowering stage, the highest root length 15.50 cm was recorded in the treatment $N_{90}P_{50}$. The lowest root length 10.26 cm was found in treatment with no fertilizer. At maturity stage, the highest root length 15.70 cm was found with $N_{90}P_{75}$ treatment, the lowest root length 10.86 cm was found in treatment with no fertilizer.

The maximum number of branches per plant (3.71) was obtained from the treatment combination of 90 N/ha and 50 kg P/ha ($N_{90}P_{50}$). The rest of the treatments were statistically same. Plant receiving N @ 90 kg/ha along with 75 kg P/ha produced the highest number of pods per plant (6.58/plant). The lowest number of pods/plant (4.35) was found from treatment N_0 P_{75}. The highest pod length (7.40 cm) was recorded from the treatment consisting of 90 kg N /ha along with P @ 50 kg/ha. The lowest pod length (6.10 cm) was found in the control treatment. The maximum number of seeds per pod (4.01) was found in the treatment supplied with N @ 90 kg/ha with P @ 50 kg/ha. The lowest number of seeds per pod (3.06) was obtained in treatment N_0P_{75}. The highest green 237.97 g and mature 147.78 g 1000-seed weight were obtained with the treatments containing N @ 90 kg/ha with P @ 75 kg/ha.

The highest average green pod yield of 5 t/ha was found in the treatment containing N @ 90 kg/ha plus P @ 50 kg/ha. The lowest yield of 3.26 t/ha was being noted under control. There was no significant yield variation among the rest treatments. The highest mature seed yield of 4.43 t/ha from the treatment supplied with N @ 90 kg/ha with P @ 50 kg/ha. The lowest yield of 3.06 t/ha was recorded under control. All the treatments produced significantly higher pod yield over control.

Nutrients content in plants and in post harvest soil was also influenced by different nitrogen and phosphorus levels. The highest N content in plants (1.897 %), lowest OC content (0.087%) in post harvest soil were observed in N_{30} treatment. N application @ 90 kg/ha showed highest OC (0.557) in postharvest soil, highest P (0.443 %), K (0.574 %), S (0.439 %) in plants, highest total N (0.087 %) in postharvest soil, lowest available P (27.39 ppm), K (0.262 m.e./100 g soil), S (15.07%) content in post harvest soil. The lowest N content in plant (1.62%), minimum P content in plants (0.233%), minimums S content in plants (0.445 %) was noted in N_{60} treatment. The lowest S (0.303 %) content in plants, lowest total N content in plants (0.078 %) and highest P (37.64 ppm), K (0.389 m.e./100 g soil) and S (25.28 %) contents in post harvest soil was recorded in control (N_0) treatment.

Phosphorus @ 75 kg/ha gave the highest N (1.797%), K (0.582%) and S contents (0.379%) in plants, highest OC content (0.543 %) in postharvest soil, highest P (43.22 ppm), highest K content (0.314 m.e./100 g soil) and the minimum S content (16.69 ppm) in post harvest soil. Highest N content (1.85%) and lowest P (307 %), K (0.445%), S content (0.344 %) in plants, lowest total N content (0.079%), available P (37.30 %) and maximum S content (23.35 %) in post harvest soil were observed in control (P_0) treatment. The highest total N content (0.081%), lowest OC content (0.387%) and exchangeable K (0.292 m.e./100 g soil) in postharvest soil, highest phosphorus content (0.377 %) in plants were observed in control treatment. Total Nitrogen and exchangeable K in postharvest soil had no significant effect on different levels of phosphorus.

The combined application of nitrogen and phosphorus showed significant differences in respect of nutrient contents in plants and soil after harvest. The highest N in plants (1.96%), P (0.47 %), K (692 %) and S content (0.496 %) in plants, exchangeable K content (0.401 m.e./100 g soil) and available S (27.47 %) in postharvest soil was obtained with $N_{90}P_{75}$ treatments. The treatment combination of 90 kg N/ha + 50 kg P/ha showed the maximum OC content (0.60 %) and minimum exchangeable potassium content (0.205 m.e./100 g soil) in postharvest soil. The lowest N content (1.43 %), minimum P content (0.21 %), minimum K content (0.335 %) and S 0.362 %) in plant were observed in control treatment. The highest exchangeable K (0.401 m.e./100 g soil), available S content (27.47 %) and the lowest total N (0.073 %), minimum available P (27.10 ppm) in post harvest soil was obtained with N_0P_0 treatment.

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

- The effect of N and P on the growth and yield of garden pea was found positive and significant.
- The effect of N and P enhanced growth, yield and yield attributes of garden pea.
- Application of N @ 90 kg/ha and P @ 50 kg/ha was the most suitable combination to give the highest pod yield of garden pea.

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

Chapter 6
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Appendix 1 . Monthly records of meteorological observation at the period of experiment (November, 2007 to February, 2008).

Month	Temperature (^0C)		Humidity (%)	Precipitation (mm)	Potential Evapotranspiration (mm/day)	Solar radiation (Mj/m2/d)
	(Maximum)	(Minimum)				
November	30.20	20.13	83.30	31	2.966	15.364
December	26.60	13.5	81.00	9	2.43	14.089
January	25.40	12.93	78.00	7	2.387	14.766
February	25.30	14.2	73.68	7	2.37	14.866

Source : Weather Yard, Bangladesh Metrological department, Dhaka.