FERTILITY MANAGEMENT OF A NEWLY DEVELOPED GENOTYPE OF PEA (*Pisum sativum* L.)

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THESIS ABSTRACT

FERTILITY MANAGEMENT OF A NEWLY DEVELOPED GENOTYPE OF PEA (*Pisum sativum* L.)

By

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A field experiment was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm during the period from November 10, 1997 to March 1, 1998 to determine the optimum requirement of N, P, and K for maximum yield of the advanced line (Local White) of pea. There were 14 treatment combinations comprising of four levels of N (0, 30, 60, and 90 kg N/ha), four levels of P (0, 50, 75, and 100 kg P_2O_5/ha), 4 levels of K (0, 30, 60, and 90 kg K_2O/ha), two levels of inoculum as a *Rhizobium* strain ($N_{0+Inoc.}$ and $N_{20+Inoc}$), and one level of organic matter (cow dung) at the rate of 10 t/ha. Moderate rate of N, P, and K application (N : 60 kg, P_2O_5 : 75 kg, and K_2O : 60 kg/ha) was found to be the balanced combination of the nutrient elements to give the highest yield of green pod (13.12 t/ha) and matured seed (2.27 t/ha) and the maximum total uptake of N (123.62 kg/ha), P (4.78 kg/ha), and K (69.03 kg/ha) by the plants and as well as the largest sized green seeds (41.51 g) and matured seeds (17.68 g) per 100 seeds. Although, the highest level of N application (90 kg/ha) with the same rates of P and K application produced the tallest plants (94.44 cm), maximum number of branches per plant (3.02) and the highest number of pods per plant (8.07) gave 4.5 % lower yield of green pods and 19.3 % lower yield of matured seeds and as well as 3.21 % lower uptake of N, 1.46 % P, and 13.42 % K as compared to the highest yield and the highest nutrient uptake observed under moderate application of nutrients elements. Seed inoculation with *Rhizobium* strain along with one third of optimum N (20 kg/ha) and moderate amount of P and K (75 kg P_2O_5 and 60 kg K_2O/ha) was found to be encouraging to give satisfactory and acceptable yield of 12.37 t/ha of green pod (only 5.7% lower than the highest yield) of pea. From the viewpoint of yield and nutrient uptake of garden pea and the nutrient requirement of the crop, the N, P, and K combination at the rates of 60 kg N, 75 kg P_2O_5, and 60 kg K_2O/ha was considered to be the balanced combination of fertilizer nutrients for achieving the maximum output through cultivation of pea in Shallow Red-Brown Terrace Soil of BSMRAU farm.

DEDICATED

TO

MY BELOVED PARENTS

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Summer, 1999 The Author

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CHAPTER I

INTRODUCTION

The pea (*Pisum sativum*) is a spreading, glabrous, herbaceous annual self pollinated legume crop. It is under sub family Papilionideae belonging to the family Leguminosae. Pea is a cold climatic crop. It can be grown in tropical areas at high altitudes of up to 2700 m and during cold winter months in the subtropics. The crop is reported to perform better in subtropical areas having a winter cold period of five month duration (Makasheva, 1983). Rice-wheat combinations have always predominated the traditional diets of the people 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 the production of pulses in recent years that has resulted in reduced per capita availability of protein. Considering the importance of pea in the diet of the people and their beneficial effect on soil fertility, there is a need to enhance pea production in Bangladesh. Cultivation of this crop is highly profitable and attractive to the farmers because pea has great agronomical value. As a nitrogen fixing crop with a high assimilating capacity of the roots, it utilizes the chemical compounds which are low in solubility and rarely accessible to cereals from the cultivated soil layer or deeper layers. As a preceding crop, the pea facilitates increase in the efficiency of utilization of organic matter by subsequent crops, especially grain

and cash crops. Peas in crop rotation helps in improvement of soil fertility and yield of the succeeding crops (Rana and Sharma, 1993).

This new genotype of pea is a very high yielding variety. But it takes about 80 to 85 days for green seed harvest and 105 to 110 days for matured seed harvest. It can be grown successfully after the harvest of transplanted aman or jute crops. The biomass of pea can be used as green manure which can increase both nitrogen and organic matter content of the soil.

The pea is grown mainly for young pod to get tender green seeds as vegetables. The matured seeds can be used for preparing dal or chatpati and other delicious food. For its high nutritive value and attractive taste the crop has gained popularity. Green peas are rich in vitamins and protein. Matured seed contain 9-15% water, 18-35% protein, 4-10% sugar, 0.6-1.5% fat, 2-10% cellulose and 2-4% minerals (Makasheva, 1983). Peas contain all the essential amino acids. After the main produce is used, the waste material of peas, still rich in protein, can serve as a reserve for improving the quality of feeds.

Successful production of pea depends on various factors. Fertilizer is one of the most important factors which assured better crop production. Pea responds greatly to major essential nutrient elements like nitrogen, phosphorus and potassium in respect of its growth and yield. On the other hand manure like cowdung, when applied helps in maintaining good soil structure besides being a continuous source of nutrient. Being a legume crop inoculation with efficient strain of *Rhizobium* may be sufficient to meet the requirement of nitrogen in normal soils. 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 (Mclean *et al.*, 1974; Sonia 1974; Ahmad and Shafi 1975; Trevino and Murray, 1975; Foutes *et al.*, 1979). The green pod yield increases with the in 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, Singh, 1959). Similar yield increase to added P in the presence of N and K have been reported by Takahi, 1971; Sonia, 1974; and Ahmad and Shafi, 1975. Soils having low potash have been found to respond to application of up to 60 kg K_2O/ha (Sheveleva, 1974; Kay, 1979). Combination of phosphate and potassium was found to give good responses in some soils deficient in both P and K (Sen and Kavitkar, 1958; Sonia 1974).

Therefore, it is imperative that an optimum dose of various nutrients in the form of fertilizer should be determined for the cultivation of new genotype of pea before it is released to the farmer level. This experiment was therefore, undertaken with the following objectives.

1. To study the growth and yield performance of the new genotype of pea by using different fertilizer combinations.

2. To determine the optimum fertilizer requirement of pea under the present agroecological conditions.

CHAPTER II

REVIEW OF LITERATURE

Pea being a leguminous grain vegetable having high yield potential, would require an ample supply of plant nutrients to ensure proper growth, development and satisfactory yield. As this genotype of the pea has recently been developed, its production technologies including fertilizer management under varying agro-climatic regions are yet to be standardized. A little research work has been conducted on pea in Bangladesh, hence the literature with regards to its fertilizer management are scarce. However, the crop has many similarities with other leguminous corp. Hence a brief review of available literature with regards to fertilizer management of pea is furnished in the following paragraphs which may be relevant to the present study.

Azad *et al.*, (1992) conducted an experiment with field Pea cv. PG-3 with varying N levels of 0, 15, 30, 37.5 and 45 kg/ha. Seed yield without N were 1.97, 1.28 and 1.35 t/ha while yields at the highest N rates were 2.94, 2.05 and 2.09 t/ha.

Yadav *et al.*, (1992) carried out an experiment to find out the effect of irrigation, phosphorus and row spacing on yield contributing characteristics of pea. They concluded that the application of P_2O_5 up to 25 kg/ha increased the yield of pea from 1.47- 1.64 t/ha under rainfed condition, while, with 2 irrigations the yield increased from 1.81 - 1.84 t/ha.

Singh *et al*,. conducted a field trial with field pea cv. Rachna, given 0-30 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.

Sati *et al*,. (1991) found that neither N fertilizer nor seed inoculation with *Rhizobium* had any significant effect on any of the measured parameters. They found that nodulation increased significantly after inoculation, but this did not affect growth or yield. Both growth and yield in that study responded positively to fertilization, but the treatment effects did not differ significantly.

Rathi *et al*., (1993) worked on the effect of irrigation and phosphorus levels on protein content and uptake of nutrients in field pea. N and P content in the seed was highest with irrigation at branching stage and protein content was highest with irrigation at branching and pod development period. They fond that protein content was highest at 60 kg P/ha.

Naik *et al*., (1993) conducted an experiment on the growth and yield of pea in relation to phosphorus fertilization. They worked with 4 levels of P i.e. 40, 80, 120 kg P_2O_5/ha as single superphosphate in powder or glandular form, or rock phosphate with or without seed inoculation with phosphorus solubilizing bacteria. The mean seed yields with 4 P sources were 2.02, 2.02, 1.34 and 1.33 t/ha, respectively. They found seed yield was not affected by P rate.

Saini and Thakur (1996) conducted an experiment on the effect of nitrogen and phosphorus on vegetable pea in cold desert area. An application of 30 kg N/ha increased plant height, branches/plant, leaf area index, yield attributes and grain yield/plant. They got significantly higher green pod yield with N application. However 30 and 60 kg N/ha did not differ significantly.

Vijai *et al,*. (1990) carried out an experiment with garden pea cv. Bonnerille and showed that increasing rates of N or P application significantly increased growth and pod yield. The highest rates of N and P_2O_5 application (45 and 80 kg/ha respectively) showed the best performance in terms of yield and yield attributes of garden pea.

Naik (1989) conducted an experiment in winter season with the cultivar Bonneville having three spacings 30x5, 20x10, or 30x15 cm and three N fertilizer doses, at the rate of 25-75, P_2O_5 25-100 and K_2O at 25 or 50 kg/ha. Data were recorded on plant height, pod length and girth. The closest spacing and application of N and P at the highest rates produced in the highest yield but no appreciable response to K was observed. Pachauri *et al.,* (1988) conducted an experiment in 2 years trials with the garden pea cultivar Lincoln. He applied N at 0, 37.5 or 75 kg/ha; P_2O_5 at 0, 75 or 175 kg/ha and K_2O at 0, 50 and 100 kg/ha. The highest seed yield was obtained on plant receiving N: P_2O_5:K_2O at 75:150; 50 kg/ha.

Naik, LB *et al.,* (1991) conducted an experiment in the rabi (winter) season. They applied 0, 40, 80 or 120 kg P_2O_5/ha and found that DM yield was increased with increase in P. Hussain *et al.,* (1992) conducted an experiment on the effect of different levels of nitrogen and phosphorus alone and in combination on growth, maturity and yield of pea cultivar 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 cultivar P-8. Maximum height (202.91 cm) of the plants was obtained by the application of nitrogen + phosphorus each at 80 kg/acre. The highest number of pickings (6) were taken by highest dose of nitrogen while

highest yield/picking 13.95 tones was obtained from plots that received the highest dose of phosphorus.

Shekar and Sharma (1991) conducted an experiment on pea cv. Lincoln with all combinations of 3 row spacing (40, 50 and 60 cm) and 5 levels of N, P and K. Yield was not significantly affected by spacing, while shelling percentage was highest with row spacing of 60 cm apart. Pod yield was 10 t/ha by using no fertilizer. Highest green pod yield of 12.1 t/ha was obtained by applying N, P, and K at the rates of 60, 70 and 66 kg/ha, respectively. The yield decreased at higher rates of fertilizer application.

Naik (1989) concluded that minimum spacing (30x5 cm^2) and highest rates of N-P (75-100) resulted the highest yield. Bhopal and Singh (1990) conducted an experiment with the semidwarf garden pea cv. Lincoln. They applied N at the rate of 0, 20, 40 and 60 kg/ha, P_2O_5 at 0, 30, 60, and 90 kg/ha and K_2O at 30 kg/ha. They concluded that the mean green pod yield increased with increasing N rates up to 40 kg/ha and then decreased at 60 kg N/ha. Vigorous vegetative growth was attributed at the highest N rates.

Simon (1990) in a pot trial used 5 Rhizobium strain on 3 new and 1 local varieties of garden pea. Inoculation with selected strains in most cases increased seed yield as compared to the unselected native Rahizobia. There were significant differences among different variety and Rhizobial strain combinations.

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/ha.

Negi (1992) carried out an experiment with vegetable pea at 4 levels of N (10, 20, 40, 60 kg/ha) and 3 levels of P (0, 60, 120 kg P_2O_5/ha). He reported that the highest green pod yield was 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.

Tej Singh *et al.*, (1975); Chowdhury *et al.*, (1975); Gowda and Gowda, (1978); Podder and Habibullah (1982) concluded from different experiments that low dose of N (15-25 kg/ha) compared with moderate increments of P (40-60 kg P_2O_5/ha) produce higher grain yield in mungbean.

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, and 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.

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.

Lytsenko (1981) concluded that at the end of the vegetative growth period of pea the seed protein content was increased by 4.2 % and N^{15} applied to leaves was accumulated in globulins. He also observed that N as urea was more effective than N as ammonium sulphate.

Rana and Sharma (1993) conducted a field experiment on sandy loam soil with direct seeded upland (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 was obtained in the field pea rice cropping system.

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.

From different experiments it was found that the addition of fertilizer N at the rate of 15-30 kg/ha with inoculation of efficient Rhizobium strain are beneficial for pea cultivation (Mclean *et al.*, 1974; Sonia, 1974; and Ahmad and Shafi, 1975).

Songis an Coyz (1985) carried out a field experiment with four cultivars of pea applying N at the rate of 0, 30, 60 and 90 kg/ha on the plant density of 75, 100 and 125 plants/m^2. They concluded that seed yield were highest at a density of 100 plants/m^2 for Kujawski Wezesny and 125 plants/m^2 for R-4006 and Kaliski. They also found highest response of 30 kg N/ha for R-4006 and 60 kg N/ha for Kujawaski Wezesny and Kaliski Varieties of pea.

Baswan and Saharan (1993) conducted a field experiment with pea cv. PH-1 with row spacing of 20, 30 and 40 having the seed rates of 50, 75 and 100 kg/ha. They observed that row spacing of 20, 30, and 40 cm produced mean pod yields of 4.95, 5.12 and 5.42 t/ha respectively. The highest pod yield of 6.44 t/ha was obtained from seed

rate of 100 kg seeds /ha at 30 or 40 cm spacing which was not significantly different from the sowing rate of 75 kg/ha at 30 or 40 cm spacing.

Tripathi *et al.*, (1991) conducted an experiment of 4 fertilizer treatments (untreated control, 25 kg N/ha + 50 kg P_2O_5/ha or 25 kg N + 50 kg P_2O_5/ha) and 5 weed control treatments. Plant height, number of pods/plant, number of grains/pod, shelling percentage, pod yield/ha and net profit/ha were greatest with 25 kg N + 50 kg P_2O_5/ha and hand weeding.

Shukla and Kohli worked with 5 early pea cultivars at two diverse agroclimaters. They concluded that, highest yield was obtained in one place at 60 kg P_2O_5/ha and in another place at 60-75 kg P_2O_5/ha.

Stoker (1975) reported that yield of pea could be as much as 242 % higher with higher planting density under irrigation than that of the lower density under dry farming. Fifty plants/m^2 was reported as optimum under dry farming condition.

Singh *et al.*, (1973) reported that seed yield of pea may be increased significantly by increasing the plant density by reducing the spacing of the crop.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during November 10, 1997 to March 01, 1998.

Experimental Site

The experimental site was previously under Sal forest and located at 24°05′ N latitude and 90°16′ E longitude with an elevation of 8.4 meter from sea level.

Soil

The experiment was carried out in a high land belonging to Salna series under Madhupur Tract (AEZ 28) of Shallow Red-Brown Terrace Soil type (Brammer 1971; Shaheed, 1984). Information on some basic soil properties is presented in Table 1.

Climate

The experimental area is situated in the subtropical climate zone, characterized by scanty rainfall during the months from October to January and heavy rainfall during the months from May to September. The mean monthly maximum air temperature varies between 24.2 and 33.6° C and the mean monthly minimum air temperature between 12.0

and 27.3° C. Monthly rainfall, air temperature, relative humidity and evaporation are presented in Appendix Fig. 3, 4 and 4 respectively.

Soil and Plant Analysis

Soil texture was determined by hydrometer method (Bouyoucos, 1927). Bulk density was determined by core sampling method (Karim *et al.*, 1988.)

Soil P^H was determined by a glass electrode P^H meter in soil water suspension having soil: water ratio of 1:2.5 (Black *et al.*, 1965).

Organic carbon of soil was determined by wet combustion method (Black *et al.*, 1965).

Total phosphorus content of the collected soil and plant samples was determined by perchloric acid digestion essay method using perchloric acid ($HClO_4$) and nitric acid (HNO_3). The absorbance was measured at 440 nm in a double beam spectrophotometer. (Yamakawa 1992). For available P of soil extracted by 0.5 M $NaHCO_3$ (P^H 2.5) and determined colorimetrically using molybdate blue method (Olsen *et al.*, 1965). Total potassium content of the collected soil and plant samples was determined by perchloric acid digestion assay method (Yamakawa, 1992) using perchloric acid ($HClO_4$) and nitric acid (HNO_3). Potassium content of sample solution was measured at 766.5 nm by an atomic absorption spectrophotometer.

CEC was estimated using Schollenbergers method in which soil was treated with ammonium acetate and 1M NaCl solution and finally the aliquot was distilled with 40% NaOH and titrated against N/50 H_2SO_4.

The crude protein content has been estimated by multiplying the %N (determined) with a factor of 6.25.

Table 1. Basic soil properties of the experimental plot .

Soil Properties	Analytical data
Soil texture	clay loam
Bulk density	1.58 g/cm^3
Soil P^H	5.3
Organic matter (%)	1.51
Total N(%)	0.078%
Total P(%)	0.025
Available P (ppm)	9.20
Total K(%)	0.10
CEC (meq/100 g soil)	16.34
C:N ratio	11.28

Design of Experiment

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each replication consisted of 14 treatment combinations of N, P, K, Rhizobium inoculation, and manuring. The dimension of each plot was 2.8 m x 2.0 m having a plot to plot and block to block spacing 0.75 m and 1.0 m, respectively.

Treatment

There were 14 treatment combinations in the experiment comprising four levels of N (0, 30, 60 and 90 kg/ha) four levels of P_2O_5 (0, 50, 75 and 100 kg/ha), four levels of K_2O (0, 30, 60 and 90 kg/ha), two levels of bio fertilizer i.e. *Rhizobium inoculum* (N_{0+ino} and N_{20+ino}) and organic manure (cow dung) at the rate 10 ton/ha. S, Zn, Mo, and B at the rate of 20, 4, 1 and 1 kg/ha, respectively were commonly used for all treatments. The treatment combinations used in the experiment are shown in Table 2.

Table 2. Treatment combinations of different fertilizers and manure.

Treatment	N	P_2O_5	K_2O	CD t/ha
T_1	0	75	60	0
T_2	30	75	60	0
T_3	60	75	60	0
T_4	90	75	60	0
T_5	60	0	60	0
T_6	60	50	60	0
T_7	60	100	60	0
T_8	60	75	0	0
T_9	60	75	30	0
T_{10}	60	75	90	0
T_{11}	0+ino	75	60	0
T_{12}	20+ino	75	60	0
T_{13}	-	-	-	10
T_{14}	0	0	0	0

Test Crop

An advanced line of pea, named, "Local White" was used as a test crop for the experiment. The seeds were collected from Professor Dr. M. A. Khaleque Mian, Department of Genetics and Plant Breeding of BSMRAU.

Land Preparation

The selected land for the experiment was prepared very well by deep and cross ploughing with the tractor followed by harrowing and laddering up to a good tilth. The weeds and stubbles were removed, drains were made around each plot and the excavated soil was used for raising the plots to about 10 cm high from the soil surface.

Fertilization and Manuring

Full amount of TSP, MP, gypsum, zinc oxide, ammonium molybdate, borax, cowdung and half of the total urea were applied to the plots during final land preparation. The rest amount of urea were top-dressed at the pre-flowering stage. The mixture of three strain, BINA-MO-634, BINA-MO-L3 and BINA Ma-L3 were used as a source of inoculum.

Sowing of Seeds

The seeds of pea were shown on November 10, 1997. Fifty five seeds were sown in each row which emerged within 5 to 6 days after sowing.

Cultural Operation

First irrigation was given on November 11, 1997. First weeding and mulching was done on November 23, 1997. Second irrigation was given on December 8, 1997 after top dress of urea fertilizer. Again, weeding was done on December 26, 1997. Third irrigation was given on January 13, 1998. At the time of pod formation, severe insect infestation was found. Insect attack was controlled by spraying pesticide, Nuvacrone at the rate of 33 ml ingredient with 15 litre water.

Sample and Data Collection

Plant samples were collected at three different stages of crop. First sampling was done on December 2, 1997, at pre-flowering stage. Second sampling was done on January 13, 1998 at 50% flowering stage. Third sampling was done on 1st March 1998 at the maturity of the crop. Pods were harvested at two different stages of the maturity.

The first pod harvest was done on February 17, 1998 at green seed stage from half portion of each plot. The rest half of the crop of each plot were kept to allow the pods to get maturity. The matured pods were harvested on March 01, 1998. Data on following parameters were recorded.

1. Number of primary branches per plant.
2. Plant height.
3. Number of pods per plant
4. Weight of 100 pod
5. Raw weight at 100 green seeds.
6. Total dry matter production at green harvesting stage (excluding seed).
7. Green pod yield and matured seed yield.
8. Nitrogen, content of biomass at pre-flowering, green harvest and matured harvest stages.
9. Protein content of green and matured pea seeds.
10. Nitrogen, phosphorus and potassium content of matured pea seed.

Statistical Analysis

The data recorded on different plant parameters were statistically analyzed through partitioning the total variance with the help of computer "MSTAT" program. The difference between treatment means were compared by Duncan Multiple Range Test (DMRT).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter deals with the presentation of experimental results along with their interpretation and discussion in relation to the different combinations of N. P and K doses as well as the organic matter and *Rhizobium* strain used in the study. The yield and yield component of garden pea responded remarkably to different treatments. The effect of different fertilizers on most of the plant characters and yield of the crop were significant and are discussed below under different subheadings.

Plant Height

Plant height of garden pea was significantly influenced by different fertilizer doses (Table- 3). Maximum plant height (94.44 cm) was recorded in T_4 ($N_{90}P_{75}K_{60}$) treatment, receiving the highest level of N and second highest amount of P and K. The height as recorded in treatments T_7 ($N_{60}P_{100}K_{60}$), T_6($N_{60}P_{50}K_{60}$), T_8($N_{60}P_{75}K_0$), and T_3($N_{60}P_{75}K_{60}$) were 92.32. 90.59, 88.76 and 88.56 cm, respectively. There was no significant variation in height among these treatments. The minimum plant height of 65.33 cm is recorded in T_1 ($N_0P_{75}K_{60}$) treatment where no N was added. The above findings indicate that N is the most dominating factor influencing the plant height. Increment of only the N dose from 0 to 90 kg/ha has led to increasing plant height form 65.33 cm to as high as 94.44 cm. Increased N application to soil had favoured in increasing vegetative growth of the

crop that has resulted in increasing the plant height appreciably. Hossain *et al.*, (1992) reported that maximum height of garden pea was obtained by the application of N at 80 kg/ha which is close to our findings. P addition to soil has also contributed to substantial increment in plant height from 80.16 cm in T_5 (P_0) to 94.44 cm in T_4 (P_2O_5 : 75 kg/ha) treatment. The highest dose of P in T_7 (P_2O_5 : 100 kg/ha) has led to 2.2 % reduction in plant height as compared to that noted in T_4. The impact of K on the plant height of garden pea was not found. Naik (1989) reported that N and P increase plant height and pod length of pea but K does not have any effect on these parameters. This finding is similar to our observation.

Number of Branches Per Plant

Nitrogen played a significant positive role in increasing the number of primary branches per plant (Table- 3). The highest average number of branches per plant (3.02) was recorded in T_4 treatment which was followed by T_6 (2.90), T_3 (2.82) and T_9 (2.82) treatments. The lowest value of 2.13 was recorded in T_{14} treatment where no fertilizer was used. The positive effect of N was also reported by Negi (1992) and Singh *et al.*, (1992). Although minimum effect of P was found on increasing the number of branches, there was no contribution of K on it.

Number of Pods Per Plant

There was significant variation in number of pods per plant with the change of fertilizer doses (Table- 3). The highest average number pods per plant (8.07) was

100 Seed Weight

The effect of N, P and K on weight of 100 green and matured seeds of garden pea was positive and significant (Table- 3). Addition of N or P up to the highest level has led to increased weight of green seed, but its weight reduced under the highest level of K. At the matured stage the weight of seeds increased with increasing the dose of each of the three nutrient elements up to the 2nd highest level. Further increment of dose to the highest level has led to reduced seed weight. The highest average weight of green seeds (41.51 g) was recorded in T_3 (N_{90} P_{75} K_{60}) treatment being followed by T_6 (41.16 g), T_7 (40.74 g), T_4 (40.37 g), and T_{12} (40.32 g). In case of matured seeds the highest weight of 17.68 g was found in T_3 treatment which was followed by T_6 (17.49 g), T_4 (16.91g), and T_{12} (16.78 g).

Green Pod Yield

The combinations of different doses of nutrient elements used in the trial had played a significant role in varying the pod yield of green pea (Table- 4). The highest average green pod yield (13.12 t/ha) was found in T_3 treatment which was followed by the treatments T_6 (12.89 t/ha), T_9 (12.59 t/ha), T_4 (12.53 t/ha), T_2 (12.42 t/ha) and T_{12} (12.37 t/ha). The lowest yield of 9.08 t/ha being noted under absolute control (T_{14}). There was no significant yield variation between the treatments T_3 and T_6. The yield as recorded in T_3, T_6, T_9, T_4, T_2, and T_{12} treatments were 44.5, 42.0, 38.3, 38.2, 36.8 and 36.3 % higher respectively as compared to the treatment T_{14}, where no nutrient was

added. It is important to note that increment of N dose from 0 to 60 kg (in T_1 through T_3) has led to increased pod yield, but beyond this N addition seemed to be detrimental to give 4.5 % lower yield at 90 kg N/ha in T_4 treatment as compared to the highest yield observed in T_3 (60 kg N/ha). The effect of P and K addition has followed the same trend as was found in case of N. Increment of P dose from 0 to 75 kg/ha has favoured in increasing pod yield from 10.72 t/ha to 13.12 t/ha, but further addition of P to 100 kg/ha has created a negative impact to reduce the yield by 8.7 %. Similarly increment of K dose up to 60 kg/ha has played a positive role in increasing the yield, but the highest level of K application (90 kg/ha in T_{10}) has resulted to decline the green pod yield by 7.2 %. These findings indicate that an optimum quantity of each of these nutrient elements is needed to be applied to the soil for achieving the highest yield potential of garden pea. Both over-supply and under-supply of the nutrients lead to reduced pod yield. Sarker and Sarma (1991) reported exactly the same findings. Shukla and Kohli (1992) concluded that highest yield was obtained at 60 kg P_2O_5/ha in one place while in the other, it was 75 kg P_2O_5/ha.

Seed inoculation with *Rhizobium* strain along with starter dose of N (20 kg/ha) as executed in T_{12} treatment was found to be an important means for reducing N application by 200 % without hampering the crop yield. Mclean *et al.*, (1974) concluded that the addition of fertilizer N at the rate of 15-30 kg/ha with inoculation of efficient *Rhizobium* strain has bean found to be efficient. This is in agreement with our findings.

Matured Seed Yield

The response of N, P and K on yield of matured seed was significant (Table- 4). The highest average yield of 2.27 t/ha was observed in T_3 treatment. The yield as recorded in T_9 (2.09 t/ha), T_{10} (2.05 t/ha), T_4 (2.03 t/ha) and T_6 (1.98 t/ha) were 7.9, 9.5, 10.8 and 12.8 % lower as compared to that found in T_3 treatment. A balanced combination of N, P and K at the rates of 60 kg/N 75 kg P_2O_5 and 60 kg K_2O respectively was found to be optimum to get the highest weight of 100 green and matured seed, and as well as the highest yield of green pods and matured seeds of garden pea.

The individual effect of N, P and K on matured seed yield has followed the same trend as was noted for green pod yield. N addition up to 60 kg/ha was found to increase matured seed yield from 1.41 t/ha in T_1 treatment to 2.27 t/ha in T_3. Further increment of N application to 90 kg/ha in T_4 has reduced seed yield by 10.8 %. Without addition of P the yield was as low as 1.53 t/ha, but increasing P rate to 75 kg/ha in T_5 treatment has led to increased matured seed yield to 2.27 t/ha. The yield subsequently decreased to 1.88 t/ha (17.2 % in T_7) as the P application rate increased to 100 kg/ha. K application up to certain level (60 kg/ha) has also contributed significantly to increase seed yield, but the maximum application of it (90 kg/ha in T_{10}) has created an adverse effect to record a reduced yield of matured seeds of garden pea (9.5 %).

The above findings reveal that both without application or excess application of any one of N, P and K are detrimental to higher yield of green pod and matured seeds of garden pea. An optimum amount (N : 60, P_2O_5 : 75 and K_2O : 60 kg/ha) of each of these three nutrient elements should be applied to the soil to achieve the highest yield

potential of garden pea in Shallow Red-Brown Terrace Soil. Seed inoculation by effective *Rhizobium* strain along with the reduced amount of N (20 kg/ha) and moderate amount of P and K (75 kg P_2O_5 and 60 kg K_2O/ha) may also be a good combination of fertilizers for getting comparable and satisfactory yield of garden pea in this soil. The reduced N use under this condition will not only save the use of costly urea but will also reduce the pollution of ground water by nitrate.

Crude Protein Content in Grain

The effect of different fertilizer treatments on N content as well as crude protein content in green seeds was significant (Table- 5). The highest mean crude protein content (6.79 %) was noted in T_4 treatment. The lowest value (6.01 %) was exhibited by T_{14} treatment. Among the N treatments an increasing trend of seed protein was observed with increased rate on N application. The highest value (6.79 %) was found in T_4 (90 kg/ha N) treatment and the lowest amount (6.08 %) being recorded in plot (T_1) where no N was added. The impact of P and K application on protein content of green seed was positive and increased with increasing rate of application of those two elements up to 2nd highest levels (75 and 60 kg/ha of P_2O_5 and K_2O for P and K, respectively) used in the experiment, but further increment to the highest level (100 and 90 kg P_2O_5 and K_2O respectively) could not lead to further increment of protein content.

The response of crude protein content of matured seeds to different combinations of fertilizer treatments has followed almost similar trend as was found for green seeds. The highest protein content (24.39 %) was found in T_4 treatment which was followed by

T_3 (23.96 %) T_7 (23.71 %), T_9 (23.29 %), T_{10} (22.81 %) and T_6 (22.79 %) treatments. The lowest value of 20.21 % being recorded under absolute control (T_{14}). Considering the impact of individual fertilizer/nutrient on seed protein of garden pea it was found that N has played the most vital role in increasing the seed protein with every increasing in N rate of application. As a result, protein increased from 20.56 % with no N application in T_1 to the highest amount of 24.39 % under the highest level of N application in T_4 treatment (90 kg N/ha).

With respect to P and K application, it was noted that addition of both of these elements have favoured in increasing the protein content up to a certain limit (24.39 %) by adding P and K up to 75 kg P_2O_5 and 60 kg K_2O/ha respectively in T_4 treatment, but the seed protein declined to 23.71 % and 22.81 % when the P and K application reached to the highest level of 100 kg P_2O_5 and 90 kg K_2O/ha, respectively in T_7 and T_{10} treatments. These findings reveal that N addition to the soil has contributed more in increasing the crude protein content of both green and matured seeds of garden pea as compared to the other two nutrient elements. Use of *Rhizobium* inoculum together with the minimum application of N (20 kg/ha) in T_{12} treatment was also found to be promising to achieve appreciably higher protein contents of 6.19 % and 22.46 % in green and matured seeds, respectively.

Nitrogen content of above ground biomass of pea.

The total dry matter (TDM) production of pea plants and its N content is presented in Table 6. The three different crop stages when the N content of the plants

was determined were: preflowering, green pod harvest, and matured seed harvest stages. Pods were removed at the time of chemical analysis of plants for N determination. The effect of different treatments of fertilizer on N content of the pea plants was significant at all the three stages studied. At the preflowering stage the highest N content (4.38 %) of the plants was recorded under the highest level of N application (90 kg/ha) in T_4 treatment which was followed by the treatments T_3 (4.26 %), T_6 (4.26 %), T_9 (4.22 %), T_{10} (4.19 %) and T_7 (4.18 %). There was no significant variation in N content among these treatments. The impact of N addition on increasing the N content of the plants was more strong as compared to the other two nutrient elements used. Plant N content increased linearly with increasing rate of N addition and contained 30.7 % higher plant N under the maximum rate of N application in T_4 treatment as compared to the plot (T_1) where no N was added. The effect of P and K on plant N content at the preflowering stage was minimum. The highest level of both of theses elements showed detrimental effect on plant N.

The plant N content of garden pea at green harvest stage has declined remarkably as compared to that found at preflowering stage. The highest amount of plant N (3.18 %) was noted under the highest dose of N application in T_4 treatment (N : 90, P_2O_5 : 75, and K_2O : 60 kg/ha). The values as recorded in T_9 (3.13 %), T_6 (3.11 %), T_7 (3.10 %), T_3 (3.09 %), T_5 (3.06 %) and T_8 (3.02 %) did not have any significant variation with the highest value. P and K behaved similarly for plant N content as was found at preflowering stage.

The plant N content at the matured harvest stage was lower than that found at the preflowering or the green harvest stages. The highest plant N content (2.42 %), at this stage of the crop was also recorded under the highest level of N application (90 kg/ha) in T_4 treatment which was closely followed by T_6 (2.38 %), T_7 (2.38 %), T_{12} (2.37 %), T_3 (2.36 %), T_9 (2.35 %) and T_{10} (2.33 %) treatments. There was no significant variation in plant N among these treatments. The contribution of P and K on plant N was similar as was found at the other two stages of the crop.

It is important to note that at all the three crop stages there was no significant difference in plant N between the treatments T_1 (where only N was not applied) and T_{14} (where nothing was added), which reveal clearly that N application to the soil is the key factor for regulating the variation in N content of pea plants. The above findings thus reflects that N application alone play a vital role in governing the variation in N contents of garden pea plants.

Total dry matter (TDM) production of biomass (excluding seed) during green harvest

The different treatments of N, P, and K played a significant role in the production of dry matter of pea at green pod harvest (Table- 6). The highest amount of dry matter (1.85 t/ha) was recorded under highest dose of N application (90 kg/ha) in T_4 treatment which was followed by T_3 (1.68 t/ha), T_6 1.67 t/ha), T_2 (1.53 t/ha), and T_{10} (1.52 t/ha) treatments. The lowest production (1.30 t/ha) was noted in T_{14} which was very close to that recorded under absence of N application in T_1 treatment (1.35 t/ha).

As before N addition to soil played the sole role in increasing the TDM of pea plants. Without application of N in T_1 the TDM production was almost the lowest (1.35 t/ha) which increased linearly to 1.53, 1.68 and finally to the highest value of 1.85 t/ha by adding N at the rates of 30, 60, and 90 kg/ha, respectively. The individual effect of P and K addition on TDM production was positive up to certain limit. Under the highest level of application both of these elements proved to be detrimental for TDM production.

Nutrient uptake by plant

The data on uptake of N, P, and K by green pea plants at matured stage are presented in Table- 7. The nutrient uptake was directly influenced by both the nutrient content and the yield of the plant (seed and plant weight). The highest uptake of N by the biomass (53.28 kg/ha) was found in T_4 treatment which was followed by T_{10} (48.76 kg/ha), T_3 (48.32 kg/ha), T_6 (48.31 kg/ha), and T_9 (46.29 kg/ha) treatments. The lowest uptake (29.53 kg/ha) being recorded in treatment T_{14} where no fertilizer was added. N uptake by pea seeds was maximum in T_3 treatment (75.30 kg/ha). The uptake under the treatments T_{10}, T_9, T_4, T_7, and T_6 treatments were 69.63, 68.32, 66.38, 63.96, and 63.64 kg/ha, respectively. The minimum uptake of this element was noted in T_{14} as before. Now from the cumulative values of uptake of the element it was found that the highest total N uptake (123.62 kg/ha) being in T_3 treatment (N : 60, P_2O_5 : 75, K_2O : 60 kg/ha) where moderate amount of each of the three elements was applied. The total N uptake in T_4, T_{10}, T_9, and T_6 treatments were 119.66, 118.39, 114,61, and 111.95 kg/ha, respectively. N addition to soil alone has dominated in N uptake by the plants. BY virtue

of the highest green seed yield in T_3, the total N uptake in this treatment was also calculated to be the highest.

The uptake of P and K by the crop has followed almost the same trend as was found for N. The highest total uptake of both the elements (4.78 and 69.03 kg/ha P and K, respectively were noted in T_3 treatment. The lowest values (2.31 and 34.40 kg/ha P and K respectively) being recorded in T_{14} treatment. From the viewpoint of seed yield and nutrient uptake by the crop, the treatment T_3 (N : 60, P_2O_5 : 75, K_2O : 60 kg/ha) using moderate amount of each of the three elements and giving the highest output may be considered as the best combination of different nutrient elements for successful cultivation of garden pea in BSMRAU farm soil.

Table 3. Effect of different level of fertilizers on the yield contributing characters of pea.

	Plant height (cm)	Primary branches/ plant	Pods/plant	100 Seed weight (g)	
				Green	Mature
T_1	65.33 h	2.507 c	5.773 ef	37.80 bcd	15.92 e
T_2	83.71 def	2.580 c	7.257 b	38.68 abc	16.21 cde
T_3	88.56 abcd	2.823 b	7.43 b	41.51 a	17.68 a
T_4	94.44 a	3.023 a	8.073 a	40.37 ab	16.91 b
T_5	80.16 ef	2.503 c	6.153 de	36.68 cd	16.06 de
T_6	90.59 abcd	2.897 b	7.293 b	41.16 a	17.49 a
T_7	92.32 abc	2.597 c	7.520 ab	40.74 a	16.43 bcde
T_8	88.76 abcd	2.517 c	6.463 cd	36.88 cd	16.35 bcde
T_9	85.51 cde	2.823 b	6.907 b	40.03 ab	16.75 bc
T_{10}	86.46 bcde	2.621 c	7.258 b	39.48 abc	16.60 bcd
T_{11}	73.27 g	2.58 c	6.483 cd	37.58 bcd	16.41 bcde
T_{12}	86.43 bcde	2.597 c	7.193 b	40.32 ab	16.78 bc
T_{13}	78.36 fg	2.367 d	6.347 cde	39.20 abc	16.62 bcd
T_{14}	72.22 g	2.130 e	5.440 f	35.53 d	16.25 cde

$T_1 = N_0P_{75}K_{60}$

$T_2 = N_{30}P_{75}K_{60}$

$T_3 = N_{60}P_{75}K_{60}$

$T_4 = N_{90}P_{75}K_{60}$

$T_5 = N_{60}P_0K_{60}$

$T_6 = N_{60}P_{50}K_{60}$

$T_7 = N_{60}P_{100}K_{60}$

$T_8 = N_{60}P_{75}K_0$

$T_9 = N_{60}P_{75}K_{30}$

$T_{10} = N_{60}P_{75}K_{90}$

$T_{11} = N_{0+ino}P_{75}K_{60}$

$T_{12} = N_{20+Ino}P_{75}K_{60}$

T_{13} = OM @ 10 t/ha

T_{14} = Control

Table 4. Effect of different level of fertilizers on the yield of pea.

Treatment	Green pod (t/ha)	Matured seed (t/ha)
T1	10.16 g	1.410 h
T2	12.42 bc	2.025 b
T3	13.12 a	2.269 a
T4	12.53 b	2.030 b
T5	10.72 f	1.534 g
T6	12.89 a	1.979 bc
T7	11.98 d	1.879 cd
T8	10.33 g	1.637 fg
T9	12.55 b	2.089 b
T10	12.17 cd	2.053 b
T11	10.79 f	1.655 f
T12	12.37 bc	1.839 d
T13	11.58 e	1.726 ef
T14	9.077 h	1.330 h

$T_1 = N_0P_{75}K_{60}$ $T_6 = N_{60}P_{50}K_{60}$ $T_{11} = N_{0+ino}P_{75}K_{60}$

$T_2 = N_{30}P_{75}K_{60}$ $T_7 = N_{60}P_{100}K_{60}$ $T_{12} = N_{20+Ino}P_{75}K_{60}$

$T_3 = N_{60}P_{75}K_{60}$ $T_8 = N_{60}P_{75}K_0$ T_{13} = OM @ 10 t/ha

$T_4 = N_{90}P_{75}K_{60}$ $T_9 = N_{60}P_{75}K_{30}$ T_{14} = Control

$T_5 = N_{60}P_0K_{60}$ $T_{10} = N_{60}P_{75}K_{90}$

Table 5. Crude protein content of green and matured seeds of pea as influenced by different fertilizer treatments.

Treatment	Crude protein content (%) of green seed	Crude protein content (%) of Matured seed
T_1	6.080 gh	20.56 ef
T_2	6.31 cde	20.93 ef
T_3	6.49 b	23.96 ab
T_4	6.79 a	24.39 a
T_5	6.18 efg	22.41 d
T_6	6.46 bc	22.79 cd
T_7	6.49 b	23.71 abc
T_8	6.35 cde	22.91 cd
T_9	6.41 bcd	23.29 bcd
T_{10}	6.42 bcd	22.81 bcd
T_{11}	6.14 fgh	21.25 e
T_{12}	6.19 rfg	22.46 d
T_{13}	6.22 efg	21.17 ef
T_{14}	6.01 h	20.21 f

$T_1 = N_0P_{75}K_{60}$ $T_6 = N_{60}P_{50}K_{60}$ $T_{11} = N_{0+ino}P_{75}K_{60}$

$T_2 = N_{30}P_{75}K_{60}$ $T_7 = N_{60}P_{100}K_{60}$ $T_{12} = N_{20+Ino}P_{75}K_{60}$

$T_3 = N_{60}P_{75}K_{60}$ $T_8 = N_{60}P_{75}K_0$ T_{13} = OM @ 10 t/ha

$T_4 = N_{90}P_{75}K_{60}$ $T_9 = N_{60}P_{75}K_{30}$ T_{14} = Control

$T_5 = N_{60}P_0K_{60}$ $T_{10} = N_{60}P_{75}K_{90}$

Table 6 Nitrogen content of above ground biomass at different stages of crop growth and TDM (excluding seed) at green harvest as influenced by different fertilizer treatments.

Treatments	N content (%) of biomass at preflowering stage	N content (%) of biomass at green harvest stage	N content (%) of biomass at matured	TDM (excluding seed) production at green harvest stage (t/ha)
T_1	3.350 f	2.243 d	2.117 c	1.352
T_2	3.903 cde	2.653 c	2.280 ab	1.531
T_3	4.260 ab	3.087 a	2.363 ab	1.680
T_4	4.380 a	3.180 a	2.417 a	1.854
T_5	4.033 bcd	3.063 a	2.283 ab	1.462
T_6	4.260 ab	3.107 a	2.380 ab	1.673
T_7	4.183 abc	3.103 a	2.380 ab	1.521
T_8	4.067 abc	3.023 a	2.304 ab	1.480
T_9	4.220 ab	3.133 a	2.350 ab	1.502
T_{10}	4.187 abc	3.087 a	2.330 ab	1.524
T_{11}	3.740 de	2.647 c	2.250 b	1.443
T_{12}	3.947 bcd	2.827 b	2.373 ab	1.511
T_{13}	3.633 e	2.627 c	2.263 b	1.482
T_{14}	3.340 f	2.173 d	2.080 c	1.304

$T_1 = N_0P_{75}K_{60}$

$T_2 = N_{30}P_{75}K_{60}$

$T_3 = N_{60}P_{75}K_{60}$

$T_4 = N_{90}P_{75}K_{60}$

$T_5 = N_{60}P_0K_{60}$

$T_6 = N_{60}P_{50}K_{60}$

$T_7 = N_{60}P_{100}K_{60}$

$T_8 = N_{60}P_{75}K_0$

$T_9 = N_{60}P_{75}K_{30}$

$T_{10} = N_{60}P_{75}K_{90}$

$T_{11} = N_{0+Ino}P_{75}K_{60}$

$T_{12} = N_{20+Ino}P_{75}K_{60}$

T_{13} = OM @ 10 t/ha

T_{14} = Control

Table 7 Nitrogen, phosphorus and potassium uptake by pea at matured harvest stage as influenced by different fertilizer treatments.

Treatment	Nitrogen uptake			Phosphorus Uptake			Potassium Uptake		
	By biomass kg/ha	By Seed kg/ha	Total kg/ha	By Biomass kg/ha	By Seed kg/ha	Total kg/ha	By Biomass kg/ha	By Seed kg/ha	Total kg/ha
T_1	31.15	40.82	71.97	1.21	1.44	2.65	19.12	19.04	38.16
T_2	43.32	59.71	103.03	1.65	2.11	3.76	30.92	27.04	57.96
T_3	48.32	75.30	123.62	2.25	2.53	4.78	35.02	34.01	69.03
T_4	53.28	66.38	119.66	2.59	2.12	4.71	34.07	25.69	59.76
T_5	40.04	48.14	88.1895	1.47	1.48	2.95	21.00	23.87	44.87
T_6	48.31	63.64	111.95	2.03	2.02	4.05	26.72	24.60	51.32
T_7	45.08	63.96	108.96	2.29	2.23	4.52	26.30	23.05	49.35
T_8	43.42	52.80	96.22	2.13	1.80	3.93	21.25	18.92	40.17
T_9	46.29	68.32	114.61	2.30	2.22	4.52	23.97	25.56	49.47
T_{10}	48.76	69.63	118.39	2.39	2.18	4.57	30.22	28.74	58.96
T_{11}	40.50	49.53	90.03	1.56	1.78	3.34	22.35	19.82	42.17
T_{12}	44.60	58.14	102.74	1.82	1.99	3.81	23.95	21.30	45.25
T_{13}	41.15	51.39	92.546	1.58	1.68	3.26	21.47	21.73	43.0
T_{14}	29.53	37.73	67.26	1.08	1.23	2.31	18.30	16.10	34.40

$T_1 = N_0P_{75}K_{60}$

$T_2 = N_{30}P_{75}K_{60}$

$T_3 = N_{60}P_{75}K_{60}$

$T_4 = N_{90}P_{75}K_{60}$

$T_5 = N_{60}P_0K_{60}$

$T_6 = N_{60}P_{50}K_{60}$

$T_7 = N_{60}P_{100}K_{60}$

$T_8 = N_{60}P_{75}K_0$

$T_9 = N_{60}P_{75}K_{30}$

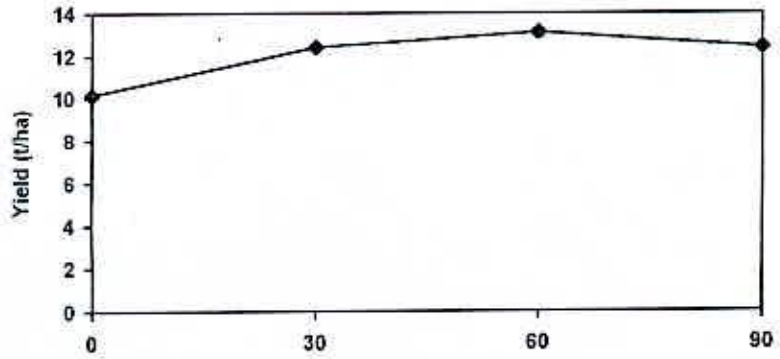
$T_{10} = N_{60}P_{75}K_{90}$

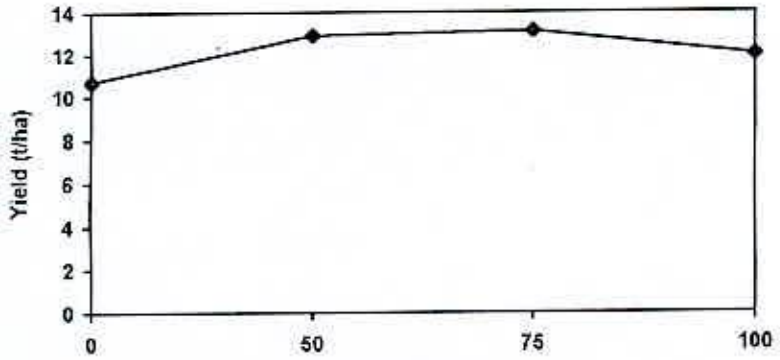
$T_{11} = N_{0+ino}P_{75}K_{60}$

$T_{12} = N_{20+ino}P_{75}K_{60}$

T_{13} = OM @ 10 t/ha

T_{14} = Control





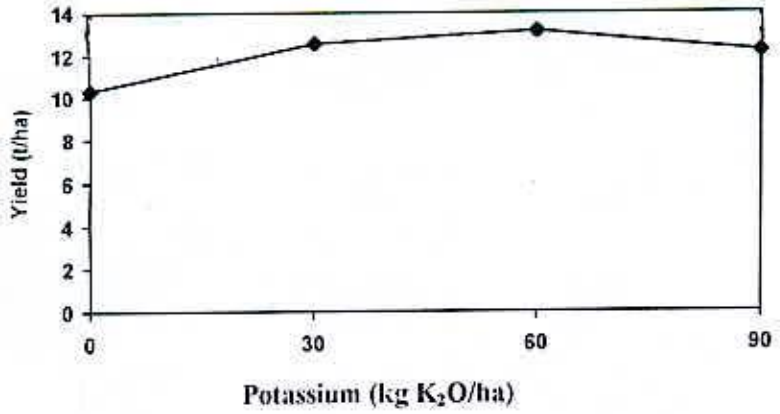
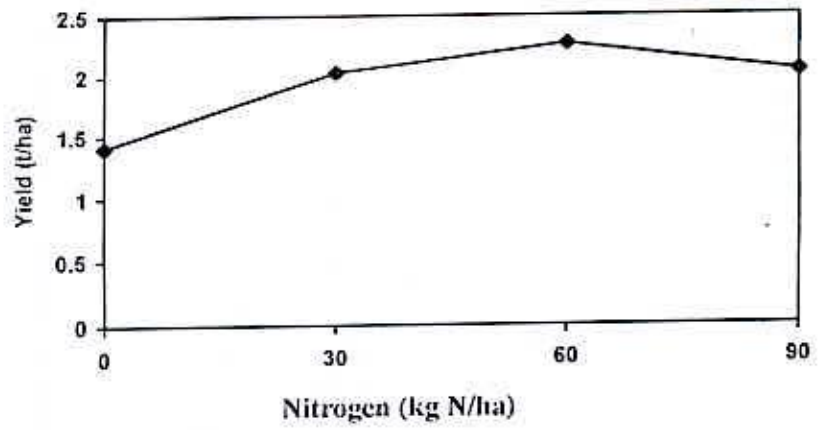
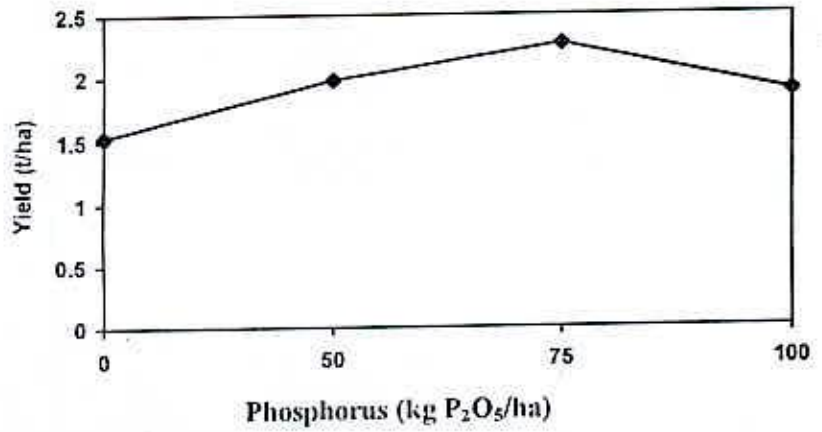


Fig. : Effect of different levels of N,P and K on green pod yield of Pea.





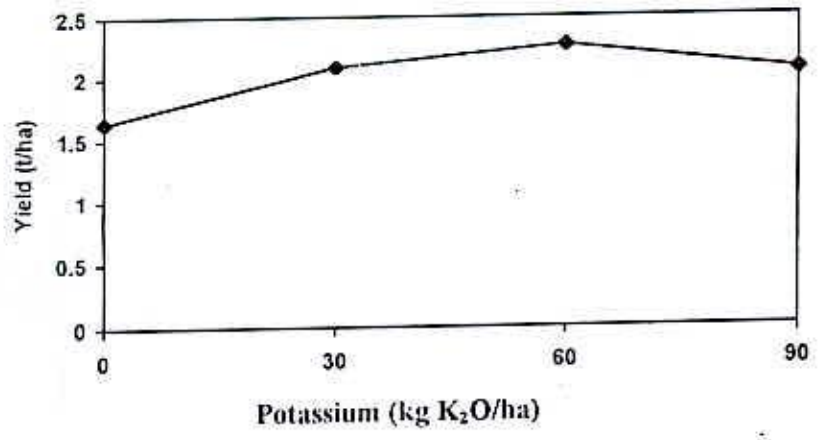


Fig. : Effect of different levels of N, P and K on matred seed yield of Pea.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm during the period from November 10, 1997 to March 01, 1998 to findout the optimum levels of nitrogen, phosphorus and potassium fertilizers for maximum yield of the advanced line (local white) of pea.

There were 14 treatment combinations comprising of four levels of N (0, 30, 60 and 90 kg N/ha), 4 levels of P (0, 50, 75, and 100 kg P_2O_5/ha), 4 levels of K (0, 30, 60, and 90 kg K_2O/ha), 2 levels of inoculum as a Rhizobium strain (N_{0+ino}, N_{20+ino}), one level of organic matter (cow dung at the rate of 10 t/ha). A common dose of 20 kg S/ha, Zn 1 kg/ha, M_o 1 kg/ha and B 1 kg/ha were applied in all plots. A significant variation was observed among the treatments with respect to most of the yield components, TDM, yield and protein content of garden pea. The highest average plant height (94.44 cm), number of primary branches per plant (3.02), pods plant (8.07), and total dry matter (TDM) production (excluding seed) at green harvest (1.85 t/ha) were recorded under in treatment T_4. The lowest plant height (65.33) was found in T_1 treatment. The lowest number of primary branches per plant (2.13), pods/plant (5.44) and lowest TDM production (1.30 t/ha) were recorded in absolute control (T_{14} treatment).

The maximum weight of 100 seed at green (41.51 g) and matured (17.68 g) stages, maximum green pod yield (13.12 t/ha), and maximum matured seed yield (2.27 t/ha) were recorded in T_3 treatment. The minimum weight of green seeds (35.53 g), lowest yield of green pod (9.08 t/ha), and matured seed (1.33 t/ha) were observed in T_{14} (control) treatment.

With respect to the rate of N, P and K application. The response of garden pea was not biased to a particular rate of N, P and k application. Maximum average plant height (94.44) and TDM production at green harvest (1.85 t/ha) was recorded in highest dose of N application in T_4 treatment. But highest of 100 seed, green pod yield and matured seed yield were recorded in T_3 treatments indicating the individual superiority of T_3 treatment over other treatment.

The interaction effect of different level on N, P and K were significant on plant height, number of pods per plant, 100 seed weight green pod yield and on matured seed yield. The highest green pod yield (13.12 t/ha) was recorded in T_3 treatments which was followed by the treatment T_6, T_9, T_4, T_2, and T_{12} treatment. Similar trend was also observed in case of matured seed yield. The highest yield of matured seed (2.27 t/ha) was recorded in T_3 treatment which was closely followed by T_9, T_{10}, T_2, and T_6 treatment. Although, the seed protein of pea increased with increased rate of N application, the difference was not remarkable. The highest mean crude protein content (6.79 %) of green seed was noted in T_4 treatment and the lowest value (6.01 %) in T_{14}. The impact of P and K application on protein content of green seed was positive and increased with increasing rate of application of those two elements up to the 2nd highest

level (75 kg P_2O_5 and 60 K_2O/ha). The response of crude protein content of matured seeds to different fertilizer treatments were almost similar to that found in green seeds. The highest protein content (24.39 %) was found in T_4 and lowest (20.21 %) was found in T_{14} treatment.

The highest N content of plant biomass at preflowering (4.38 %), green harvest (3.09 %), and at matured harvest (2.42%) stages were noted under the highest level of N application (90 kg/ha) with moderate level of P (75 kg P_2O_5/ha) and K (60 kg K_2O/ha) in T_4 treatment. The minimum values (3.34 % at preflowering, 2.17 % at green harvest, and 2.08 % at matured stages) were found under absolute control treatment (T_{14}). The plant N content in T_1 treatment (N was not applied) has also approached to the lowest values in all the three growth stages of the crop as was found in T_{14} and there was no significant differences in N content between these two treatments. The findings thus revealed that N application alone played the supreme role in N content of plants. The more the N was added to the soil the higher the plant contained N in it. The effect of P and K on plant N content at different stages were minimum. The highest levels of both P and K elements showed detrimental effect on plant N content.

The highest TDM production (1.85 t/ha) was also recorded under the highest level of N application in T_4 treatment as was found for plant N content. The minimum TDM was noted in T_{14} (where nothing was added). By virtue of the highest seed yield in treatment T_3 (N : 60 kg, P_2O_5 : 75 kg, K_2O : 60 kg/ha), the total N, P, and K uptake (123.62, 4.78, and 69.03 kg/ha, respectively) in this treatment was also the highest.

The study thereby indicates that the moderate rate of N, P, and K application (N: 60 kg, P_2O_5 : 75 kg, and K_2O : 60 kg/ha) in T_3 treatment gave the maximum weight per unit number of green and matured pea seeds, the highest yield of green pods and matured seeds and as well as the highest total uptake of N, P, and K by the plants, thus, proved to be the balanced combination of different fertilizers for achieving the maximum output through pea cultivation in Shallow Red Brown Terrace Soil of BSMRAU farm. Although, the highest rate of N application (90 kg/ha) in T_4 treatment has led to attain the maximum plant height, the highest number of pods/plant, the highest amount of crude protein content in green and matured seeds, and as well as the maximum N content in plant biomass, this treatment could neither approach closer to the highest yield nor could it achieve the maximum uptake of N, P, and K in plants which are badly needed for economic cultivation of a crop. The treatment involving seed inoculation by *Rhizobium* strain along with 200 % reduction in N application in T_{12} (as compared to the standard dose in T_3) has been found to be satisfactory and acceptable to get only 5.7 % less yield of green pea as compared to that of the highest yield in T_3 treatments.

The following conclusion may be drawn from the study:

1) The application of N, P, and K is indispensable at BSMRAU farm soil for successful cultivation of pea.

2) The optimum requirement of N, P, and K are 60 kg N, 75 kg P_2O_5, and 60 kg K_2O/ha, respectively for approaching the highest yield potential of pea at BSMRAU farm soil.

3) *Rhizobium* inoculation along with 75 kg P_2O_5, 60 kg K_2O/ha and reduced N rate of 20 kg/ha may be used for green pod yield as an alternate dose for avoiding the inorganic N pollution in soil.

This result however is generated from single trial. Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

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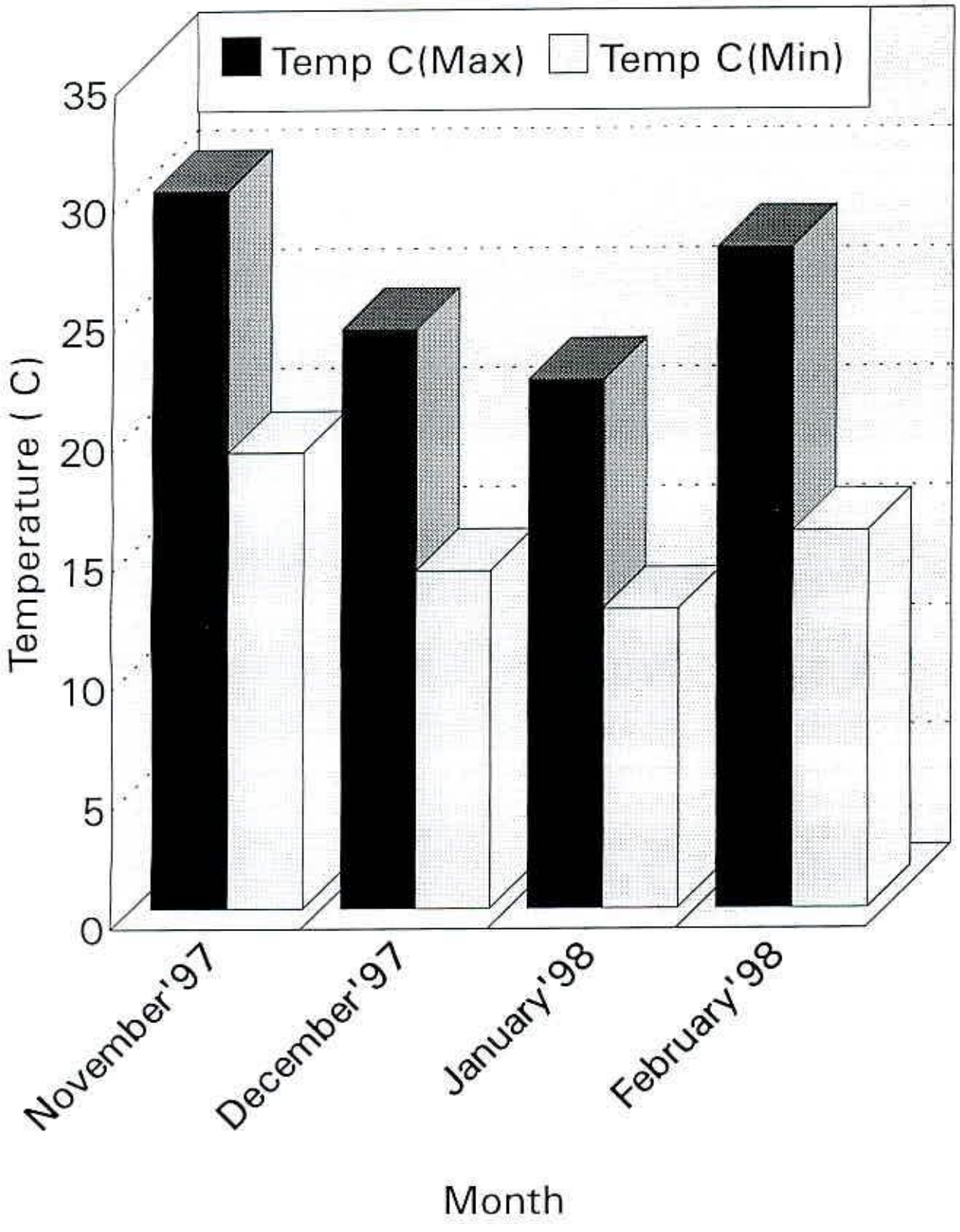
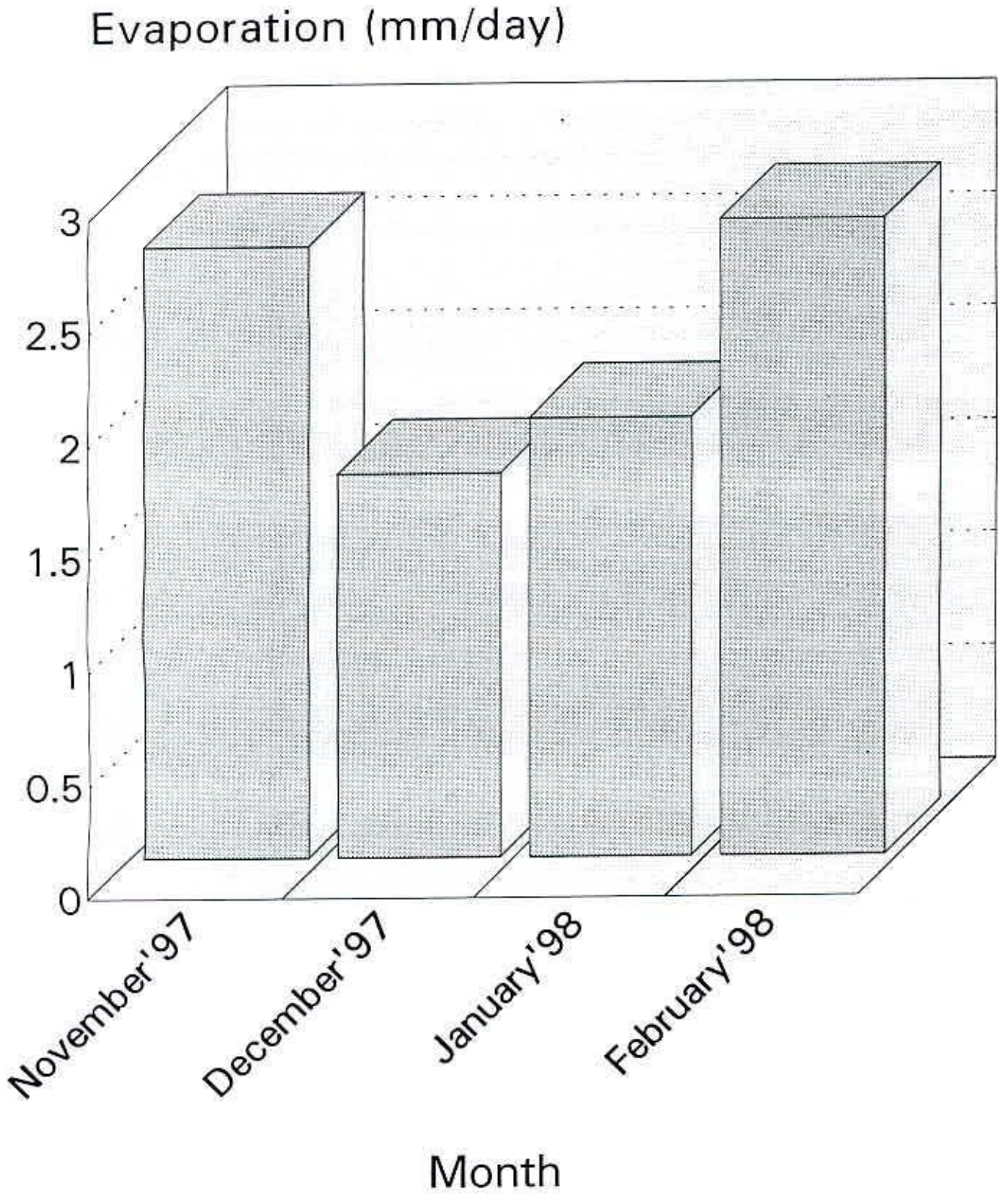
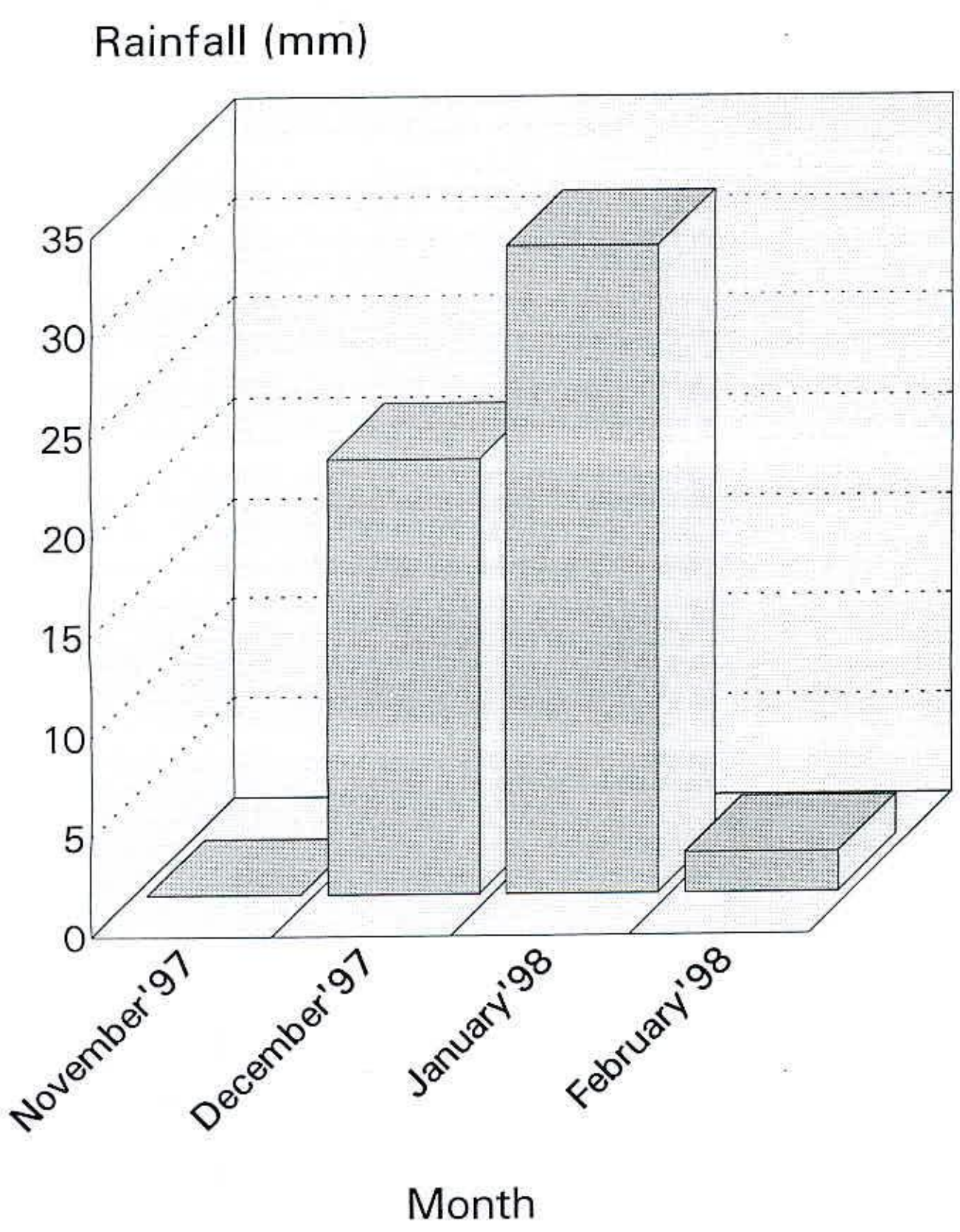


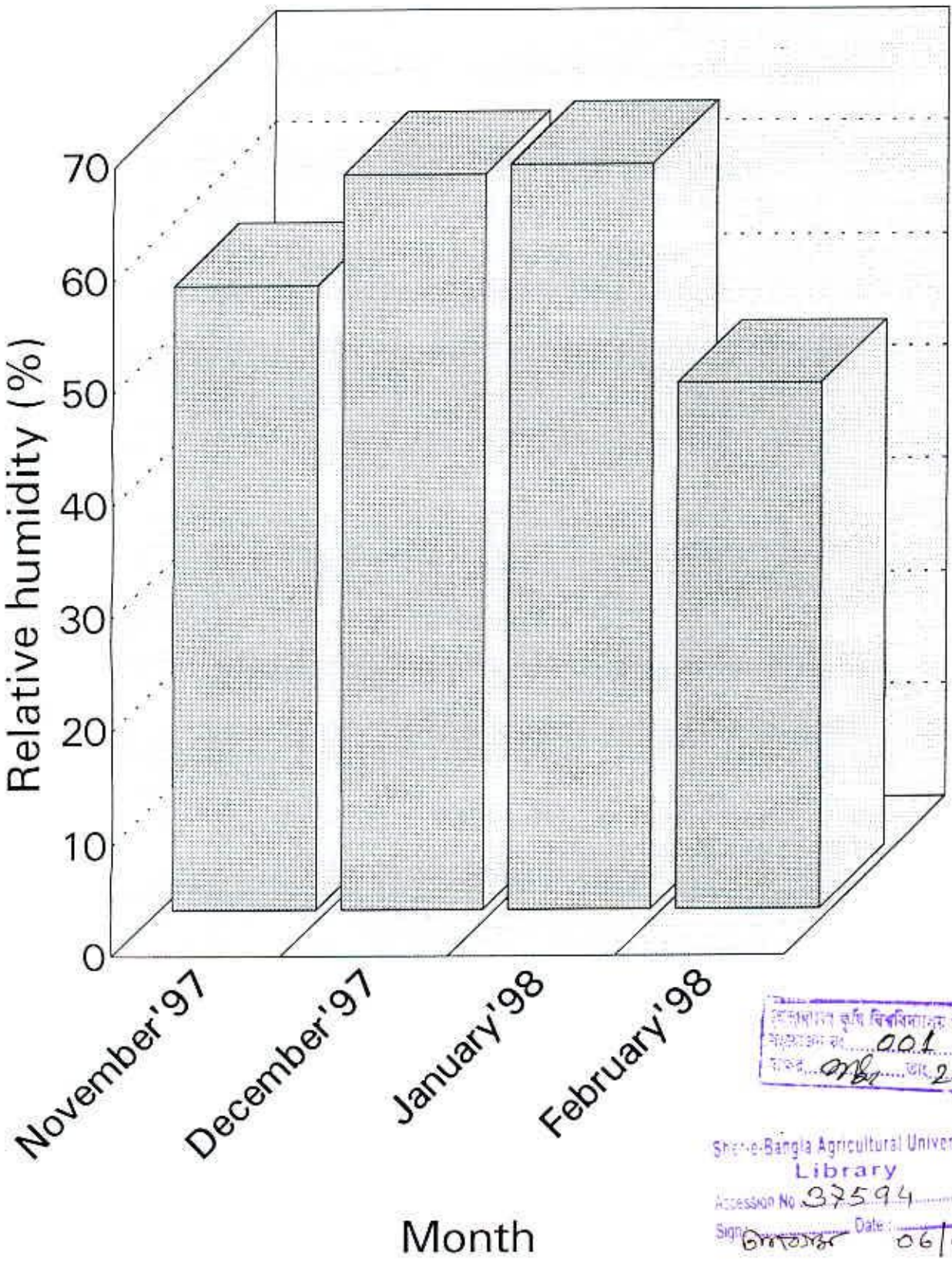
Appendix Figure 3 Monthly average maximum and minimum air temperature during Nov'97 to Feb'98



Appendix Figure 4 . Monthly average evaporation (mm/day) during Nov'97 to Feb'98



Appendix Figure 5 . Monthly total rainfall (mm) during Nov'97 to Feb'98



Appendix Figure 6 Monthly average relative humidity (%) during Nov'97 to Feb'98