INFLUENCE OF DATE OF SOWING AND DIFFERENT LEVELS OF PHOSPHORUS ON GROWTH AND YIELD OF GARDEN PEA (*Pisum sativum* L.)

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CERTIFICATE

*This is to certify that the thesis entitled, "**INFLUENCE OF DATE OF SOWING AND DIFFERENT LEVELS OF PHOSPHORUS ON GROWTH AND YIELD OF GARDEN PEA (Pisum sativum L.)**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **MD. NAHIDUL ISLAM,** Registration No. **11-04454** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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Dated: June, 2018
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Dedicated
to My
Beloved Parents

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ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2017 to March, 2018. The experiment consisted of two factors. Factor A: three levels of sowing time, S_1: 15 November, S_2: 25 November, S_3: 5 December and Factor B: four levels of phosphorus fertilizer, P_0: Control (No Phosphorus), P_1: 50 kg P_2O_5/ha, P_2: 75 kg P_2O_5/ha, P_3: 100 kg P_2O_5/ha. This experiment was laid out in Randomized Complete Blocked Design with three replications. Sowing time and phosphorus application influenced significantly on most of the parameters. In case of sowing time, maximum plant height (46.72 cm), pod length (8.30 cm), number of pods per plant (12.10), number of seeds per pod (4.62) and green pod yield (8.48 t/ha) were recorded from S_2 treatment. In case of phosphorus application, maximum plant height (48.56 cm), pod length (8.68 cm), number of pods per plant (12.70), number of seeds per pod (4.90) and green pod yield (9.23 t/ha) were found in P_2 treatment. Among the treatment combination, S_2P_2 treatment gave the highest green pod yield (10.50 t/ha) and the lowest (4.48 t/ha) was obtained from S_3P_0 treatment. The highest gross return (Tk. 315000), net return (Tk. 181248) and BCR (2.35) were obtained from the treatment combination of S_2P_2 where the lowest gross return (Tk. 134400), net return (Tk. 3146) and lowest BCR (1.02) were obtained from S_3P_0. So, garden pea may be sown at 25 November along with 75 kg P_2O_5/ha for commercial green pea production in Dhaka region.

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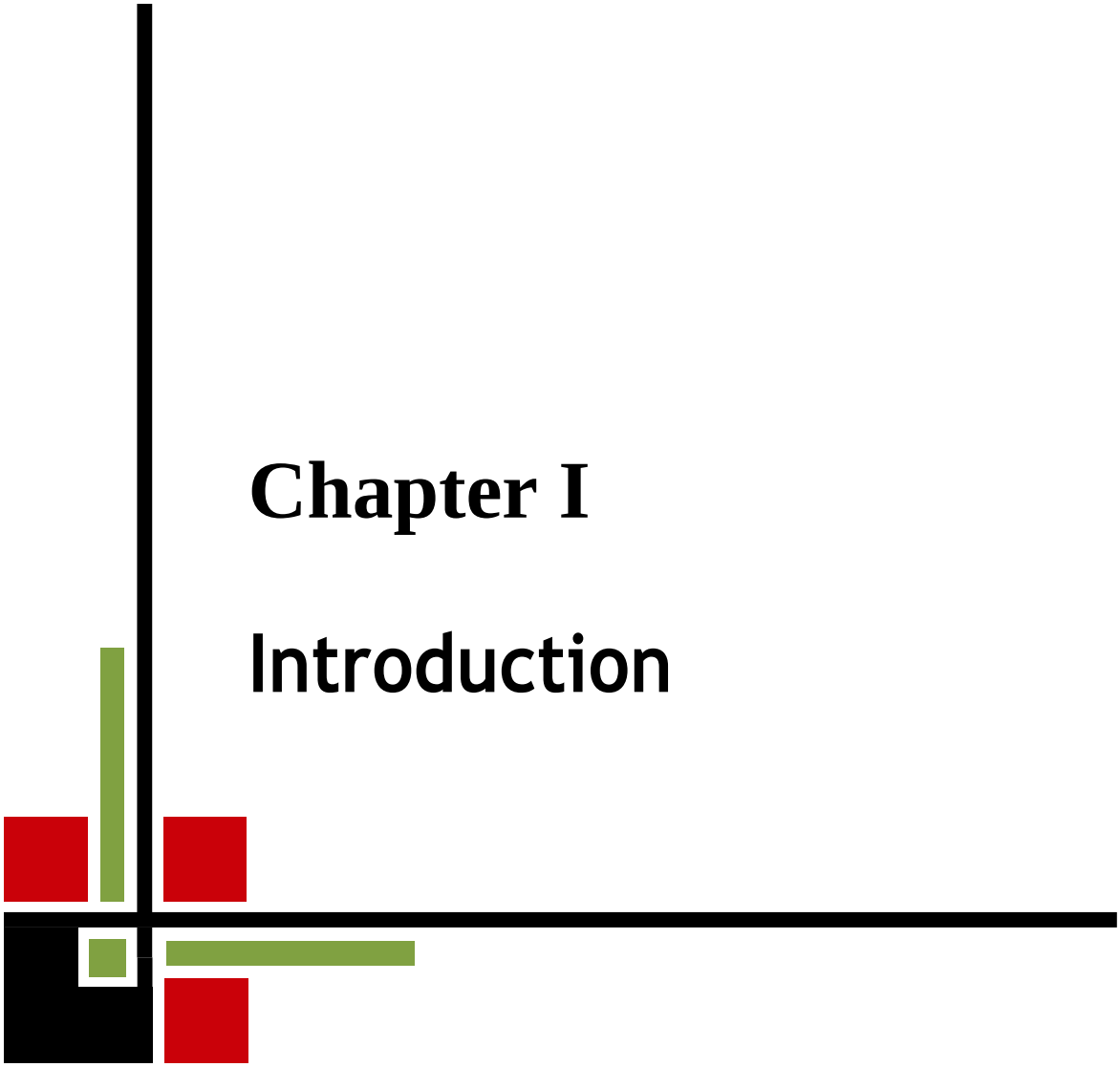
ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	: Agro-Ecological Zone
ANOVA	: Analysis of Variance
BDT	:Bangladesh Taka
CV%	: Percentage of Coefficient of Variation
Df	: Degrees of freedom
DM	: Dry matter
et al.	: and others
FAO	: Food and Agricultural Organaization
SAU	: Sher-e-Bangla Agricultural University
BARI	: Bangladesh Agricultural Research Institute
BAU	: Bangladesh Agricultural Universiry
BBS	: Bangladesh Bureau of Statistics
DAS	: Day after Sowing
LSD	: Least Significant Difference
TDM	:Total Dry Matter



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Garden pea (*Pisum sativum* L.) belongings to the family Fabaceae (formerly Leguminosae) and subfamily Papilionoideae is one of the most important legume vegetables in Bangladesh and mostly grown for green pods and seeds. Peas are native to Southwestern Asia, being grown there for ancient times (De Candolle, 1886). It is a cool season crop now grown in many parts of the world.

The green pods and immature seeds are rich in vitamin and have a balanced amino acid composition. Moreover, some important mineral such as calcium, phosphorus, iron are present in abundant quantities in peas. The crop becomes popular for its high nutritive value and good taste. It contains 15-35% protein, 20-50% starch, 4-10% sugar, 0.6-1.5% fat and 2-4% minerals (Makasheva, 1983). The importance of garden pea as a vegetables crop has sharply increases in many countries of the world.

In Bangladesh people consumes 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. At present pea is being cultivated in an area of 7468 ha with a production of 13540 tons (BBS, 2016). The average yield is only 0.82 ton per hectare which is much lower as compared to other pea growing countries such as USA 3.94 ton/ha and France 2.23 ton/ha (Makasheva, 1983). The yield is mainly due to lack of modern cultural practices.

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.

The production of a crop depends on many factors such as quality of seed, management practices including sowing time, plant spacing, soil fertility management, intercultural operations etc. Sowing time is an important factor for the yield of any crop. Optimum sowing time ensures proper plant growth through efficient utilization of moisture, temperature, light etc. and also increases production.

It is important that, sowing time determines the nutrient contents in seeds of pea. Ekeberg (1994) reported that protein concentration increased with delay in sowing. Ali *et al.* (1994) reported that late sowing also increases starch content of green seed of pea. Sowing time also affects the shelf life of garden pea. Early sowing crops which gave early harvest have a longer shelf life and lower weight loss.

In Bangladesh garden pea is grown during cool period in the winter season with short durability. Thus sowing time is a very important factor which influences yield and quality. Garden pea cultivation requires cool weather with abundant moisture during early growth stage and minimum rain fall at later stage (Suteliffe and Pate, 1977). Sowing of peas beyond or before its optimum period causes reduction in pod yield (Ram *et al.*, 1973). Late sowing and high temperature resulted in 38% lower yield than normal (Vander Graff, 1968). When crop was sown after 4 December yield was adversely affected (Chaubey, 1997). Time of sowing determines the flowering time and also has great influence on pod formation seed setting and seed yield (Ali *et al.*, 1985). If the temperature is higher than 25°C during the flowering and pod filling stage, seeds yields must be reduced (Pumphrey *et al.*, 1979).

On the other hand, fertilizer management is another important factor that contributes the production and yield of any crop. Adequate supply of nutrients increased yield. Since, the land is limited in Bangladesh, it is important to

increase per hectare yield of any crop through all possible means. Plants required food for growth and development in the form of doses of N, P, K, S and other nutrients. Soil is the main source of plant nutrients. It supplies almost all of the essential nutrients to crop plants. Again fertilizer exerts significant influence on yield, vigorous growth and yield attributes of legumes. Significant yield responses found with the addition of 36 to 90 kg P_2O_5 /ha were reported (Sen and Kavitkar, 1958). It is known that, phosphorus is an essential component of deoxyribonucleic acid (DNA), the set of genetic inheritance in plant and various forms of ribonucleic acid (RNA) are needed for protein synthesis (Alberghina *et al.*, 1975). 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. In addition, 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.

Research with pea in Bangladesh has been neglected compare to other vegetables. So it has now become necessary to undertake research program to develop some cultivation technology for approaching the highest yield potential of garden pea. Therefore, it is imperative that an optimum sowing time should be determined for the cultivation of pea and the optimum dose of phosphorus in the form of fertilizer for the better production of pea.

This experiment was therefore, undertaken with the following objectives,

I. To determine the optimum sowing time for obtaining maximum yield of garden pea.
II. To determine the appropriate dose of phosphorus for increasing yield of pea.
III. To investigate the combined effect of optimum sowing time and phosphorus on the yields of garden pea.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Among the pulse crops, garden pea occupies the greater position in Bangladesh. Pea being a fabaceae 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 fabaceae crops. Growth and yield of garden pea have been studied in various parts of the world, but a little study has been done on this crop under the agro-ecological condition of Bangladesh. Hence a brief review of available literature with regards to the influence of sowing time and Phosphorus fertilizers on this crop are presented in this Chapter.

Literature on the effect of sowing time

A field experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur, Gazipur and ARS, Burirhat, Rangpur by Ali *et al.* (2016) to evaluate crop growth, yield and seed quality of garden pea in prevailing temperature at different sowing dates (10 November, 20 November, 30 November, 10 December, 20 December and 30 December). Sowing date based temperature variations significantly affected the crop growth, TDM production, yield and seed quality of BARI Motorshuti-3. Plants with November 20-30 sowing performed the best in respect of yield and yield contributing characters. However, with the delayed in sowing dates, the temperatures at the later growth phases were increased, while the grain growth duration, grain yield and grain quality decreased substantially. Results revealed that November 20-30 would be the optimum time of sowing for maximum yield with quality seed production of garden pea in Bangladesh.

Among the three sowing dates (10, 20 or 30 October) in Pakistan, yield decreases with later sowing mainly due to lower branch and pod number per plant, with no significant difference in 100 seed weight (Baloch *et al.*, 1999).

Among four sowing dates (15 October, 5 November, 1 November and 6 December), October is the most suitable for sowing pea cultivars as the yield is higher compared with other date in Bihar, India (Kumar and Prasad, 1998).

For winter pea, November sowing is the better than sowing in Peterborough, UK (Knott and Belcher, 1998), marches region of Italy (Pirani *et al.*, 1993), Punjab in India (Randhir *et al.*, 1996) and Himachal Pradesh in India (Bharadwaj and Thakur, 2000).

The average yield of peas is 8.2 t/ha for those sown in winter and 8.9 t/ha for those sown in spring at Dabuleni, Romania. The best performance is recorded for peas cv. Isalnita 60, which produces 9.7 t/ha on average with winter sowing (Ifrim, 1998).

Sowing season has a significant effect on the yield determination of pea varieties. The actual number of seedling per unit area varies greatly among cultivars, sowing season and climatic conditions during emergence. Autumn sowings produces the taller plants and more pods and seeds per plant. In general, autumn sowing produces the highest dry matter, seed and protein yields in all pea cultivars at Busra region of Turkey (Uzun and Acikgoz, 1998).

Among the various factors responsible for high yield, the cultivars itself plays a great role. Ranali *et al.* (1997) reported that production of pea was influenced by sowing date and the genotype interaction.

An experiment was conducted on the performance of edible podded pea with sowing at 10, 20, 30 November 10, 20, 30 December 1996 and 9, 19 January 1997. The higher vegetative pod yield (13.56 t/ha) and seed yield (2.42 t/ha) were obtained when pea was sown on 20 November and statistically similar vegetable yield was obtained from 30 November sowing. Its vegetable pod and seed yield also started to declines significantly after November sowing.

Economic return from early seeding date (10 November) was the maximum and the lowest return was obtained from 19 January. The return from the seed was higher than the return from the vegetable (Anon., 1996).

Mean values for green pod yield of peas and associated characters is found higher with October sowing among the five different sowing dates (1, 15 and 30 September or 15 and 30 October) in Himachal Pradesh, India. October sowing produces the taller plants, the highest number of marketable pods and the highest green pod yield (Bharadwaj and Sharma, 1996).

The optimum sowing date for early variety of garden pea is either 23 October or 03 November and for late variety it is either 13 November or 23 November at Kalyani,West Bengal (Das *et al.*, 1996).

Varshney (1995) reported that delay in showing by 15 and 30 days after 8 November decreases seed yield of dwarf pea by 67.3% at Kanpur, India.

Seeds of pea cv. Lincoln and Rondo were sown early (21-22 October), mid season (4-6 November) or late (18-19 November). Pod length, pod weight and 100 green seed weight were found superior in cv. Rondo, whereas Lincoln produced more pods/plant (Alsadon and Khalil, 1994).

According to Shukla *et al.* (1994), seeds of five garden pea cultivars were sown on 10, 20 or 30 May or 10 June during 1988 at Kalpa, Himachal Pradesh. They found that seedling growth was greatest with the earliest sowing. The earliest sowing (10 May) also results in the best yield and yield contributing characters.

Early sowing (15 October) induces early flowering. Sowing on 15 November improves plant stand percentage, number and weight of fresh pods/plant, total fresh and dry weight, dry matter, total sugar content and fresh pod weight as well as resulting in the tallest plants. Late sowing (15 December) increases the starch content of green seeds (Ali *et al.,* 1994).

The highest seed yield obtained when peas are sown on 30 October at 15 cm row pacing with no thinning of plants (Batra *et al.,* 1992).

Later sown results in earlier flowering at Kalpa and Solan in Himachal Pradesh. In a field trial with three pea cultivar e.g. Karina, Puget and Davina and three sowing time (15 December, 10 and 27 February) seed yield of 8.03, 8.70 and 7.0 t/ha were obtained with the delay in sowing and in the order was Karina>Davina>Puget (Shukla and Kohli, 1992).

The pea plant start from auxiliary flower buds at about 49 days after sowing, and full bloom takes further 6-7 days. Growth and development of pod is rapid about 9 days after full bloom. Fresh and dry weight of pod increases slowly in the first two or three days and then rapidly declines until eight days after when it is leveled off, with pod dry weight from flowering onward and pod development follows a simple sigmoid curve (Kesta and Poopattarangk, 1991).

Vonella *et al.* (1991) carried out a field trial to determine the effect of sowing date on growth cycle and yield of protein pea in 1998-90 at Foggia, Italy, with 5 pea cultivars sown on 30 November, 20 December or 10 January. Seed yields decreased from 2.77 t/ha to 2.09 t/ha with delay in sowing.

Conducting varietal studies on peas in Uttar Pradesh, India, Srivastava (1991) recommended different sowing dates for different varieties. He recommended sowing dates to be 29 October-19 November for Arkel, 22 October- 19 November for Pant Uphar.

Chatterjee and Som (1991) conducted an experiment at west Bengal, India with peas. Seeds were sown in the second week of every month from January to December. It is reported that those sown between January and August fails to grow well or to produce seeds. In a second experiment with seeds sown only from September to December showed that October sowing achieved the greatest height (49.7 cm), number of pods (5.7) and produced seed with the highest germination percentage (88.0).

It is reported that autumn sown peas produce higher shoot dry matter, secondary branches, the number of aborted flower and total number of flowers than spring sown ones. It is found that seed yield declines as sowing is delayed.

Crops sown in autumn took an average of 6 months to mature whereas those sown in spring took only 3 months (Aziz *et al.*, 1989).

In India, peas in mid October gives higher pod yield compare to early October or November (Dwivedi *et al.*, 1998, Sharma *et al.*, 1997, Sing and Yadab, 1989).

The highest green pod yields are obtain from peas cv. Arkel sown on 1 November (8.19 t/ha), V.L-1 sown in 1 November (7.03 t/ha) and Bonneville sown on 15 October (6.14 t/ha) at Uttarkashi, India. Sowing on 1 December gave yields between 3.70 and 5.17 t/ha (Maurya and Lal, 1988).

Another investigation on four dwarf pea cultivars was carried out at Assam, India. Seeds were sown on 30 October, 15 November or 30 November in 1985-1987 which produces average seed yields of 0.92, 0.82 and 0.63 t/ha, respectively. Cv. KPSD-1 produced the highest yield of 1.17 t/ha compared with 0.58-0.6 t/ha for other 3 cultivars (Saharia and Thakuria, 1988).

The duration from sowing to germination in peas under similar conditions of the temperature and humidity does not vary. However, the moisture deficiency in the spring the vertical differences for this character is manifested more strongly (Makasheva, 1983).

The optimum temperature for germination of pea seed is 24 °C and germination rate gradually slows as temperature declines; 4.4 °C was considered the minimum for germination and growth (Weier *et al.*, 1982).

The pea is a cool season crop and is genetically grown in rabi season in Bangladesh. Growth and development of this crop is sensitive to temperature and day length. Dry weather interferes in seed setting and lowers the quality of pod produced. Flowering is accelerating by long days with low temperature. Plant growth is favoured by intermediate temperature (13 °C -18 °C). Yield is reduced as average temperature increases, and plants may be dying if exposed to prolonged periods above 26 °C (Meicenheimer and Muchlbauer, 1983).

Higher temperature above 27 °C reduced the total growth period resulting in reduced yields (Key, 1979).

Pea seed can germinate at a minimum temperature 5 °C but the process is slow. The time require for emergence decreases rapidly as the temperature increases (Sing and Kumar, 1979).

The pea can be sown at the end of September to middle of November. Chowdhury and Ramphal (1975) observed that under Delhi conditions sowing during second week of October is the best time. Sowing can be safely advanced by about 10-15 days in areas where the temperature becomes significantly low by the end of September in India.

There are reports that the maximum and minimum number of day from flowering to maturity of pea in Leningard district may be 75 days and 18 days, respectively (Ancherbak,1971).

Germination to flowering of the pea varies in different years from 20 to 70 days. In Leningard district the difference between the maximum and minimum duration of the period from germination to flowering is 38 days. In the shorter day length (Verbitskii, 1968).

Milbourn and Hard Wick (1968) observed that high temperature during pod development and pod filling stage cause yield reduction in peas. At high temperature, while germination of pea is rapid, loss of plant stand may result from various decay organisms present in the soil (Thompon and Kelly, 1957).

Literature on the effect of phosphorus application

Manore and Alteye (2018) evaluate the effect of different level of to phosphorous (0, 23, 46, and 69 kg /ha) with four types of field pea varieties: Local Tegegnech, Burikitu and Wolimera combined in RCBD. Data grain yield and yield components were recorded during specific physiological stages. The effect of phosphorous was significant in hastening physiological maturity of crop, and its effect was significant on flowering and growth

parameters. The grain yield ranged between 2.43 t/ha at 0 kg phosphorous and 2.67 to t/ha at applications of 69 kg phosphorous per ha. Besides, total biomass was also significantly influenced by phosphorous and ranged between 4.4 t/ha at control to 4.87 t/ha at rate of 69 kg p/ha. The highest phosphorous use efficiency (48.3%) was obtained at 69 kg p/ha and increased with increasing rates of phosphorous application, whereas apparent phosphorous recovery was found to be highest at 46 and 69 kg p/ha respectively. Both agronomic and physiological phosphorous use efficiencies of the crop were highest at the rate of 69 kg p/ha. Therefore, Wolimera and Birukit with application of 69 kg p/ha are recommended for field pea production at Duna area.

Kharbamon *et al.* (2016) tried to find out the availability of vegetables during off-season with higher yield an experiment was conducted to study the response of semi-dwarf photo-insensitive line of dolichos bean (RCDL-10) to time of planting (May, June, July, August, September and October) and graded dosage of phosphorus (30, 40, 50 and 60 kg/ha P_2O_5) for growth, flowering behavior, yield and quality traits. Longest vine (331.16 cm) and highest number of primary branches (15.31) were recorded in the July sowing whereas, shortest vine length (158.66 cm) and lowest number of branches per plant was recorded in October sowing (10.08). May sowing took the least number of days to complete the physiological and developmental stages. May planting gave the highest yield (168.70 g/plant) and yield attributes as well as highest crude protein (25.3%) content of the pods. Similarly, phosphorus dose of 60 kg/ha recorded the highest plant growth, number of flowers per panicle (9.41), yield (123.04 g/plant) and maximum crude protein content (25.22 %) of the pods as compared to the lower dosage. Hence, photo-insensitive line RCDL-10 can be cultivated as an off season crop during may having higher yield with the application of 60 kg P_2O_5/ha.

Akhtar *et al.* (2003) evaluate the growth and yield response of pea (P*isum sativum*) crop to phosphorus and potassium application Phosphorus (0, 23, 46 or 69 kg P_2O_5/ha) and potassium (0, 50, 100 or 150 kg K_2O/ha) were applied in

different combinations to pea cv. Samrina Zard at the time of seed bed preparation. Nitrogen level (46 kg N/ha) was kept constant and applied in two split doses, i.e. half at the time of sowing while the other half was applied before flowering. Vine length, number of pods per plant, pod length, number of grains per pod and green pod yield were significantly affected by the levels of P_20_5. Number of grains pod and green pod yield were maximum at the highest dose of P_2O_5 (69 kg/ha). However, vine length, number of pods per plant and pod length increased up to the level of 46 kg P_2O_5 per ha. Application of K_2O to the crop up to the dose of 100 kg/ha had significant positive effect on all the parameters studied, beyond this dose further application of K_20 was ineffective. As combined effect of P_2O_5 and K_2O is concerned, it significantly influenced the pod length and green pod yield. Maximum pod length was attained when 69 or 46 kg P_2O_5/ha was applied in combination with 100 or 150 kg K_2O /ha. Green pod yield was maximum at 69 kg P_2O_5/ha × 100 or 150 kg K_2O/ha.

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

Srivastava and Varma (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.* (1997) 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 *Rhizobium* inoculants 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 *Rhizobium* inoculants in association with Mo and B.

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.

Singh and Prasad (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_5/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 al.* (1991) studied the response of pea to different levels of P (40, 80and 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, Missorie rock phosphate (MRP) alone or MRP + seed inoculation with Pseudomonas strain. SSP in

powder and granular forms produced similar growth 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.

Naik *et al.* (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 TDM yield and P uptake of peas were studied at flowering and maturity. P application increased total TDM 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 and Kamath (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.

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* inoculants 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* inoculants.

Naik (1989) carried out an experiment in 1983-84 at Ranchi, Bihar with garden pea with the cultivar Bonneville, spaced at 30×5, 30×10 or 30×15 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).

Chapter III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

There are many information require to conducted this experiment, these includes this chapter regarding methodology that was used in execution of the experiment. It contains a short description of location of the experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Experimental period

The experiment was conducted from October 2017 to March 2018

3.2 Location of the experimental plot

The experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from October 2017 to March 2018. The experimental site is situated between 23.5^0 E latitude and 90.2^0 N longitude and the altitude of 8.2 m from the sea level.

3.3 Characteristics of soil

The characteristic of the soil of the experiment site was Non- calcareous, dark gray, medium high land. The texture of soil was silty loam with a pH 5.6. The experimental plot soil samples were collected from a depth of 0 to 15 cm before conducting the experiment. Soil was analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka. The experimental site was a medium high land (Appendix- IA).

3.4 Climatic condition

The experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season and scanty in the Rabi season (October, 2017 to March, 2018). There was no rainfall during the month of October, November, December and January. The average maximum

temperature during the period of experiment was 26.5˚C and the average minimum temperature was 12.4˚C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Weather Station of Agargoan, Dhaka (Appendix- IA).

3.5 Agro-ecological region

The experimental site belongs to the agro-ecological region of the Modhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces related with either shallow or broad, deep valleys.

3.6 Planting materials

The variety BARI Motorshuti-3 was used as the test variety of the crop. The seeds was collected from the Horticulture Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI Motorshuti-3 was the released variety of garden pea, which was recommended by the national seed board.

3.7 Experimental treatments

There are two factors in the experiment

Factor A: Three levels of sowing time

1) S_1: 15 November
2) S_2: 25 November
3) S_3: 5 December

Factor B: Four levels of Phosphorus

1) P_0: Control (No Phosphorus)
2) P_1: 50 kg P_2O_5 /ha
3) P_2: 75 kg P_2O_5 /ha
4) P_3: 100 kg P_2O_5 /ha

There was (3×4) treatments combination such as

1. S_1P_0
2. S_1P_1
3. S_1P_2
4. S_1P_3
5. S_2P_0
6. S_2P_1
7. S_2P_2
8. S_2P_3
9. S_3P_0
10. S_3P_1
11. S_3P_2
12. S_3P_3

3.8 Experimental 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 equal three blocks and each block consist of 12 units of plots. Each unit of plot was 1m × 0.6 m in size. All together there were 36 plots in experiment. Distance between replication was 1 m and plot to plot was 0.5 m. The treatments were assigned randomly to each block as per design of the experiment.

3.9 Cultivation procedure

3.9.1 Land preparation

The land was preparation was started at 23 October 2017 by ploughing and cross ploughing followed by laddering. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the field. The first ploughing and the final land preparation was done on23 October 2017 and 05 November 2017 respectively. The layout of the experiment was done in accordance with the design adopted. Finally, individual plots were prepared by using spade before organic manure (15 t/ha) application.

3.9.2 Application of manure and fertilizer

Well decompose cow dung was used as manure applied before final land preparation at the rate of 15 ton per hectare. Required amounts of phosphorus fertilizers were applied as per treatments and all other fertilizers were applied

in final plots preparation for each sowing time as basal dose, according to the Fertilizer Recommendation Guide (BARC, 2014). Half of nitrogen and whole of phosphorus according to treatment 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 (ZnSO4) and Gypsum ($CaSO_4$. $2H_2O$), respectively. The fertilizers were mixed thoroughly with the soil and rest nitrogen was applied in two equal splits on 05 December and 25 December, 2017 for first time sowing; for second time sowing it was done at 15 December, 2017 and 05 January, 2018 and for third sowing it was done at 25 December, 2018 and 15 January, 2018.

Table 01. Dose and application of manure and fertilizer in pea

Nutrient	**Dose/ha**	**Dose/plot**
Nitrogen (N)	130 kg N/ha	10 g
Phosphorus (P)	0, 50, 75 and 100 kg P_2O_5/ha (as per treatment)	0 g, 6.5g, 9.5 g and 12.5 g (as per treatment)
Potassium (K)	100 kg K_2O/ha	8 g
Sulphur (S)	10 kg S/ha	1 g
Zinc (Zn)	2 kg Zn/ha	250 mg

Source: Fertilizer Recommendation Guide (BARC, 2014).

3.9.3 Sowing of seeds

Seeds were sown in each row at a depth of 3.0 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands .The sowing was done on 15 November, 25 November and 05 December 2017 with a spacing of 25 cm ×15 cm. The seeds were covered with loose soil. For each time sowing seeds were treated with vitavex-200 @ 3g/kg seed for preventing soil borne disease.

3.9.4 Intercultural operations

3.9.5 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.

3.9.6 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.

3.9.7 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 to 10 days depending on soil moisture content.

3.9.8 Staking

After 30 days of seed sowing, staking was done with the help of bamboo split.

3.9. 9 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.

3.9.10 Harvesting

Harvesting was done according to its maturity. Green pods were harvested at tender stage on 25 January, 2018 for first time sowing, it was done on 15 February for second time sowing and for third time sowing it was done on 20

February. After harvest pods were separated from plants. Then plants and pods were weighed.

3.10 Methods of data collection

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:

3.10.1 Plant height

The plant height was measured at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.10.2 Days to first flowering

It was time duration between germination to first flowering. Date of germination of seeds to date of first flowering was recorded.

3.10.3 Grain growth duration

It was time duration between first flowering to harvesting .Total number of days from first flowering to harvesting of green pod was recorded.

3.10.4 Number of pods per plant

Numbers of total pods of selected plants from each plot was counted and the mean numbers was expressed as per plant basis. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.10.5 Pod length (cm)

Pod length was taken of randomly selected ten pods and the mean length was expressed in cm.

3.10.6 Pod breadth (cm)

Pod breadth was taken of randomly selected ten pods and the mean length was expressed in cm.

3.10.7 Green pod yield per plant (g)

The weight of green pods per plant was recorded from randomly selected 10 plants at the time of harvest. Data was recorded as the average of 10 plants from each plot.

3.10.8 Weight of 10 green pods (g)

Ten cleaned, green pods from each treatment was counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.10.9 Number of seeds per pod

The number of seeds/pod was recorded from randomly selected 10 pods at the time of harvest. Data was recorded as the average of 10 pods from each plot.

3.10.10 Weight of 100 green seeds (g)

One hundred cleaned, green seeds from each treatment was counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.10.11 Dry matter percentage of plant (%)

A sample of 100 g of plants was collected and dried under direct sunshine for 72 hours and then dried in an oven at 70^0C for 3 days. After oven drying, plants were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight of plants}}{\text{Fresh weight of plants}} \text{ x } 100$$

3.10.12 Green pod yield per plot (g)

The pod collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken in gram.

3.10.13 Green pod yield per hectare (t)

The pod collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken and converted the yield in t/ha.

3.10.14 Green seed yield per plot (g)

The seeds are collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of seeds was taken in gram (g).

3.10.15 Green seed yield per hectare (t)

The seeds are collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken and converted the yield in t/ha.

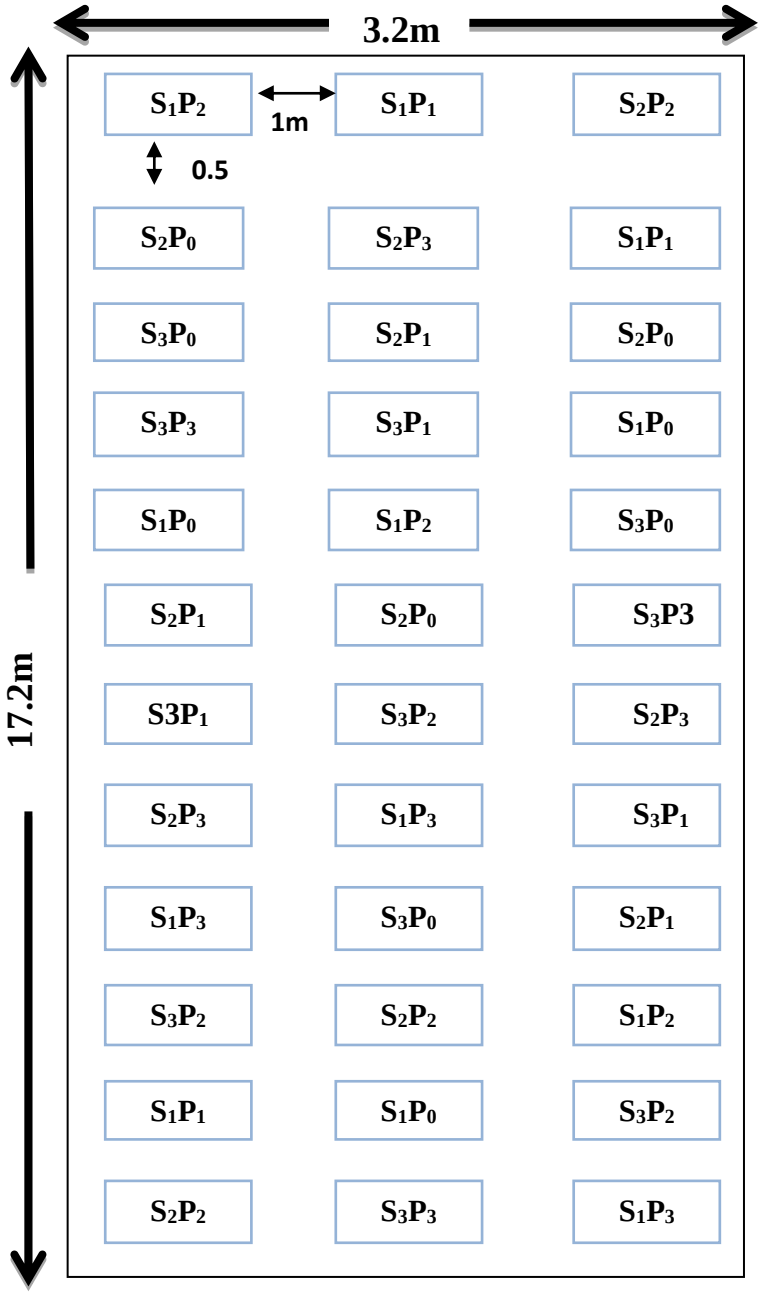
3.11 Statistical analysis

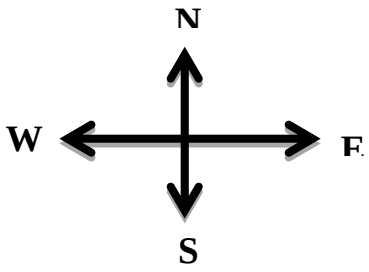
The data obtained were statistically analyzed to find out the variation resulting from experimental treatments following F-variance test. The difference between treatments was adjusted by Least Significant Difference Test (LSD) (Gomez and Gomez, 1984).

3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different sowing time and different levels of phosphorus for garden pea cultivation. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of garden pea was considered as local market for estimating the cost and return. Economic analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return (TK.)}}{\text{Cost of production (TK.)}}$$





Plot size: 1 m × 0.6 m

Spacing: 25 cm × 15 cm

Spacing between plot: 50 cm

Spacing between row: 1.0 m

Factor A: Three levels sowing time

i. S_1=15 November
ii. S_2=25 November
iii. S_3=5 December

Factor B: four level of Phosphorus

i. P_0= Control(No Phosphorus)
ii. P_1=50 kg P_2O_5 /ha
iii. P_2=75 kg P_2O_5 /ha
iv. P_3=100 kg P_2O_5 /ha

Fig. 1. Layout of the experimental Plot

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of date of sowing and phosphorus dose on growth and yield of garden pea. Data on different growth characters yield and yield related characters were recorded. The findings of the experiment have been presented and discussed with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Plant height

Days of sowing exhibited a significant influence on the plant height of garden pea after different days of sowing time at 30, 45 days after sowing (DAS) and at harvesting (Table 2, Appendix II). At 30 DAS the tallest (27.87 cm) plant was found from 25 November sowing (S_2) and the shortest (23.57 cm) plant was found from 5 December sowing (S_3). At 45 DAS, the tallest (39.05 cm) plant height was recorded from 25 November sowing (S_2) and the shortest plant (34.55 cm) was found from 5 December sowing (S_3). At harvesting, tallest plant height (46.72 cm) was recorded from 25 November sowing (S_2) and shortest plant (41.37 cm) was recorded from 5 December sowing (S_3). It was observed that plant height reached its maximum stage at harvest in all the treatments. The highest plant height was obtained from 25 November sowing (S_2). This height was due to the temperature variation. Similar results had been reported by Sharma *et al.* (1997).

Plant height of garden pea influenced significantly by the application of different levels of phosphorus (Table 3, Appendix II). Plant height of pea varied with the variation of phosphorus dose. Most of the treatments recorded significantly higher plant height over control. The highest plant height for 30 DAS was (29.43 cm) was found in 75 kg P_2O_5/ha (P_2) and the smallest plant height (21.60 cm) was found from control (P_0) treatment. At 45 DAS, tallest plant height (40.46 cm) was recorded from 75 kg P_2O_5/ha (P_2) and the shortest

plant (32.43 cm) was recorded from control (P_0) treatment. At harvesting, the tallest plant (48.56 cm) was recorded from 75 kg P_2O_5/ha (P_2) and the shortest plant (39.46 cm) was recorded from control (P_0) treatment. Solaiman (1999) reported that P and K application resulted significant increases of plant height. Kanauija *et. al.* (1997) also found that growth increased significantly with increasing levels of phosphorus (0, 30, 60 kg/ha).

Table 2. Effect of different sowing time on plant height of garden pea

Treatments	Plant height at 30 DAS	Plant height at 45 DAS	Plant height at harvest
S_1	26.85 b	37.70 b	44.80 b
S_2	27.87 a	39.05 a	46.72 a
S_3	23.57 c	34.55 c	41.37 c
CV%	7.68	8.82	11.70
LSD	0.54	0.87	1.37

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing ;
DAS= Days after sowing.

Table 3. Effect of different levels of phosphorus on plant height of gardenpea

Treatments	Plant height at 30 DAS	Plant height at 45 DAS	Plant height at Harvest
P_0	21.60 d	32.43 d	39.46 c
P_1	25.96 c	36.90 c	43.93 b
P_2	29.43 a	40.46 a	48.56 a
P_3	27.40 b	38.60 b	45.23 b
CV%	7.68	8.82	11.70
LSD	0.63	1.02	1.59

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha;
DAS= Days after sowing.

Table 4. The combined effect of sowing time and different levels of phosphorus on plant height of garden pea

Treatments	Plant height at 30 DAS	Plant height at 45 DAS	Plant height at Harvest
S_1P_0	21.90 i	32.20 jk	39.50 hi
S_1P_1	26.80 ef	37.60 ef	44.80 c-e
S_1P_2	30.30 b	41.40 b	48.80 b
S_1P_3	28.40 cd	39.60 cd	46.10 b-d
S_2P_0	22.50 hi	33.80 ij	40.60 g-i
S_2P_1	27.60 de	38.70 de	45.60 cd
S_2P_2	32.20 a	43.20 a	53.40 a
S_2P_3	29.20 c	40.50 bc	47.30 bc
S_3P_0	20.40 j	31.30 k	38.30 i
S_3P_1	23.50 h	34.40 hi	41.40 f-h
S_3P_2	25.80 f	36.80 fg	43.50 d-f
S_3P_3	24.60 g	35.70 gh	42.30 e-g
CV%	7.68	8.82	11.70
LSD	1.09	1.74	2.75

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha ;
DAS= Days after sowing.

The plant height was significantly influenced by the combined effect of the date of sowing and phosphorus dose at 30, 45 DAS and at harvesting (Table 4, Appendix II). At 30 DAS, the highest plant height (32.20 cm) was measured from the S_2P_2 (25 November sowing with 75 kg P_2O_5) treatment combination and the lowest (20.40 cm) was recorded from S_3P_0 (5 December sowing with no phosphorus) treatment combination. At 45 DAS, the highest plant height (43.20 cm) was measured from S_2P_2 (25 November sowing with 75 kg P_2O_5) treatment

combination and the lowest (31.30 cm) from S_3P_0 (5 December sowing with no phosphorus) treatment combination. At harvesting, the highest plant height (53.40 cm) was measured from S_2P_2 (25 November sowing with 75 kg P_2O_5) treatment combination and the lowest (38.30 cm) from S_3P_0 (5 December sowing with no phosphorus) treatment combination. From the results, it is inferred that the variation of plant height of garden pea depend on the variation of sowing time and phosphorus levels. Plant height continued to increase up to the maturity. In this study it was observed that, 25 November sowing plant with 75 kg P_2O_5 gave the highest plant height. Hence it may be fact that 25 November sowed crops possibly got favorable environmental condition for better vegetative growth and balanced nutrient absorption which ultimately increases plant height of garden pea. This result is in agreement with the findings of Uzan and Acikgoz (1998).

4.2 Days to first flowering

Sowing time had a significant effect on the days to first flowering (Fig. 2, Appendix III). Early sowing plants require significantly more time compared to late sown plants for first flowering. Sowing on S_3 (5 December) took the shortest time (24.25 days) and S_2 (25 November) sowing took maximum time (28 days) to first flowering; it was differed significantly of the other sowing dates. For inducing flower, cool temperature is required which was not available during early sowing. For this reason early sown plants took more time for completing the vegetative growth for first flowering. Shinohara (1989) reported that, in all type pea variety flowering individual in low temperature. Gilliand and Hang (1984) reported that days to first flower and maturity varied year to year with temperature.

There was significant variation was found on the days to first flowering due to the application of different levels of phosphorus (Fig. 3, Appendix III). This might be due to the fact that optimum absorption of phosphorus nutrients might improve physiological activities which resulted endogenous growth resulting

maximum days for flowering in plants. From this experiment it showed that P_2 (75 kg P_2O_5/ha) treatment took maximum days (27.02)for flower initiation and P_0 (Control) treatment took minimum days (25.30) for flower initiation. Phosphorus helps to increase first flowering days of pea.

Combined effect was found significantly influenced due to the different date of sowing and phosphorus application dose on the days to first flowering (Fig 4, Appendix III). At S_2 (25 November) sowing with different phosphorus dose combination took maximum dates to first flowering. Here, S_2P_2 (25 November sowing with 75 kg P_2O_5/ha) treatment took maximum days (28.5) to first flower initiation, on the other hand, At S_3 (5 December) sowing with different phosphorus dose combination took minimum dates for first flowering. Here, S_3P_0 (5 December sowing with no phosphorus) treatment took minimum days (23.5) to first flowering. In the present study it was observed that first flowering time varied with change of sowing time and different levels of phosphorus application. This might due to the fact that optimum sowing time and phosphorus involved in the reproductive process of plants and influence induced first flowering.

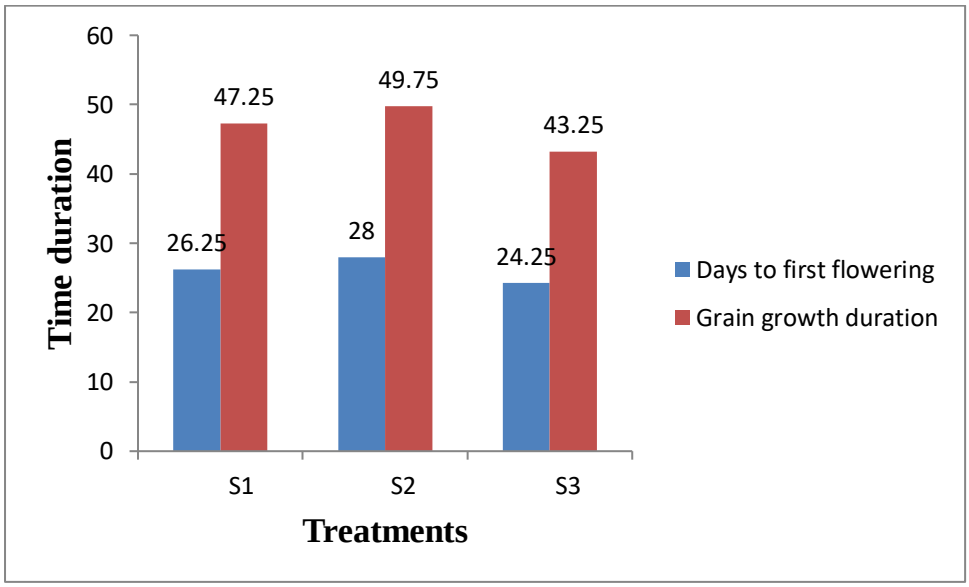


Fig. 2. The effect of different sowing time on yield and yield attributes of garden pea.

Here, S_1=15 November sowing, S_2=25 November sowing, S_3=5 December sowing

4.3 Grain growth duration

Noticeable significant variation was observed among different date of sowing on grain growth duration (Fig 2, Appendix III). Grain growth duration of S_2 (25 November) treatment and S_1 (15 November) treatment were longer due to low temperatures (Min. 12.13 - 12.63 °C and Max 23.03 - 23.54 °C) prevailed at those time that might prolonged the grain growth period (47-51 days). On the contrary, S_3 (5 December sowing) treatment received high temperatures (Min. 13.36- 14.23 °C and Max 25.58- 26.61 °C) that shorten the grain growth period of BARI Motorshuti-3 (41-45 days). S_2 (25 November sowing) treatment requires 49.75 days for grain growth and S_3 (05 December sowing) treatment requires 43.25 days. Similar results were observed by Gardner *et al.* (1985), Savin and Nicolas (1996) who reported that high temperature reduced the length of reproductive period.

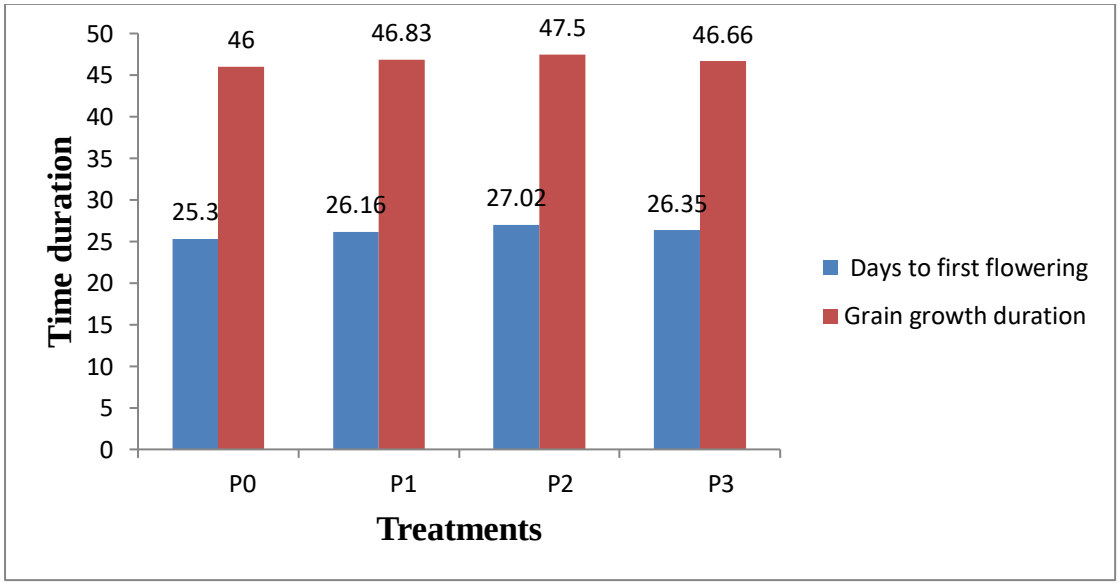


Fig. 3. The effect of different levels of phosphorus on yield and yield attributes of garden pea.

Here, P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

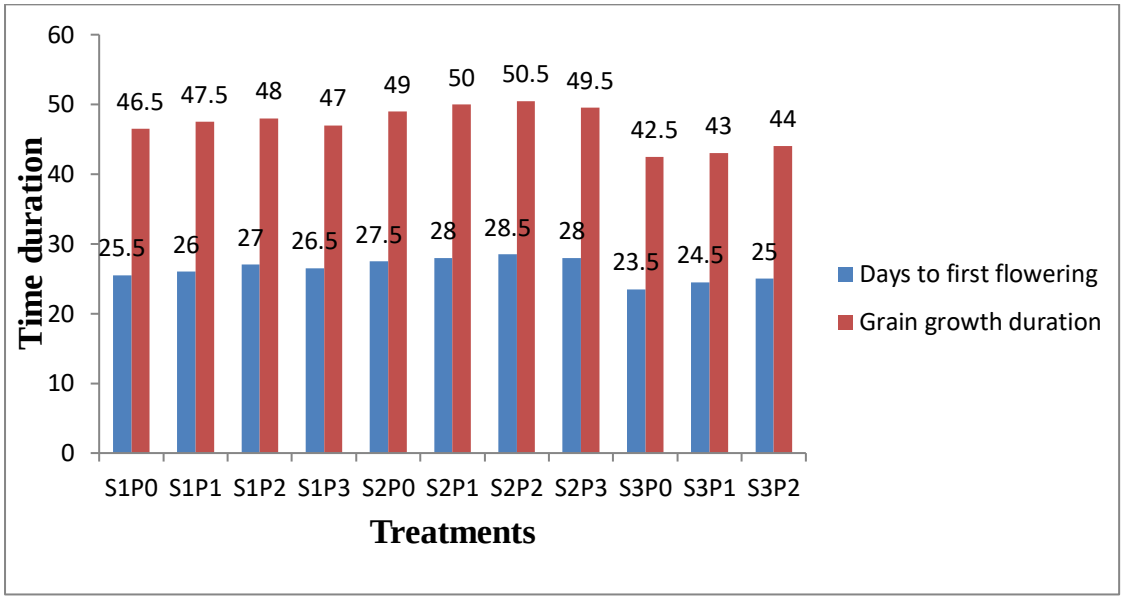


Fig. 4. The combined effect of sowing time and different levels of phosphorus on yield and yield attributes of garden pea.

Here, S_1=15 November sowing, S_2=25 November sowing, S_3=5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

Noticeable significant variation was observed among different levels of phosphorus application on grain growth duration (Fig 3, Appendix III). Grain growth duration increased with increasing levels of potassium. For P_0 (control) treatment it requires 46 days which is minimum than other treatment. In P_2 (75 kg P_2O_5/ha) treatment, it requires 47.50 days which is maximum than other treatment.

The combined effect of different sowing time and phosphorus on grain growth duration of garden pea showed significant difference (Fig 4, Appendix III). S_2P_2 (25 November sowing with 75 kg P_2O_5/ha) treatment requires maximum 50.50 days and S_3P_0 (5 December sowing with no phosphorus) treatment requires minimum 42.50 days for grain growth.

4.4 Number of pods per plant

Among the yield contributing characters, number of pods per plant is one of the most important yield contributing character in garden pea. Yield per unit area is the function of number of pods per plants (Table 5, Appendix III). The number

of pods per plant was significantly influenced by different sowing time. The number of pods per plant ranged from 10.45 to 12.10. The highest number of green pods per plant (12.10) was recorded from S_2 (25 November sowing) treatment and the lowest number of pods per plant (10.45) was found in S_3 (5 December sowing) treatment. Similar findings have been reported by Shaukat *et al.* (2012).

The effect of different levels of phosphorus on number of pods per plant was statistically significant (Table 6, Appendix III). The number of pods per plant ranged from 9.63 to 12.70. The highest number of green pods per plant (12.70) was recorded from the P_2 (75 kg P_2O_5/ha) treatment and the lowest number of pods per plant (9.63) was found in the P_0 (control) treatment. Vijay *et al.* (1990) reported that the highest number of pods per plant of garden pea was obtained with higher doses P application. Sinha *et al.* (2000) also reported that phosphorus application greatly improves the yield attributes, i.e., pods per plant and grains per pod.

Combined effect of different sowing time and phosphorus showed a significant variation on the number of pods per plant (Table 7, Appendix III). Plant sowing S_2P_2 (25 November sowing along with 75 kg P_2O_5/ha) treatment produced the highest number of pods per plant (13.60). This treatment was statistically similar with S_2P_3, S_1P_2 and S_1P_3 treatment combination, respectively. The lowest number of pods per plant 9.30 found in the treatment of S_3P_0 (5 December sowing with no phosphorus). The contribution of sowing time and phosphorus on increasing the pod number was remarkable. It was resemblance with the findings of Rahman *et al.* (1994). They reported that, phosphorus fertilizer produces significantly the highest number of pods and seeds per pod in chick pea.

4.5 Pod length

The pod length differed significantly observed due to the effect of different date of sowing (Table 5, Appendix IV). The length of pods ranged from 7.13 to 8.30 cm .The highest pod length (8.30 cm) was recorded in S_2 (25 November

sowing) treatment. The lowest pod length (7.13 cm) was found in S_3 (5 December sowing) treatment. There was linear decrease in pod length with delayed sowing of 25 November. In early sowing the temperature was optimum for plant growth and development which resulted in vigorous plants with long pods. These results are in agreement to the findings obtained by Tiwari *et al.* (2014).

Table 5. The effect of different sowing time on yield and yield attributes of garden pea

Treatments	Number of pods/plant	Pod length (cm)	Pod breadth (cm	Green Pod yield/plant (g)
S_1	11.70 b	7.98 b	1.35 a	42.07 b
S_2	12.10 a	8.30 a	1.37 a	45.52 a
S_3	10.45 c	7.13 c	1.27 b	33.10 c
CV%	9.26	10.05	6.46	7.46
LSD	0.42	0.29	0.03	1.55

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing

Significant variation was observed among the phosphorus levels in respect of pod length of garden pea (Table 6, Appendix IV). The length of pods ranged from 8.68 to 6.44 cm. The highest pod length (8.68 cm) was recorded from P_2 (75 kg P_2O_5/ha) treatment and the lowest pod length (6.44 cm) was found in P_0 (control) treatment. It may be fact that optimum levels of phosphorus play more role in vegetative growth and resulting in increasing pod length.

The combined effect of sowing time and phosphorus on the pod length was significant (Table 7, Appendix IV). The length of pods ranged from 6.16 to 9.32 cm. The highest pod length (9.32 cm) was recorded from the treatment combination of S_2P_2 (25 November sowing along with 75 kg P_2O_5/ha) which was statistically similar with S_1P_2 (8.92 cm), S_2P_3 (8.72 cm) and S_1P_3 (8.54 cm)

treatments, respectively. The lowest pod length (6.16 cm) was found in the S_3P_0 (5 December sowing with no phosphorus) treatment.

4.6 Pod breadth

Marked variation was noted on the different sowing time as to the pod breath (Table5, Appendix IV). The pod breadth ranged from 1.27 to 1.37 cm .The highest pod breadth (1.37 cm) was recorded from S_2 (25 November sowing) treatment and the lowest p od breadth (1.27 cm) was found in S_3 (5 December sowing) treatment. This probably due to the fact that early sowed crops enjoyed better climatic conditions for maximum vegetative growth than later sowed crop, which resulted in increase of breadth of pod.

Distinct variation was observed different levels of phosphorus in respect of pod breadth (Table 6, Appendix IV). The breadth of pods ranged from 1.23 to 1.40 cm. The highest pod breadth (1.40 cm) was recorded from P_2 (75 kg P_2O_5/ha) treatment and the lowest pod breadth (1.23 cm) was found in the P_0 (control) treatment.

Table 6. Effect of different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Number of pods/plant	Pod length (cm)	Pod breadth (cm	Green Pod yield/plant (g)
P_0	9.63 c	6.44 c	1.23 c	27.90d
P_1	11.33 b	7.87 b	1.33 b	39.13c
P_2	12.70 a	8.68 a	1.40 a	48.90a
P_3	12.00 b	8.22 b	1.35 b	45.00b
CV%	9.26	10.05	6.46	7.46
LSD	0.51	0.32	0.03	1.79

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

The combined effect of different dates of sowing and phosphorus levels on pod breadth was significant (Table 7, Appendix IV). The breadth of green pods ranged from 1.20 to 1.45 cm. The highest pod breadth (1.45 cm) was obtained from the treatment combination of S_2P_2 (25 November sowing with 75 kg P_2O_5/ha) which was statically similar with S_1P_2 and the lowest pod breadth (1.20 cm) was obtained from the S_3P_0 (5 December sowing with no phosphorus) treatment.

4.7 Green pod yield per plant (g)

Statistically significant variation was recorded in terms of pod yield per plant of garden pea due to different dates of sowing (Table 5, Appendix IV). The highest pod yield per plant (45.52 g) was recorded from S_2 (25 November sowing) treatment whereas the lowest pod yield per plant (33.10 g) was observed from S_3 (5 December sowing) treatment. This was probably due to 25 November sowed plant receive comparatively favourable environment for higher vegetative growth. The temperature prevailed during the time was perhaps favorable for maximum vegetative growth of plant and lead to formation of higher photosynthetic products which resulted in higher production of pods per plant. This study indicated that raise in temperature reduced the grain growth duration resulted in yield reduction, which is in agreement with the findings of Mohanty *et. el.*(2001) and Bosswell (1926).

Different levels of phosphorus showed statistically significant differences on pod yield per plant of garden pea (Table 6, Appendix IV). The highest pod yield per plant (48.90 g) was found from P_2 (75 kg P_2O_5/ha) treatment, while the lowest pod yield per plant (27.90 g) was found from P_0 (control) treatment. Pod yield of garden pea was gradually increased with increasing level of phosphorus up to 75 kg P_2O_5 per hectare then decreased. These findings have the resemblance with the result of Srivastava *et al.* (1998).

Combined effect of different date of sowing and phosphorus levels varied significantly in terms of pod yield per plant of garden pea (Table 7, Appendix

IV). The highest pod yield/plant (57.70 g) was recorded from the treatment combination of S_2P_2 (25 November sowing with 75 kg P_2O_5/ha). On the other hand, the lowest pod yield/plant (25.40 g) was found from S_3P_0 treatment combination which was statistically similar (27.90 g) to S_1P_0 (15 November sowing with no phosphorus) treatment combination.

Table 7. The combined effect of owing time and different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Number of pods/plant	Pod length (cm)	Pod breadth (cm	Green Pod yield/plant (g)
S_1P_0	9.60 gh	6.32 gh	1.24 gh	27.90 hi
S_1P_1	11.60 c-f	8.16 b-d	1.34 c-e	40.50 e
S_1P_2	13.20 ab	8.92 ab	1.42 ab	52.40 b
S_1P_3	12.40 a-d	8.54 a-c	1.38 b-d	47.50 cd
S_2P_0	10.00 gh	6.85 f-h	1.26 f-h	30.40 gh
S_2P_1	12.00 b-e	8.32 bc	1.36 b-d	44.40 d
S_2P_2	13.60 a	9.32 a	1.45 a	57.70 a
S_2P_3	12.80 a-c	8.72 ab	1.40 bc	49.60 bc
S_3P_0	9.30 h	6.16 h	1.20 h	25.40 i
S_3P_1	10.40 f-h	7.14 e-g	1.28 e-g	32.50 g
S_3P_2	11.30 d-f	7.80 c-e	1.33 d-f	36.60 f
S_3P_3	10.80 e-g	7.41 d-f	1.27 fg	37.90 ef
CV%	9.26	10.05	6.46	7.46
LSD	1.24	0.86	0.06	3.10

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

4.8 Weight of 10 green pods (g)

Different date of sowing varied significantly in terms of weight of 10 green pods of garden pea (Table 8, Appendix V). The highest weight of 10 green

pods (36.12 g) was found from S_2 (25 November sowing) treatment, while the lowest weight of 10 green pods (30.22 g) was recorded from S_3 (5 December sowing) treatment.

Weight of 10 green pods showed statistically significant differences due to different levels of phosphorus (Table 9, Appendix V). The highest weight of 10 green pods (37.50 g) was recorded from P_2 (75 kg P_2O_5/ha) treatment, whereas the lowest weight of 10 green pods (27.41) was observed from P_0 (control) treatment.

Statistically significant variation was recorded due to the combined effect of different sowing time and phosphorus levels in terms of weight of 10 green pods of garden pea (Table 10, Appendix V). The highest weight of 10 green pods (40.40 g) was observed from S_2P_2 (25 November sowing with 75 kg P_2O_5/ha) treatment which was statistically similar with (39.60 g) S_1P_2 treatment combination and the lowest weight of 10 green pods (25.50 g) was recorded from S_3P_0 (5 December sowing with no phosphorus) treatment combination.

4.9 Number of seeds per pod

Number of seeds per pod significantly differed due to different time of sowing (Table 8, Appendix V). The maximum number of seeds per pod (4.62) was found from S_2 (25 November sowing) treatment which was statistically identical (4.46) with S_1 (15 November sowing) treatment while the lowest number of seeds per pod (3.96) was obtained in S_3 (5 December sowing) treatment. November 25 sowing received lower day/night temperature for long time that causes longer crop growth duration specially the grain growth period, so pods per plant, seeds per pod and 1000-seed weight is more than the other sowing period. Similar results were recorded by Peterson and Loomis (1949) in Kentucky bluegrass.

Different levels of phosphorus application had also significant effect on the number of seeds per pod (Table 9, Appendix V). The number of seed per pod ranged from 3.60 to 4.90. The highest number of seeds per pod (4.90) was

obtained when the application of phosphorus with P_2 (75 kg P_2O_5/ha) treatment and the lowest number of seeds per pod (3.60) was obtained in the P_o (control) treatment. It was also observed that the numbers of seeds per pod were increased with increase of phosphorus levels up to 75 kg P_2O_5 /ha and then decresed. Similar results have been reported by previous workers in French bean by Parmar *et al.,* (1999). It was also resemblance with the findings of Rahman *et al*. (1994) who reported that phosphorus fertilizer produced significantly the highest number of seeds per pod in chickpea.

Table 8. The effect of different sowing time on yield and yield attributes of garden pea

Treatments	Weight of 10 green pods (g)	Number of seeds/pod	Weight of 100 green seeds (g)
S_1	34.87 b	4.46 a	23.07 a
S_2	36.12 a	4.62 a	23.70 a
S_3	30.22 c	3.96 b	21.15 b
CV%	8.12	9.13	11.54
LSD	1.13	0.27	0.86

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing

The combined effects of different sowing time and application of phosphorus on seeds per pod was found to be significant (Table 10, Appendix V). The number of seeds per pod ranged from 3.40 to 5.35. The highest number of seeds per pod (5.35) was obtained from the S_2P_2 (25 November sowing with 75 kg P_2O_5/ha) treatment combination, which was statistically similar (5.00) with that of S_1P_2 treatment combination. The lowest number of seeds per pod (3.40) was obtained from the S_3P_0 (5 December sowing with no phosphorus) treatment combination.

4.10 Weight of 100 green seeds

The effects of different sowing time significantly on 100 green seeds weight of garden pea (Table 8, Appendix V). The ranges of 100 green seeds weight of garden pea were 21.15 g to 23.70 g. The highest weight of 100 green seeds (23.70 g) found from S_2 (25 November sowing) treatment and lowest weight of 100 green seeds (21.15 g) were found in S_3 (05 December sowing) treatment. Similar results were recorded by Gardner and Loomis (1953) in orchard grass, Lindsey and Peterson (1964) in *Poa pratensis* L.

Table 9. Effect of different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Weight of 10 green pods (g)	Number of seeds/pod	Weight of 100 green seeds (g)
P_0	27.41 d	3.60 c	20.06 c
P_1	34.06 c	4.31 b	22.43 b
P_2	37.50 a	4.90 a	24.70 a
P_3	35.98 b	4.58 b	23.36 b
CV%	8.12	9.13	11.54
LSD	1.31	0.31	1.03

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

There was a significant difference on 100 green seeds weight among the different levels of phosphorus (Table 9. Appendix V). The weight found from 20.06 g to 24.70 g. The highest weight of 100 green seeds were found (24.70 g) in P_2 (75 kg P_2O_5/ha) treatment and lowest weight of 100 green seeds were found (20.06 g) in the P_0 (control) treatment.

The combined effect of different sowing time and application of different levels of phosphorus on weight 100 green seeds was found significant (Table 10, Appendix V). Treatment combinations of S_2P_2 (25 November sowing

combined with 75 kg P_2O_5/ha) recorded higher 100 green seeds weight (26.40 g) which was statistically similar with S_1P_2 (25.50 g) treatment combination and lowest weight of 100 green seeds was found (19.30 g) in S_3P_0 (5 December sowing with no phosphorus) treatment combination. Result revealed that the combination of different sowing time and phosphorus application might have led to better vegetative growth of pea plants and ultimately produced the larger seeds.

Table 10. The combined effect of sowing time and different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Weight of 10 green pods	Number of seeds/pod	Weight of 100 green seeds (g)
S_1P_0	27.50 hi	3.65 fg	20.10 hi
S_1P_1	34.70 de	4.45 c-e	22.80 c-f
S_1P_2	39.60 ab	5.00 ab	25.50 ab
S_1P_3	37.70 bc	4.75 bc	23.90 b-d
S_2P_0	29.25 gh	3.75 fg	20.80 g-i
S_2P_1	36.50 cd	4.55 b-d	23.20 c-e
S_2P_2	40.40 a	5.35 a	26.40 a
S_2P_3	38.35 bc	4.85 bc	24.40 bc
S_3P_0	25.50 i	3.40 g	19.30 i
S_3P_1	31.00 fg	3.95 ef	21.30 f-h
S_3P_2	32.50 ef	4.35 c-e	22.20 e-g
S_3P_3	31.90 f	4.15 d-f	21.80 f-h
CV%	8.12	9.13	11.54
LSD	2.17	0.54	1.73

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

4.11 Dry matter percentage of plant (%)

There was found significant difference among the different date of sowing on dry matter percentage of plant (Table 11, Appendix V). The highest dry matter percentage of plant (18.60) was recorded from S_2 (25 November sowing) treatment. The lowest dry matter percentage of plant (15.80) was recorded in S_3 (5 December sowing) treatment.

Dry matter percentage of plant was found significant variation due to the application of different levels of phosphorus (Table 12, Appendix V). The highest dry matter percentage of plant (20.06) was recorded in P_2 (75 kgP_2O_5/ha) treatment. The lowest dry matter percentage of plant (14.13) was recorded in P_0 (control) treatment.

The significant difference was found on dry matter percentage of plant due to the combination of different sowing dates with application of different levels of phosphorus (Table 13, Appendix V). The highest dry matter percentage of plant (21.50) was recorded in S_2P_2 (25 November sowing combined with 75 kg P_2O_5/ha) treatment combination, which was statistically similar with S_1P_2 (20.80) treatment combination. The lowest dry matter percentage of plant (13.50) was recorded in S_3P_0 (5 December sowing with no phosphorus) treatment combination.

4.12 Green pod yield per plot (g)

Distinct variation was found as to the green pod yield per plot due to different sowing time (Table 11, Appendix VI). The green pod yield ranged from 366.12 to 509.18 g per plot. The highest green pod yield (509.18 g/plot) was obtained when the crop was sown in S_2 (25 November) treatment. The lowest green pod yield (366.12 g/plot) was found when the crop was sown in S_3 (5 December) treatment. The difference in green pod yield per plot among the treatments can be explained that the 25 November plants reached favorable environment for proper growth and thus produced the maximum number of green pods, which

lead to the highest pod yield per plant and ultimately obtained highest pod yield per plot.

The green pod yield per plot was found significantly influenced by different levels of phosphorus application (Table 12, Appendix VI). Green pod yield of garden pea was gradually increased with increasing level of phosphorus up to 75 kg P_2O_5/ha and then decreased. The highest green pod yield (554.53 g/plot) was recorded in P_2 (75 kg P_2O_5/ha) treated plot. The lowest green pod yield (302.18 g/plot) was recorded in P_0 (control) treatment.

Table 11 . The effect of different sowing time on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield/plot (g)	Green pod yield/hectare (t)
S_1	17.77 b	478.40 b	7.96 b
S_2	18.60 a	509.18 a	8.48 a
S_3	15.80 c	366.12 c	6.09 c
CV%	6.39	7.31	9.87
LSD	0.77	5.71	0.32

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing

Combined effect of different sowing time and phosphorus levels found significantly influenced in producing green pod yield per plot (Table 13, Appendix VI). The highest average green pod yield of 630.24 g/plot was found in the S_2P_2 (25 November sowing combined with 75 kg P_2O_5/ha) treatment combination. The lowest yield of 269.28 g/plot was found in the S_3P_0 (5 December sowing with no phosphorus) treatment combination.

Table 12. Effect of different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield/plot (g)	Green pod yield/hectare (t)
P_0	14.13 d	302.18 d	5.03 d
P_1	17.10 c	446.96 c	7.45 c
P_2	20.06 a	554.53 a	9.23 a
P_3	18.26 b	500.81 b	8.34 b
CV%	6.39	7.31	9.87
LSD	0.89	8.90	0.37

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

4.13 Green pod yield per hectare (t)

The green pod yield per hectare was found significantly influenced by different sowing time (Table11, Appendix VI).The green pod yield ranged from 6.09 to 8.48 t/ha. The highest green pod yield (8.48 t/ha) was obtained when the crop was sown in S_2 (25 November) treatment. The lowest green pod yield (6.09 t/ha) was found when the crop was sown in S_3 (5 December). It might be fact that early sown got favorable environmental conditions for growth and development of pea plants, which encouraged higher growth and yield attributes and ultimately resulted in higher yield. These findings are corroborated with those reported by Singh and Singh (2011).

The green pod yield per hectare was found significantly influenced by different levels of phosphorus application (Table 12, Appendix VI). Green pod yield of garden pea was gradually increased with increasing level of phosphorus up to 75 kg P_2O_5/ha then decreased. The highest green pod yield (9.23 t/ha) was recorded in P_2 (75 kg P_2O_5/ha) treated plot. The lowest green pod yield (5.03 t/ha) was recorded in P_0 (control) treatment. Similar results with phosphorus application have been report by Verma *et al.* (1997).

Table 13. The combined effect of sowing time and different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield/plot (g)	Green pod yield/hectare (t)
S_1P_0	14.10 gh	300.30 k	5.00 h
S_1P_1	17.50 de	462.20 f	7.70 d
S_1P_2	20.80 ab	608.25 b	10.13 a
S_1P_3	18.70 cd	542.88 d	9.04 b
S_2P_0	14.80 f-h	336.96 j	5.61 g
S_2P_1	18.30 cd	508.08 e	8.46 c
S_2P_2	21.50 a	630.24 a	10.50 a
S_2P_3	19.80 bc	561.44 c	9.35 b
S_3P_0	13.50 h	269.28 l	4.48 h
S_3P_1	15.50 fg	372.00 i	6.20 f
S_3P_2	17.90 d	425.10 g	7.08 e
S_3P_3	16.30 ef	398.11 h	6.63 f
CV%	6.39	7.31	9.87
LSD	1.54	15.42	0.64

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

Combined effect of different date of sowing and phosphorus application showed significant influence on producing pod yield per hectare (Table 13, Appendix VI). The highest average green pod yield of 10.50 t/ha was obtained in the S_2P_2 (25 November sowing combined with 75 kg P_2O_5/ha) treatment combination, which was statistically identical (10.13 t/ha) to S_1P_2 treatment combination but was superior to the rest of the treatments. The lowest yield of

4.48 t/ha was recorded from the S_3P_0 (5 December sowing with no phosphorus) treatment combination.

4.14 Green seed yield per plot (g)

The green seed yield per plot was found significantly influenced by different sowing time (Table 14, Appendix VI). The highest seed yield (157.58 g/plot) was obtained was obtained when the crop was sown in 25 November (S_2) and lowest (102.36 g/plot) was obtained when the crop was sown in 05 December (S_3). This study indicated that rise in temperature reduced the grain growth duration resulted in yield reduction.

The seed yield per plot was significantly influenced by different levels of phosphorus application (Table 15, Appendix VI). The highest seed yield (180.82 g/plot) was obtained in P_2 (75 kg P_2O_5/ha) treated plot and the lowest (79.75 g/plot) was found in P_0 (control) treated plot. The seed yield of garden pea was gradually increased with increasing level of phosphorus up to 75 kg P_2O_5/ha and then decreased.

The combined effect of different sowing time and phosphorus application on seed yield per plot of garden pea was significant (Table 16, Appendix VI). Seed yield of pea varied significantly with the variation of different treatment combinations. All the treatment combinations produced significantly higher seed yield compared to control (no phosphorus) treatment. The highest average green seed yield of (220.33 g/plot) was found in the S_2P_2 (25 November sowing 2combined with 75 kg P_2O_5/ha) treatment combination which was out yielded the other treatment combinations. The lowest yield of (69.29 g/plot) was found in the S_3P_0 (5 December sowing with no phosphorus) treatment combination.

Table 14 . The effect of different sowing time on yield and yield attributes of garden pea

Treatments	Green seed yield/plot (g)	Green seed yield/hectare (t)
S_1	143.64 b	2.39 b
S_2	157.58 a	2.62 a
S_3	102.36 c	1.70 c
CV%	10.35	11.93
LSD	7.71	0.11

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing

4.15 Green seed yield per hectare (t)

The green seed yield per hectare was significantly influenced by different sowing time (Table 14, Appendix VI). The highest seed yield (2.62 t/ha) was obtained was obtained when the crop was sown in S_2 (25 November) treatment and the lowest (1.70 t/ha) was obtained when the crop was sown in S_3 (5 December) treatment. This study indicated that rise in temperature reduced the grain growth duration resulted in yield reduction, which is in agreement with the findings of Kruger (1973) and Silim *et al.* (1985).

The green seed yield per hectare was significantly influenced by the application of different levels of phosphorus (Table 15, Appendix VI). The highest seed yield (3.26 t/ha) was obtained in P_2 (75 kg P_2O_5/ha) treated plot and the lowest (1.32 t/ha) was found in P_0 (control) treated plot.

Table 15. Effect of different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Green seed yield/plot (g)	Green seed yield/hectare (t)
P_0	79.75 d	1.32 d
P_1	127.67 c	2.11 c
P_2	180.82 a	3.26 a
P_3	149.87 b	2.49 b
CV%	10.35	11.93
LSD	10.06	0.12

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

The combined effect of sowing time and phosphorus application on green seed yield of garden pea was found significant (Table 16, Appendix VI). Seed yield of pea varied significantly with the variation of different treatment combinations. All the treatment combinations produced significantly higher seed yield compared to phosphorus control. The highest average green seed yield of 3.67 t/ha was found in the S_2P_2 (25 November sowing combined with 75 kg P_2O_5/ha) treatment combination and the lowest yield of 1.15 t/ha was found in the S_3P_0 (5 December sowing with no phosphorus) treatment combination.

Table 16. The combined effect of sowing time and different levels of phosphorus on yield and yield attributes of garden pea

Treatments	Green seed yield/plot (g)	Green seed yield/hectare (t)
S_1P_0	80.11 ij	1.33 i
S_1P_1	135.14 ef	2.25 f
S_1P_2	195.84 b	3.26 b
S_1P_3	163.47 d	2.72 d
S_2P_0	89.85 hi	1.49 i
S_2P_1	146.93 e	2.44 e
S_2P_2	220.33 a	3.67 a
S_2P_3	173.24 c	2.88 c
S_3P_0	69.29 j	1.15 j
S_3P_1	100.96 h	1.68 h
S_3P_2	126.31 f	2.10 g
S_3P_3	112.90 g	1.88 h
CV%	10.35	11.93
LSD	17.42	0.22

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

4.16 Economic analysis of garden pea production

Input costs for land preparation, inorganic fertilizer, organic manure and manpower required for all the operations from seed sowing to harvesting of garden pea were recorded as per plot and converted into cost/hectare. Price of pod was considered as per present market rate basis. The economic analysis presented under the following headings-

4.16.1 Gross return

The combination of sowing time and phosphorus dose has different value in terms of gross return under the trial (Table 17). The highest gross return (BDT 3,15,000/ha) was obtained from the treatment combination S_2P_2 and the second highest gross return (BDT 3,039,00/ha) was found in S_1P_2 treatment. The lowest gross return (BDT 1,34,400/ha) was obtained from S_3P_0treatment.

4.16.2 Net return per hectare

In case of net return, sowing time and phosphorus dose of net return under the present trial (Table 17). The highest net return (BDT 1,81,248/ha) was found from the treatment combination S_2P_2 treatment and the second highest net return (BDT 1,70,148/ha) was obtained from the combination S_1P_2 treatment. The lowest net return (BDT 3,146/ha) was obtained from S_3P_0 treatment.

4.16.3 Benefit Cost Ratio (BCR)

In the combination of sowing time and phosphorus dose, the highest benefit cost ratio (2.35) was noted from the combination of S_2P_2 treatment (Table 17) and the second highest benefit cost ratio (2.27) was estimated from the combination of S_1P_2 treatment. The lowest benefit cost ratio (1.02) was obtained from S_3P_0 treatment. From economic point of view, it is apparent from the above results that the combination of S_2P_2 treatment was better than rest of the combination in garden pea cultivation.

Table 17. Economic analysis of garden pea (*Pisum sativum*) production as influenced by different sowing time and phosphorus application

Treatments	Green pod yield/ha (t)	Total cost of production (tk)	Gross return/ha (tk)	Net return/ha (tk)	Benefit Cost Ratio (BCR)
S_1P_0	5.0	131254.2	150000	18746	1.14
S_1P_1	7.7	133252.2	231000	97748	1.70
S_1P_2	10.13	133751.7	303900	170148	2.27
S_1P_3	9.04	135250.2	271200	135950	2.00
S_2P_0	5.61	131254.2	168300	37046	1.28
S_2P_1	8.46	133252.2	253800	120548	1.90
S_2P_2	10.5	133751.7	315000	181248	2.35
S_2P_3	9.35	135250.2	280500	145250	2.07
S_3P_0	4.48	131254.2	134400	3146	1.02
S_3P_1	6.2	133252.2	186000	52748	1.39
S_3P_2	7.08	133751.7	212400	78648	1.58
S_3P_3	6.63	135250.2	198900	63650	1.47

Here, S_1=15 November sowing, S_2=25 November sowing, S_3= 5 December sowing and P_0= Control (No Phosphorus), P_1=50 kg P_2O_5/ha, P_2=75 kg P_2O_5/ha, P_3=100 kg P_2O_5/ha

Total cost of production was done in details according to the procedure of Alam *et al.* (1989).

Where,

Sale of marketable pod @ 30000 Tk per ton.

Gross return = Marketable yield × Tk/ton

Net income = Gross return – Total cost of production

Benefit Cost Ratio (BCR) = Gross return ÷ Cost of production

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the horticultural research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2017 to March 2018 to assess the response of garden pea *(Pisum sativum* L.) on different date of sowing and levels of phosphorus. The seeds of BARI Motorshuti-3 were used as planting materials for this experiment. The experiment consisted of two factors: Factor A: Sowing time(three levels) as- S_1: 15 November, S_2: 25 November, S_3: 5 December and Factor B: Phosphorus fertilizer (four levels) as- P_0= Control (No Phosphorus), P_1: 50 kg P_2O_5/ha, P_2: 75 kg P_2O_5/ha, P_3: 100 kg P_2O_5/ha. The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth yield and quality parameters were recorded and statistically significant variation was observed for different recorded parameters.

For different days of sowing time, the tallest plant at 30, 45 DAS and at harvesting was recorded (27.87 cm, 39.05 cm and 46.72 cm respectively) for S_2 treatment, whereas the shortest plant (23.57, 34.55 and 41.37 cm, respectively) from S_3. The maximum days of initiation to first flowering (28.00 days) were found from S_2 treatment, while the minimum days (24.25 days) were observed from S_3 treatment. The maximum days require grain growth (49.75 days) were found from S_2 treatment and minimum days (43.25 days) were observed from S_3 treatment. The highest number of pods per plant (12.10) was recorded from S_2 treatment, while the lowest number of pods per plant (10.45) found from S_3 treatment. The highest pod length (8.30 cm) was recorded from S_2 treatment, while the lowest pod length (7.13 cm) found from S_3 treatment. The highest Pod breadth (1.37 cm) was found from S_2 treatment, while the lowest (1.27 cm) was recorded from S_3 treatment. The highest green pod yield per plant (45.52 g) was found from S_2 treatment, while the lowest (33.10 g) was recorded from

S_3 treatment. The highest weight of 10 green pods (36.12 g) was found from S_2 treatment, while the lowest (30.22 g) was recorded from S_3 treatment. The highest number of seeds per pod (4.62) was found from S_2 treatment, while the lowest (3.96) was recorded from S_3 treatment. The highest 100 green seeds weight (23.70 g) was found from S_2 treatment, while the lowest (21.15 g) was recorded from S_3 treatment. The highest dry matter percentage of plant (18.60) was found from S_2 treatment, while the lowest (15.80) was recorded from S_3 treatment. The highest green pod yield per plot (509.18 g) was found from S_2 treatment, while the lowest (366.12 g) was recorded from S_3 treatment. The highest green pod yield per hectare (8.48 t) was found from S_2 treatment, while the lowest (6.09 t) was recorded from S_3 treatment. The highest green seed yield per plot (143.64 g) was found from S_2 treatment, while the lowest (102.36 g/plot) was recorded from S_3 treatment. The highest green seed yield per hectare (2.62 t) was found from S_2 treatment, while the lowest (1.70 t) was recorded from S_3 treatment.

In case of different phosphorus dose, the tallest plant at 30, 45 DAS and at harvesting was recorded (29.43 cm, 40.46 cm and 48.56 cm respectively) for P_2 treatment, whereas the shortest plant (21.60, 32.43 and 39.46 cm, respectively) from P_0 treatment. The maximum days to initiation of first flowering (27.02 days) were found from P_2 treatment, while the minimum days (25.30 days) were observed from P_0 treatment. The maximum days require grain growth (47.50 days) were found from P_2 treatment and minimum days (46 days) were observed from P_0 treatment. The highest number of pods per plant (12.70) was recorded from P_2 treatment, while the lowest number of pods per plant (9.63) found from P_0 treatment. The highest pod length (8.68 cm) was recorded from P_2 treatment, while the lowest pod length (6.44 cm) found from P_0 treatment. The highest Pod breadth (1.40 cm) was found from P_2 treatment, while the lowest (1.23 cm) was recorded from P_0 treatment. The highest green pod yield per plant (48.90 g) was found from P_2 treatment, while the lowest (27.90 g) was recorded from P_0 treatment. The highest weight of 10 green pods (37.50 g)

was found from P_2 treatment, while the lowest (27.41 g) was recorded from P_0 treatment. The highest number of seeds per pod (4.90) was found from P_2 treatment, while the lowest (3.60) was recorded from P_0 treatment. The highest 100 green seeds weight (24.70 g) was found from P_2 treatment, while the lowest (20.06 g) was recorded from P_0 treatment. The highest dry matter percentage of plant (20.06) was found from P_2 treatment, while the lowest (14.13) was recorded from P_0 treatment. The highest green pod yield per plot (554.53 g) was found from P_2 treatment, while the lowest (302.18 g) was recorded from P_0 treatment. The highest green pod yield per hectare (9.23 t) was found from P_2 treatment, while the lowest (5.03 t) was recorded from P_0 treatment. The highest green seed yield per plot (180.82 g) was found from P_2 treatment, while the lowest (79.75 g) was recorded from P_0 treatment. The highest green seed yield per hectare (3.26 t) was found from P_2 treatment, while the lowest (1.32 t) was recorded from P_0 treatment.

Due to the combined effect of different date of sowing and levels of phosphorus , the tallest plant at 30, 45 DAS and at harvesting was recorded (32.20 cm, 43.20cm and 53.40 cm, respectively) for S_2P_2 treatment, whereas the shortest plant (20.40, 31.30 and 38.30 cm, respectively) from S_3P_0. The maximum days to initiation of first flowering (28.50 days) were found from S_2P_2 treatment, while the minimum days (23.50 days) were observed from S_3P_0 treatment. The maximum days require grain growth (50.50 days) were found from S_2P_2 treatment and minimum days (42.50 days) were observed from S_3P_0 treatment. The highest number of pods per plant (13.60) was recorded from S_2P_2 treatment, while the lowest number of pods per plant (9.30) found from S_3P_0 treatment. The highest pod length (9.32 cm) was recorded from S_2P_2 treatment, while the lowest pod length (6.16 cm) found from S_3P_0 treatment. The highest Pod breadth (1.45 cm) was found from S_2P_2 treatment, while the lowest (1.20 cm) was recorded from S_3P_0 treatment. The highest green pod yield per plant (57.70 g) was found from S_2P_2 treatment, while the lowest (25.40 g) was recorded from S_3P_0 treatment. The highest weight of 10 green

pods (40.40 g) was found from S_2P_2 treatment, while the lowest (25.50 g) was recorded from S_3P_0 treatment. The highest number of seeds per pod (5.35) was found from S_2P_2treatment, while the lowest (3.40) was recorded from S_3P_0 treatment. The highest 100 green seeds weight (26.40 g) was found from S_2P_2 treatment, while the lowest (19.30 g) was recorded from S_3P_0 treatment. The highest dry matter percentage of plant (21.50) was found from S_2P_2treatment, while the lowest (13.50) was recorded from S_3P_0 treatment. The highest green pod yield per plot (630.24 g) was found from S_2P_2 treatment, while the lowest (269.28 g) was recorded from S_3P_0 treatment. The highest green pod yield per hectare (10.50 t) was found from S_2P_2 treatment, while the lowest (4.48 t) was recorded from S_3P_0 treatment. The highest green seed yield per plot (220.33 g) was found from S_2P_2 treatment, while the lowest (69.29 g) was recorded from S_3P_0treatment. The highest green seed yield per hectare (3.67 t) was found from S_2P_2 treatment, while the lowest (1.15 t) was recorded from S_3P_0 treatment.

The highest gross return (BDT 3,15,000/ha) was obtained from the treatment combination S_2P_2 and the lowest (BDT 1,34,400/ha) was obtained from S_3P_0 treatment combination. The highest net return (BDT 1,81,249/ha) was found from the treatment combination S_2P_2 and the lowest net return (BDT 3,146/ha) was obtained from S_3P_0 treatment combination. The highest benefit cost ratio (2.35) was noted from the combination of S_2P_2 treatment combination and the lowest (1.02) was obtained from S_3P_0 treatment combination. From economic point of view, it is apparent from the above results that the combination of S_2P_2 treatment combination was better than rest of the combination in garden pea cultivation.

Based on the experimental results, it may be concluded that

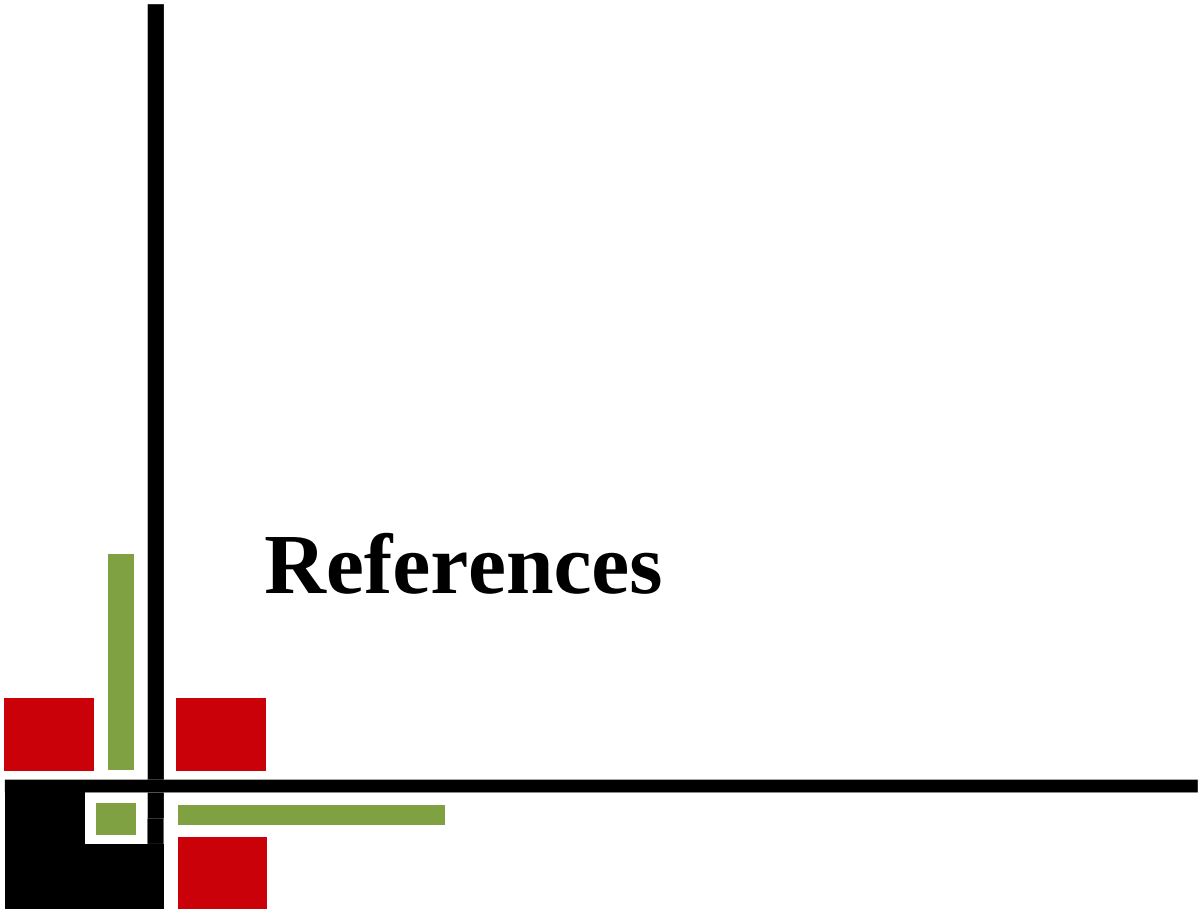
1. For obtaining the maximum green pod and seed yield, sowing of garden pea seeds at 25 November.
2. For 75 kg P_2O_5 per hectare application was found to be the best for higher growth, pod and seed yield of garden pea.

3. A combination of 25 November sowing with 75 kg P_2O_5 per hectare application was the most suitable combination in respect of pod and seed yield of garden pea.

Recommendations

Based on the findings of the study it can be recommended that

Further investigation may be conducted in different agro-ecological zones (AEZ) of Bangladesh for exploitation of regional adaptability and other performances. Since the experiment was conducted in one year only. So, some other levels of sowing time and phosphorus dose may be included in future program for more confirmation of the results.



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Appendices

APPENDICES

Appendix- I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October, 2017 to February 2018

Month	Air temperature (0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
October, 2017	26.5	19.4	81	22
November, 2017	25.8	16.0	78	00
December, 2017	22.4	13.5	74	00
January, 2018	24.5	12.4	68	00
February, 2018	27.1	16.7	67	30

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

A. Morphological characteristics of the soil of experimental field

Morphological features	**Characteristics**
Location	Expeimental Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1212

Appendix-II. Analysis of variance of data on plant height at different days after sowing of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Plant height at 30 DAS	Plant height at 45 DAS	Plant height at harvest
Replication	2	5.533	66.809	0.353
Factor A (Sowing)	2	57.377**	88.242**	7.767**
Factor B (Phosphorus)	3	46.576 **	95.986**	12.098**
A x B	6	31.049*	67.771*	4.026*
Error	22	11.566	21.538	1.152

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-III. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Days to first flowering	Grain growth duration	Number of pods/plant
Replication	2	1.208	0.458	0.486
Factor A (Sowing)	2	12.686**	4.714*	13.380**
Factor B (Phosphorus)	3	78.063**	5.989*	16.015 **
A x B	6	10.935**	4.353*	12.704*
Error	22	1.917	1.452	4.713

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-IV. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Pod length (cm)	Pod breadth (cm)	Green Pod yield/plant (g)
Replication	2	3.021	0.787	8.902
Factor A (Sowing)	2	26.481*	44.896 **	87.875**
Factor B (Phosphorus)	3	29.095*	49.280**	85.623**
A x B	6	22.282*	19.005*	55.516*
Error	22	7.458	6.046	17.932

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-V. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of			
		Weight of 10 green pods	Number of seeds/pod	Weight of 100 green seeds (g)	Dry matter percentage of plant (%)
Replication	2	0.041	20.701	5.472	2.108
Factor A (Sowing)	2	1.262*	94.121**	101.372**	64.250**
Factor B (Phosphorus)	3	4.093**	104.005**	85.430 **	75.811**
A x B	6	1.406*	78.951*	61.426*	35.811*
Error	22	0.643	31.059	21.988	23.237

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-VI. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of			
		Green pod yield/plot (g)	Green pod yield/hectare (t)	Green seed yield/plot (g)	Green seed yield/hectare (t)
Replication	2	0.021	9.991	443.5	0.184
Factor A (Sowing)	2	126.195**	197.014**	409.3**	1.504**
Factor B (Phosphorus)	3	109.876**	152.570 **	5510.2**	1.251**
A x B	6	83.697*	144.302*	428.8**	1.488**
Error	22	25.005	45.549	35.4	0.196

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VII. Cost of production of Garden pea per hectare

Input cost (A)

Treatments	Labour	Ploughing	Seed	Irrigation	Pesticides	Cowdung	Fertilizer					Subtotal input cost(A)
							Urea	TSP	MOP	Gypsum	Zinc Sulphate	
S_1P_0	25000	10000	15000	8000	6000	30000	3000	---	2400	220	100	91220
S_1P_1	25000	10000	15000	8000	6000	30000	3000	1800	2400	220	100	93020
S_1P_2	25000	10000	15000	8000	6000	30000	3000	2250	2400	220	100	93470
S_1P_3	25000	10000	15000	8000	6000	30000	3000	3600	2400	220	100	94820
S_2P_0	25000	10000	15000	8000	6000	30000	3000	---	2400	220	100	91220
S_2P_1	25000	10000	15000	8000	6000	30000	3000	1800	2400	220	100	93020
S_2P_2	25000	10000	15000	8000	6000	30000	3000	2250	2400	220	100	93470
S_2P_3	25000	10000	15000	8000	6000	30000	3000	3600	2400	220	100	94820
S_3P_0	25000	10000	15000	8000	6000	30000	3000	---	2400	220	100	91220
S_3P_1	25000	10000	15000	8000	6000	30000	3000	1800	2400	220	100	93020
S_3P_2	25000	10000	15000	8000	6000	30000	3000	2250	2400	220	100	93470
S_3P_3	25000	10000	15000	8000	6000	30000	3000	3600	2400	220	100	94820

Labour cost @ Tk. 300/Man/day

Cowdung @ Tk. 2/Kg

Urea @ Tk. 12/Kg

TSP @ Tk. 18/Kg

MoP @ Tk. 15/Kg

Gypsum @ Tk. 22/Kg

Zinc Sulphate@TK.50/Kg

ii. Overhead cost (B)

Treatment Combination	Miscellaneous cost (Tk. 5% of the input cost)	Cost of lease for 6months land rent	Interest on running capital for 6 months (Tk. 12% of cost/year)	Subtotal Overhead cost(B)
S_1P_0	4561	30000	5473.2	40034.2
S_1P_1	4651	30000	5581.2	40232.2
S_1P_2	4673.5	30000	5608.2	40281.7
S_1P_3	4741	30000	5689.2	40430.2
S_2P_0	4561	30000	5473.2	40034.2
S_2P_1	4651	30000	5581.2	40232.2
S_2P_2	4673.5	30000	5608.2	40281.7
S_2P_3	4741	30000	5689.2	40430.2
S_3P_0	4561	30000	5473.2	40034.2
S_3P_1	4651	30000	5581.2	40232.2
S_3P_2	4673.5	30000	5608.2	40281.7
S_3P_3	4741	30000	5689.2	40430.2

Total Cost of production = Input Cost(A) + Overhead Cost (B)