EFFECT OF SOWING DATE AND PHOSPHORUS ON GROWTH, SEED YIELD AND QUALITY OF FENUGREEK

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EFFECT OF SOWING DATE AND PHOSPHORUS ON GROWTH, SEED YIELD AND QUALITY OF FENUGREEK

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CERTIFICATE

This is to certify that the thesis entitled ***'EFFECT OF SOWING DATE AND PHOSPHORUS ON GROWTH, SEED YIELD AND QUALITY OF FENUGREEK'*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in 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* ***SHAMSUN NAHAR****, Registration number:* ***14-06213,*** *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 duly been acknowledged.

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Dedicated to My

Beloved Parents

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The Author

EFFECT OF SOWING DATE AND PHOSPHORUS ON GROWTH, SEED YIELD AND QUALITY OF FENUGREEK

ABSTRACT

The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during 10 October 2020 to April 2021 to study the effect of sowing date and phosphorus on growth, seed yield and quality of fenugreek. The experiment consisted of two factors. Factor A: Three sowing date *viz*., S_1= 01 November, S_2= 15 November and S_3= 30 November and Factor B: Four phosphorus fertilizer level *viz.*, P_0= Control, P_1= 35 kg P ha^{-1}, P_2= 45 kg P ha^{-1} and P_3= 55 kg P ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on growth and seed yield of fenugreek and significant variation was observed for most of the studied characters. Growth related data was maximum on S_1 (01 November) treatment but in case of seed yield, S_2 (15 November) treatment showed the best result. In case of growth characters, P_3 (55 kg ha^{-1}) revealed the best result but in case of seed yield, P_2 (45 kg ha^{-1}) treatment showed the best result. Under this investigation, it was revealed that the maximum growth was obtained by S_1P_3 (01 November with 55 kg P ha^{-1}) and the minimum growth was obtained by S_3P_0 (30 November with control) treatment combination. The maximum pods per plant (52.61), seeds per pod (12.87), pod length (10.62 cm), weight of individual pod (147.11 mg), weight of seeds per plant (7.67 g) and weight of 1000-seed (13.86 g), seed yield per plot (306.72 g), seed yield per hectare (2.13 t) and vigor index (570.27) was observed from the treatment combination S_2P_2 (15 November with 45 kg P ha^{-1}). On the other hand, the minimum pods per plant (30.25), seeds per pod (9.11), pod length (8.02 cm), weight of individual pod (92.63 mg), weight of seeds per plant (2.70 g) and weight of 1000-seed (9.17 g), seed yield per plot (108.00 g), seed yield per hectare (0.75 t) and vigor index (453.99) was revealed from the S_3P_0 (30 November with control) treatment combination. It was therefore concluded that the combination of sowing date S_2 (15 November) along with phosphorus application P_2 (45 kg P ha^{-1}) were given the better performance of all the yield contributing parameters and seed yield of fenugreek. So, S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination can be repeated in different agro ecological zones of Bangladesh.

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LIST OF ACRONYMS

Acronym		Full meanings
AEZ	=	Agro-Ecological Zone
%	=	Percent
^0C	=	Degree Celsius
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
FAO	=	Food and Agriculture Organization of the United Nations
g	=	Gram
ha^{-1}	=	Per hectare
kg	=	Kilogram
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
t	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER I

INTRODUCTION

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INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is herbaceous annual legume seed spice crop commonly known as methi, belongs to the family Fabaceae. The name fenugreek comes from the species name "*foenum-graecum*" means "Greek hay" (Flammang *et al.*, 2004). It is a self-pollinated crop with chromosome number 2n=16. It believed to be a native of an area extending from Iran to northern India (Marzougui *et al.*, 2007) and widely cultivated in China, India, Egypt, Ethiopia, Morocco, Ukraine, Greece, Turkey, etc. with 80 species (Danesh-Talab *et al*., 2014).

Fenugreek is one of the major and important seed spice crop occupies a prime position throughout the globe to add taste and flavour in various food items. The leaves and fruits have a pleasant aromatic odor. The fresh fenugreek leaves are bitter in taste and are recognized as a powerful herb. The leaves have considerably gained attention in stabilizing the insulin, blood sugar, hemoglobin levels, and condition of diabetes (Gupta *et al.*, 2001). Its leaves and seeds are consumed in different countries around the world for different purposes such as medicinal uses, making food, roasted grain as coffee-substitute, controlling insects in grain storages, and perfume industries (Mehrafarin *et al*., 2011). Its seeds also contain different amounts of nutrients, most important like Fe, Ca, P, K and other mineral elements. Fenugreek seeds contain carbohydrates (48%), proteins (25.5%), mucilaginous matter (20%), fats (7.9%), saponin (4.8%) (Rao and Sharma, 1987) and volatile oil (0.02%) (Ravindran *et al.*, 2001). The seeds contain a substantial amount of fiber, phospholipids, glycolipids, oleic acid, linolenic acid, linoleic acid, choline, vitamin A, B_1, B_2, C, nicotinic acid, niacin and many other functional elements (Ali *et al.*, 2012).

Fenugreek is a tropical crop and generally sown in the winter season for seed production. Dry and cold weather during the early stage favors better vegetative growth whereas dry and relatively high temperature promotes seed production (Al-Dalain *et al.*, 2012). Time of sowing is crucial for the vegetative growth and ultimate expressions of yield. Any early or late sowing may hamper the growth, yield as well as quality of the crop. In case of fenugreek, early sowing leads to early flowering but may be vulnerable to damage in case of extreme cold and frost (Aggarwal *et al.*, 2013). In general, the crop requires cool climate during vegetative growth and warm

dry climate during maturity. During rabi season, sowing in the month of October is recommended both for seed and leaf production. On the other hand, late sowing affected the growth as well as yield and quality in an adverse way (Halesh *et al.*, 2000).

One of the important factor responsible for yield enhancement of methi is proper time of sowing, which exerts a distinct effect on growth promote. Summer or hot days are one of the limiting factors in fenugreek production. At the same time, in summer, price of green fenugreek remains high, as compared to other seasons. Sowing date had significant effect on fenugreek significant effect on plant height, number of leaves, branches, seed yield, weight of seed and minimum days for germination was reported when sowing was done on 2nd November (Bhutia and Sharangi, 2017 and Obour *et al.*, 2015). Kumawat *et al.* (2017) observed that November 30th sown crop showed minimum per cent disease intensity, whereas 10th October sown crop showed maximum per cent disease intensity and minimum seed yield. Mahor (2018) revealed that sowing of fenugreek on 30th October was found to be the superior compared to the other dates of sowing with respect to plant growth, seed yield and quality. Result obtained by Meena *et al.* (2018) illustrated that significantly higher plant height, per plant primary branches, secondary branches, nodules, seed yield and biological yield of fenugreek were recorded when sown on 30th October. 2nd November sowing date had a significant influence on phenology, growth and yield parameter of fenugreek (Sultana *et al.,* 2016).

Phosphorus (P) is critical in plant metabolism which plays an important role in cellular energy transfer, respiration, photosynthesis and it is a key structural component of nucleic acids coenzymes, phosphorproteins and phospholipids. Phosphorus fertilization is a major input in crop production (Blackshaw *et al.*, 2004). Phosphorus is essential for the general health of the plant and root development and more stem strength. It improves flower formation and makes seed production more uniform. It also improves seed quality and resistant to plant disease. Plant growth and seed yield was increased in fenugreek when phosphorus was applied (Bairagi, 2014; Purbey and Sen, 2005). Sharma *et al.* (2014) obtained maximum number of primary branches per plant, pods per plant, seeds per pod, seed yield from optimum P application. It is also reported that an increase in seed yield of fenugreek was obtained

with judicious application of phosphorous (Khiriya *et al*., 2001; Khiriya *et al*., 2003 and Sheoran *et al*., 1999). The vegetative growth in terms of plant height, number of leaves and number of branches and the yield parameters in respect to number of pods per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare and test weight were observed significantly maximum in due to an application of nitrogen and phosphorus. The maturity parameters like number of days required for first flower initiation, days required for 50% flowering, first pod formation, 50% pod formation and maturity of seed crop were found to be delayed with an increased level of nitrogen and phosphorus per ha (Jagdale and Dalve, 2010).

But only a few information on fenugreek research regarding sowing date and phosphorous fertilization is available in Bangladesh. Keeping the above facts in view the present experiment was undertaken with following objectives:

i. To investigate the effect of sowing date on vegetative growth, seed yield and quality of fenugreek.

ii. To observe the influence of phosphorous fertilizer on growth, seed yield attributes and quality of fenugreek.

iii. To find out the suitable combination of sowing date and phosphorous fertilizer for better growth, seed yield and quality of fenugreek.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of fenugreek are considerably depended on manipulation of different management practices and nutrients for obtaining higher production. Among the mentioned different management practices like different sowing dates are more responsible for the growth and yield of fenugreek. As well as among the different nutrients, phosphorus is also responsible for the growth and yield of fenugreek. The available relevant reviews related to different sowing dates and application of phosphorus in the recent past have been presented and discussed:

2.1 Effect of sowing date

Kauser *et al.* (2018) conducted an experiment to find out the optimum date of sowing and pinching level in fenugreek in open field condition at College of Horticulture, Mudigere, UAHS, Shivamogga during 2014-15. The experiment consisted of five dates of sowing (1st October, 15th October, 1st November, 15th November and 1st December) and three stage of pinching (Pinching at 25 DAS, Pinching at 35 DAS and No pinching) which were assessed in all possible combinations for growth and yield. Among the different treatment combinations D_2P_2 (Sowing on 15th October and Pinching at 35 DAS) recorded maximum plant spread, number of branches per plant, dry matter production of leaves (DMPL), dry matter production of stem (DMPS), dry matter production of pods (DMPP), dry matter production of seeds (DMPS), total dry matter production (TDMP), number of pods per plant, length of pod, fresh weight of pod, number of seeds per pod, weight of seeds per pod, seed yield, harvest index and 1000 seed weight. Whereas maximum plant height was recorded in D_3P_3 (Sowing on 1st November and no pinching). While lower values for these parameters were observed in D_1P_1 (Sowing on 1st October and Pinching at 25 DAS).

Nandre *et al.* (2011) conducted a field experiment entitled, effect of sowing dates and nutrient management on growth, and seed yield of fenugreek was at the Main Garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during Rabi season of the years 2004-05 and 2005-06. The experiment was laid out in split plot design with four replications and twenty-four treatment combinations. The result of present investigation indicated that, the vegetative growth in terms of

plant height, number of branches and number of leaves, were increased due to an early sowing (1st November) supplied with the nutrients as 37.50 kg N + 18.75 kg P_2O_5 ha^{-1} + FYM @ 10 t ha^{-1}. While, number of pods, number of seeds per pod, weight of seeds per pod, seed yield per plot and seed yield per hectare were found to be the maximum with an early sowing (1st November) supplied with the nutrient as 37.50 kg N + 18.75 kg P_2O_5 ha^{-1} + FYM @ 10 t ha^{-1}.

Meena *et al.* (2018) carried out an experiment at ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan during Rabi season 2016-17 to ascertain the suitable sowing date, fertilizers doses and weedicide for quality production of fenugreek variety AFg-3. Result illustrated that significantly higher plant height (70.10 cm), per plant primary branches (4.64), secondary branches (3.86), nodules (4.90), seed yield (1800 kg ha^{-1}) and biological yield (5755.55 kg ha^{-1}) were recorded in 30th October sown crop as compared to 15th October and 15th November sowing dates. Irrespective of sowing dates, the application of NPK level (F_3) 50:50:25 kg ha^{-1} recoded highest plant height (67.57 cm), per plant primary branches (4.33), secondary branches (3.28), nodules (3.72), seed yield (1675.92 kg ha^{-1}) and biological yield (5333.32 kg ha^{-1}). The pre-emergence application of oxadiargyl @ 75g a.i. ha^{-1} provided more plant height (65.60cm), per plant primary branches (4.23), secondary branches (3.08), nodules (4.03), weed counts (47.88 and 65.14 weeds/m^2 area at 45 and 90 DAS, respectively), seed yield (1643.22 kg ha^{-1}) and biological yield (5027.16 kg ha^{-1}). The combined effect of the treatments $D_2 \times F_3 \times W_2$ given maximum plant height (72.33 cm), number of primary and secondary branches (5.23 and 4.33), pods per plant (42.36), seed yield (2511.13 kg ha^{-1}), gross return (Rs.158934 ha^{-1}), net return (109632 ha^{-1}) and BCR (3.22).

Sultana *et al.* (2016) conducted an experiment to identify the best date of sowing and irrigation to get the highest seed production of fenugreek *(Trigonella foenum-graecum L)* under Gangetic old alluvial plains of West Bengal during the year 2014-2015 in the months of November to March. The experiment was laid out in factorial RBD replicated twice. The fenugreek was shown in five different dates, namely, D_1, D_2, D_3, D_4, and D_5 at different days interval. The respective dates were 2nd November, 9th November, 16th November, 23rd November and 28th December. Sowing date had significant effects on seed yield and its components. The results obtained from the

study showed a significant variation with different dates of sowing. Projected seed yield/hectare was maximum (1.4 t/ha) on 2nd November. It was evident from the results that the date of sowing had a significant influence on phenology, growth, and yield of fenugreek. It may be concluded from the results that to obtain higher seed yield fenugreek should be sown earlier at 2nd November.

Anitha *et al.* (2016) carried out an experiment at Horticultural College and Research Institute, Venkataramannagudem, Dr. Y.S.R. Horticultural University with an objective of evaluating the effect of sowing date, variety and their interaction on growth, yield and quality of seed fenugreek in order to assess its fitment into sequence cropping under delayed sowing conditions. A total of five varieties viz., Hissar Sonali, Rmt-1, Co-1, Rajendrakranti and Co-2 were evaluated on five sowing dates at 15-day interval starting from 15th October to 15th December in split plot design with five main plots as sowing dates and five sub-plots as varieties. There were significant differences in the yield and quality of fenugreek. The maximum values in respect of many of these parameters was recorded by Co-1 and Co-2 by sowing on 15th October, it is also observed that Co-1 and Co-2 varieties were at par in some of these characters and on the other hand at lower level Rmt-1 and Rajendrakanthi were on par with one another. Regarding the sowing dates 15th October was found to be on par with 1st November and similarly 1st December and 15th December were also on par though recorded minimum values in respect of some of the characters including seed yield per plant and per plot.

Bhutia and Sharangi (2016) carried out an investigation at the Horticultural Research Station, BCKV, West Bengal for identifying the best date of sowing and irrigation in fenugreek. The sowing was done in five different dates i.e. 2nd, 9th, 16th, 23rd November and 28th December using three irrigation levels. The results showed significant variation with different dates of sowing and irrigation on phenology, growth and yield of fenugreek. Sowing date had significant effects on seed yield and its components. Seed yield of fenugreek was also dependent on irrigation scheduling. Projected seed yield/hectare was maximum (1.37 and 1.4 t ha^{-1}) on 2nd November (17.66 and 17.9 g) with irrigation in all major growth stages. It may be concluded that to obtain higher seed yield fenugreek should be sown earlier at 2nd November and

irrigation should be given at seedling, branching, flowering, pod formation, pod development stages.

Bhutia and Sharangi (2016) also conducted an experiment to identify the best date of sowing and soil moisture content at different soil depths to get the highest seed production for fenugreek. Plots were planted for 2 years (2012–2013 and 2013–2014) at the following sowing dates: 2nd, 9th, 16th and 23rd and 30th November (D_1, D_2, D_3, D_4 and D_5). It may be concluded that to obtain higher seed yield, fenugreek should be sown earlier at 2nd November and irrigation should be given in all the major growth phases at seedling, branching, flowering, pod formation and pod development stages.

Halesh *et al.* (2000) conducted an experiment in Bangalore, Karnataka, India during 1996-97 to study the effects of sowing date (15 June, 1 July, 15 July, 1 September, 15 September and 1 October) and spacing (15 × 15, 30 × 15, and 30 × 30 cm) on the growth and yield of fenugreek. The crop sown on 1 July responded significantly by recording the maximum plant height (56.27 cm), maximum number of branches and leaves (10.08 and 126.42, respectively), minimum number of days to 50% flowering (34.11), maximum dry weight (16.12 g), maximum number of pods/plant and seeds/pod (50.95 and 15.43, respectively) and significantly increased seed yield (23.88 q/ha) which was followed by 15 July-sown crop. Closer spacing (15 × 15 cm) produced higher seed yield, while wider spacing (30 × 30 cm) recorded the maximum growth and yield parameters except the seed yield per hectare.

Sowmya *et al.* (2017) carried out an experiment entitled effect of sowing dates and stage of pinching on growth, yield and quality of fenugreek during September 2015 to March 2016 at RVSKVV College of Horticulture, Mandsaur, M.P., India, with 12 treatment combinations, comprising four dates of sowing 25th September, 10th October, 25th October and 9th November with three stages of pinching i.e., No pinching, Pinching at 25 Days after sowing (DAS), Pinching 35 DAS. These treatments were replicated thrice in split spot design and analyzed. Treatment with 10th October sowing recorded maximum plant height, plant spreading, number of branches, fresh weight, dry weight, number of pods plant^{-1}, pod length, weight of pod, number of seeds pod^{-1}, weight of seeds pod^{-1}, thousand seed weight, seed yield, straw yield, biological yield, harvest index, chlorophyll content, germination %, seedling vigour index, protein%, galactomannon content. While, 25th September sown crop

took maximum days for 50% flowering and for maturity. Between pinching stages studied, Pinching at 35 DAS found to be superior in respect of number of branches plant^{-1}, fresh and dry weight of plant (g) at harvest, number of pods plant^{-1}, length of pod (cm), weight of pod (mg), number of seeds pod^{-1}, weight of seeds pod^{-1} (mg), thousand seed weight (g), seed yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%), chlorophyll content in leaves at 75 DAS (SPAD), germination percentage of seeds, seedling vigour index, protein (%) and galactomannon in comparison to other pinching stages.

Parmar *et al.* (2020) stated that fenugreek needed to grow at correct time for higher growth and in protected structure for increase yield. The aim of protected cultivation is to attain independence of climate and weather. During this study we tend to examine the literature of various protected structure like shade net of various colour like white, black, red, blue, green and polyhouse of low cost, medium cost and high cost conjointly examine sowing time on September, October, November, December. Result show that planted throughout November sowing in shade net compared to open field and germination, plant height, leaf yield were found to be best and also polyhouse is best compared to shade net. 15th October sowing time was best in case of higher leaf yield and 1st November were best in case of plant growth, seed yield and quality.

2.2 Effect of phosphorus

Aditi *et al.* (2020) conducted an experiment during the *rabi* season of 2014-15, to study the "Effect of nitrogen and phosphorus on growth and seed yield of fenugreek" at the Main garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Factorial Randomized Block Design with three replications. Twelve treatment combinations were formed with a view to integrate four nitrogen doses and three phosphorus doses. The allocation of treatments was made by random method. On the basis of results obtained in the present investigation, the yield parameters in respect to number of pods per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare and test weight were observed significantly maximum in the treatment T_9 (N_3P_3) i.e. 80 kg N + 60 kg P. Similarly, better seed quality parameters *viz.*, germination percentage, chlorophyll content, seedling vigour index was recorded significantly

with treatment T_{12} (N_4P_3) i.e. 100 kg N + 60 kg P and protein content was recorded significantly superior with treatment T_9 (N_3P_3) i.e. 80 kg N + 60 kg P.

Sharma *et al.* (2014) conducted an experiment at Agronomy farm, College of Agriculture, Bikaner during *rabi* season, 2010-11 on loamy sand soil to investigate the effect of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}), molybdenum (0.0, 0.5 and 1.0 kg Mo ha^{-1}) and PSB (without inoculation and with inoculation) on yield attributes, yield and seed quality of fenugreek (*Trigonella foenum-graecum* L.). The application of phosphorus up to 40 kg P_2O_5 ha^{-1} resulted in significantly higher number of branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield over their respective preceding levels (0 and 20 kg P_2O_5 ha^{-1}) but it was found at par with 60 kg P_2O_5 ha^{-1} in respect to branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield of fenugreek. Among different levels of molybdenum, 0.5 kg Mo ha^{-1} gave significantly higher branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield over respective lower level. PSB inoculation significantly enhanced the branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield of fenugreek. The test weight increased with the successive levels of applied phosphorus, molybdenum and PSB inoculation but difference could not reach the level of significance. The interaction effect of phosphorus × PSB was found significantly higher branches per plant, pod per plant and seed yield (1568 kg ha^{-1}) recorded with treatment combination 40 kg P_2O_5 ha^{-1} + with inoculation of PSB which was at par with other treatment combination 60 kg P_2O_5 ha^{-1} + with inoculation of PSB.

Bairagi (2014) carried out an experiment and obtained that the optimum dose of phosphorus and ideal row spacing for obtaining maximum yield of good quality seed of fenugreek. Four different phosphorus (as single super phosphate) doses (P_0= 0, P_3= 30, P_6= 60 and P_9= 90 kg P_2O_5 ha^{-1}) and three different row spacing (S_2= 20, S_3= 30 and S_4= 40 cm) were applied, thereby making 12 treatment combinations. The results obtained from the experiment tallest plants (49.8 cm), highest number of branches per plant (6.7), plant spreading (63.30 cm) and number of pods per plant (50.5), maximum thousand seed weight (18 g) and seed yield (1575 kg ha^{-1}) were observed

with the application of 60 kg P_2O_5 ha^{-1}. Application of 60 kg P_2O_5 ha^{-1} coupled with a row spacing of 30 cm was found to be most suitable for obtaining highest yield of good quality fenugreek seed in North Indian conditions.

Godara *et al.* (2013) studied during *rabi* 2005-06 at research farm of Adaptive Trial Centre, Ajmer to study the response of *Nagauri Methi* i.e. also called *Kasuri Methi* (*Trigonella corniculata* L.) to phosphorus and sulphur. In this study three levels of phosphorus (0, 40 and 60 kg ha^{-1}) and three levels of sulphur (0, 30 and 45 kg ha^{-1}) consisted of nine treatments were taken under factorial RBD with three replications. Growth parameters and yield of dried leaves of the crop increased almost linearly with increasing levels of phosphorus, however influence of sulphur was marginal on both growth as well as marketable yield. Maximum plant height (11.8 cm), numbers of trifoliate leaves (7.7) and dried leaves yield (21.56 q ha^{-1}) was obtained with 60 kg P_2O_5 + 45 kg S ha^{-1} which was at par with 60 kg P_2O_5 + 30 kg S ha^{-1}.

Jagdale and Dalve (2010) carried out an experiment on fenugreek with five levels of nitrogen *i.e.* 0, 30, 60, 90 and 120 kg ha^{-1} and five levels of phosphorus *i.e.* 0, 15, 30, 45 and 60 kg ha^{-1}. The result of present investigation indicated that the vegetative growth in terms of plant height, number of leaves and number of branches was increased due to an application of 120 kg nitrogen and 60 kg phosphorus per ha. The maturity parameters like number of days required for first flower initiation, days required for 50% flowering, first pod formation, 50% pod formation and maturity of seed crop were found to be delayed with an increased level of 120 kg nitrogen and 60 kg phosphorus per ha.

Nehara *et al.* (2006) conducted an experiment during winter seasons (rabi) of 2001–02 and 2002–03 on a loamy sand soil of Jobner in Rajasthan, to study the response of fenugreek (*Trigonella foenum-graecum* L.) under different levels of phosphours (0, 25 and 50 kg P_2O_5 ha^{-1}), sulphur (0, 25 and 50 kg S ha^{-1}) and plant-growth regulators (control, Tricontanol 2 ppm, naphthaline acetic acid 20 ppm and etheophon 100 ppm). An increase in P level up to 50 kg P_2O_5 ha^{-1} and sulphur up to 50 kg S ha^{-1} significantly increased the yield-attributing characters; the seed, straw and biological yields; and the net returns of fenugreek. The N, P and S contents of fenugreek in seed and straw and their total uptake increased significantly with increase in the level of applied phosphorus and sulphur up to 50 kg ha^{-1}, except the P and S content in seed

and straw, where significant increase was recorded only up to 25 kg P_2O_5 ha^{-1} and 25 kg S ha^{-1}. Among different growth-regulators, the application of NAA @ 20 ppm proved significantly better than the control, tricontanol and etheophon.

Nandre *et al.* (2011) carried out a field experiment entitled effect of sowing dates and nutrient management on growth, and seed yield of fenugreek was at the Main Garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during Rabi season of the years 2004-05 and 2005-06. The experiment was laid out in split plot design with four replications and twenty-four treatment combinations. The result of present investigation indicated that, the vegetative growth in terms of plant height, number of branches and number of leaves, were increased due to an early sowing (1st November) supplied with the nutrients as 37.50 kg N + 18.75 kg P_2O_5 ha^{-1} + FYM @ 10 t ha^{-1}. While, number of pods, number of seeds per pod, weight of seeds per pod, seed yield per plot and seed yield per hectare were found to be the maximum with an early sowing (1st November) supplied with the nutrient as 37.50 kg N + 18.75 kg P_2O_5 ha^{-1} + FYM @ 10 t ha^{-1}.

Khan *et al.* (2005) conducted an experiment on growth and yield of fenugreek. Effect of different phosphorus levels (0, 30, 45, 60 kg P_2O_5 ha^{-1}) and spatial arrangement of 1.8 × 6 m, 2.4 × 6 m and 3 × 6 m for row spacing 30, 40, and 50 cm, respectively was investigated at Research Area, University college of Agriculture, Bahauddin Zakariya University Multan, during 2003-2004. Spatial arrangement only affected fenugreek plant population per unit area. Interaction effect of phosphorus and spatial arrangement was non-significant on growth and yield of fenugreek. Phosphorus application improved the performance of fenugreek plants for number of seeds $plant^{-1}$, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek. Number of branches and pods per plant remained unaffected by phosphorus application. Significant increased seed yield of fenugreek (1358.29 kg ha^{-1}) was obtained for the crop raised with 60 kg P_2O_5 ha^{-1} but was statistically at par with 45 kg P_2O_5 ha^{-1} (1326.47 kg ha^{-1}). It is concluded that optimum dose of phosphorus for fenugreek crop is 45 kg P_2O_5 ha^{-1}. It is also suggested that further research should be done on planting geometry of fenugreek under different environmental conditions.

Khiriya *et al.* (2003) conducted an experiment and revealed that phosphorus uptake in seed and straw of fenugreek increased with increasing levels of phosphorus up to 40 kg ha^{-1}.

Anonymous (2015) carried out an experiment on effect of row spacing and phosphorous doses on yield and yield contributing attributes of fenugreek (*Trigonella foenum-graecum* L.) for the two cropping seasons of 2013-14 and 2014-15 to determine the effects of different row spacings (20, 30 and 40 cm) and phosphorous applications (0, 30, 60 and 90 kg ha^{-1}) on the yield and yield attributes of fenugreek. The highest seed yield was obtained from 30 cm row spacing in 2013-14 (1.52 t ha^{-1}) and from 20 cm row spacing in 2014-15 (1.53 t ha^{-1}). Plant to plant distance was maintained as 10 cm.

Tuncturk (2011) conducted and experiment to determine the effects of different row spacing (20, 30 and 40 cm) and phosphorus applications (0, 30, 60 and 90 kg ha^{-1}) on the yield and quality of fenugreek in Van-Turkey, in 2006 and 2007 growing seasons. Field experiments were arranged in Completely Randomized Block Design with three replications at the experimental fields of Agricultural Faculty of Yuzuncu Yil University. As a result of the research, while all the growth and yield parameters except for thousand seed weight and protein content were significantly affected by row spacing applications. Phosphorus fertilizer applications positively affected all the traits examined except for pod length. Consequently, the highest seed yield (777.0-785.0 kg ha^{-1}) was obtained from 30 cm row spacing in the both experimental years, respectively. In phosphorus applications, while the highest seed yield (731.0 kg ha^{-1}) was obtained from 60 kg P ha^{-1} applications in 2006 year, the highest seed yield (742.0 kg ha^{-1}) was obtained from 90 kg P ha^{-1} applications in 2007 year. But, between 60 and 90 kg P ha^{-1} applications there was not an important difference in the both experimental years. However, the highest protein content (23.0 %) was obtained from 20 cm row spacing and 30 kg P ha^{-1} applications in the 2006 year.

Mehta *et al.* (2012) carried out an experiment to study response of nitrogen, phosphorus and bio-fertilizers on fenugreek. The experiment conducted with 16 treatment combinations in factorial RBD with three replications. The soil of the experimental field was low in organic carbon, available nitrogen, medium in phosphorus and good in respect to available potassium. Application of 20 kg N and 40

kg P_2O_5 ha^{-1} gave significantly higher plant height at all the growth stages, and seed, straw and biological yields as well as protein content in seed and straw over 10 kg N and 20 kg P_2O_5 ha^{-1}, respectively.

From the above review of literature it is evident that sowing date and phosphorus fertilization has a significant influence on growth and seed yield of fenugreek. The literature suggests that early or delay sowing other than optimum time reduces the seed yield of fenugreek which is directly related with the temperature of the growing period of the crop. From the above review of literature it is evident that phosphorus fertilizer itself influenced the growth and seed yield of fenugreek. The literature revealed that accurate knowledge of the optimum doses of phosphorus fertilizer for any particular fenugreek variety at a particular area is critical to achieve a higher seed yield of fenugreek.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from 10 October 2020 to March 2021 to find out the optimum sowing date and phosphorous fertilization rate on growth, seed yield attributes and quality of fenugreek. This chapter provides a brief description of the experimental site, climate, soil, soil preparation, planting materials, treatments, experimental design, soil preparation, application of fertilizers, transplantation, irrigation and drainage, intercultural operation, data collection, data recording and analysis of the materials and methods of the experiment. Details of the investigation to achieve the stated objectives are outlined below.

3.1 Site description

The experiment was conducted during the period from 10 October 2020 to March 2021 at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental site was located at 23°74′ N latitude and 90°35′ E longitudes at an altitude of 8.2 m.

3.2 Agro-ecological region

The experimental site belongs to the "Madhupur Tract" agro-ecological zone, AEZ-28 (Anon., 1988a). This was an area of complex relief and soils created above the Madhupur clay, where the analyzed edges of the Madhupur Tract were covered by floodplain sediments, leaving small hills of red soils as 'islands' encompassed by floodplain (Anon., 1988b). The experimental site is shown for better understanding in the AEZ Map of Bangladesh in Appendix I.

3.3 Climate and weather

The geographical location of the experimental site was characterized by three specific seasons in the sub-tropical climate, namely the monsoon or rainy season from May to October, associated with high temperatures, high humidity and heavy rainfall; the winter or dry season from November to February, associated with moderately low temperatures; and the pre-monsoon period. Information on the monthly maximum and minimum temperature, rainfall, relative humidity and

sunshine during the period of the experimental site study was collected from the Meteorological Department of Bangladesh, Agargaon, and is provided in Appendix III.

3.4 Soil characteristics

The experiment was conducted in the typical crop growing soil of the Madhupur Tract. Top soil was silty clay in texture, red brown terrace soil type, olive-gray with common fine to medium dark yellowish brown mottles. The pH of the soil was 5.6 and the organic carbon was 0.45%. With good irrigation facilities, the experimental land was well drained. The experimental site was a medium-high land. It was above the level of the flood. During the experimental period, sufficient sunshine was available. Soil series: Tejgaon, General soil: Non-calcareous Dark Grey (Appendix II). The morphological characteristics of the soil of the experimental plots are as follows. Appendix II presents the physicochemical properties of the soil.

3.5 Crop/planting material

High yielding variety of fenugreek (cv. BARI Methi-2) developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used as experimental material. The seed was collected from Regional Spices Research Centre, BARI, Joydebpur, Gazipur.

3.6 Description of the planting material

Variety: BARI Methi-2	
Main Features of the Variety	
Developed by	Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh
Year of release	2006
Main characteristics	Plant height 60-70 cm, number of leaf/primary branch 6-7, leaf length 3.0-3.5 cm, leaf breadth 1.0-1.4cm, number of pod/plant 60-65, pod length 9-10cm, number of seed/pod 10-12, number of branch/plant 5-6, 1000 seed weight 12-15g, seed yellowish brown. Very low disease and pest infestation. Fruit size 8-10 cm, fruit color immature stage green and mature stage brown, seed dry and yellowish.
Planting season and time	Sowing Mid October to 1st week of November
Harvesting time	March
Yield	1.8-2.1 t/ha

3.7 Treatments of the experiment

The experiment consisted of two factors as mentioned below:

Factor A: Sowing date (3) *viz:*

S_1= 01 November

S_2= 15 November

S_3= 30 November

Factor B: Phosphorus level (4) *viz:*

P_0= Control (no phosphorus)

P_1= 35 kg P ha^{-1}

P_2= 45 kg P ha^{-1}

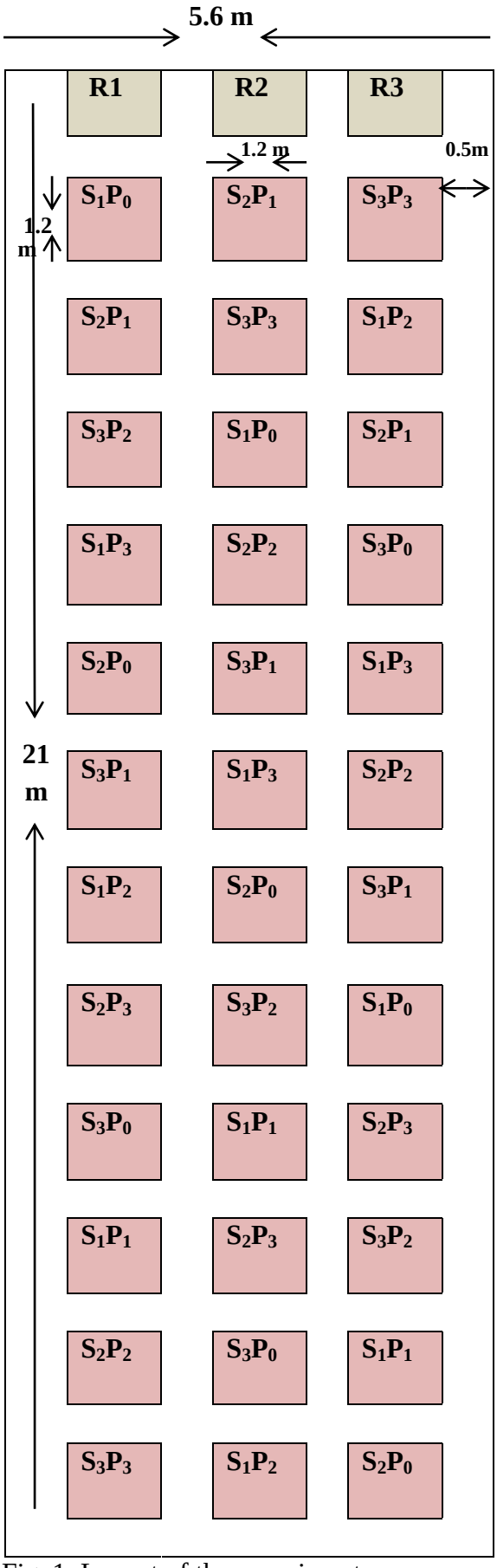
P_3= 55 kg P ha^{-1}

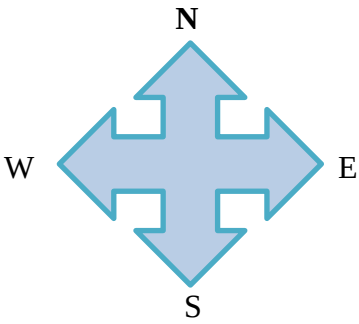
A total of 12 treatment combinations:

S_1P_0	S_1P_1	S_1P_2	S_1P_3
S_2P_0	S_2P_1	S_2P_2	S_2P_3
S_3P_0	S_3P_1	S_3P_2	S_3P_3

3.8 Design and layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The size of unit plot was 1.2 m × 1.2 m. The total number of treatments was 12 (3 sowing date × 4 levels of phosphorous) and the number of plots were 36. The unit plot size was 1.44 m^2 (1.2 m × 1.2 m) and row to row distance to be maintained 30 cm. The blocks and unit plots were separated by 0.50 m and 0.50 m spacing, respectively. The layout of the experimental field was shown in Fig. 1.





Plot size: 1.2 m × 1.2 m

Factor A: Different sowing date (3)

S_1= 01 November

S_2= 15 November

S_3= 30 November

Factor B: Phosphorus level (4)

P_0= Control

P_1= 35 kg P ha^{-1}

P_2= 45 kg P ha^{-1}

P_3= 55 kg P ha^{-1}

Fig. 1. Layout of the experiment

3.9 Land preparation

The land was opened by disc plough 15 days before sowing. Thereafter, the land was prepared thoroughly by ploughing and cross ploughing followed by laddering and harrowing to have good tilth. Weeds and stubbles of the previous crops were collected and removed from the field during land preparation. Soil clods were broken and plots were prepared as 15 cm raised seed bed so that irrigation and rain water easily could drain out and seeds could easily be germinated.

3.10 Manures and fertilizers application

Manures and fertilizers were applied at the following doses Anon. (2010).

Nutrient/Fertilizer	**Rate (Doses)**	**Fertilizer applied**
Cowdung	5 t ha^{-1}	Well rotten cowdung
Nitrogen	80 kg ha^{-1}	Urea
Phosphorus	As per treatment	TSP
Potassium	67 kg ha^{-1}	MoP
Sulphur	20 kg ha^{-1}	Gypsum

The entire amount of cowdung, phosphorus from TSP and potassium from MoP, sulphur from gypsum and one-half of nitrogen from urea were applied during final land preparation. The rest of the nitrogen was top dressed in two equal splits at 30 and 60 days after sowing.

3.11 Sowing of seed

Fenugreek seeds were soaked in water for 6 hours to enhance germination. Seeds were also treated with Bavistin at the rate of 2 g per kg of seeds before sowing. The seeds were sown in rows 30 cm apart continuously by hand @ 15 kg/ha (Anon., 2010). To allow uniform sowing in rows seeds were mixed with some loose soil (about four to ten times of weight of seeds). The seeds were covered with good pulverized soil just after sowing and gently pressed by hands. The sowing was done from 1 November, 2020 to 30 November 2020 with slight watering just to supply sufficient moisture needed for quick germination. Seedlings of the plots were thinned later to maintain 10 cm intra spacing (plant to plant distance) 25 days after sowing (DAS).

3.12 Intercultural operations

The desired population density was maintained by thinning plants 20 DAS. Irrigation, mulching, weeding and plant protection measures etc. were performed for better crop establishment and proper plant growth.

3.12.1 Weeding

The field was kept free by hand weeding. First weeding was done after 2 days after sowing (DAS). Plant thinning was also done at the time of weeding. Second and third weeding was done after 35 and 50 DAS, respectively.

3.12.2 Irrigation

For good germination water was given to the plots every two days by water cane with fine mashed nozzle till germination. Then three irrigations were given at 30, 60 and 90 days after sowing.

3.13 Harvesting

Seeds were harvested on 3 different dates *viz.* 25 February, 11 March and 25 March 2021 when pod color changed into yellowish brown in color (Anon., 2010). To avoid shattering of fruits, harvesting of seed plant was cut to the base by sickles in the early morning. Then the stalks with seeds were dried in the sun. Seeds (grains) were separated by beating with sticks and cleaned by winnowing and dried properly (10% moisture of seed).

3.14 Data collection

Ten (10) plants from each plot were selected randomly and were tagged for the data collection. Some data were collected from sowing to harvesting with 10 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and straw yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

3.14.1 Plant height

Plant height was measured four times at 15 days interval such as 35, 50, 65 and 80 days after sowing (DAS). The plant height was measured in centimeter by scale considering the distance from the soil surface to the tip of the randomly ten selected

plants and mean value was calculated for each treatment and expressed in centimeter (cm).

3.14.2 Number of compound leaves per plant

Number of compound leaves per plant was counted four times at 15 days interval such as 35, 50, 65 and 80 days after sowing (DAS) of fenugreek plants. Mean values of data were calculated and recorded.

3.14.3 Plant spread

At first the measurement was made in centimeter North-South (N-S) direction of the plant canopy of randomly selected ten plants at first flowering stage. Again the measurement was made in centimeter East-west (E-W) direction of the plant canopy of randomly selected ten plants. Average plant spread (cm) was measured by adding those two values and dividing by two.

3.14.4 Branches per plant

Number of branches was counted from randomly selected ten plants from each plot and mean values were calculated and recorded.

3.14.5 Days to 50% flowerings

In each plot 5 plants were tagged and dates of first flowering from each tagged 5 plants were counted gradually. When five plants flowered, five dates of flowering were taken, added and the added values were divided by five. This parameter was treated as days to 50% flowering.

3.14.6 Pods per plant

Pods of ten randomly selected plants of each replication were counted and then the average number of pods for each plant was determined. It was done at final harvest.

3.14.7 Pod length

Pods of ten randomly selected plants of each replication were counted and the length of the individual pod was measured from the base to the tip of the pod and finally the lengths were recorded as per treatments and expressed in centimeter (cm).

3.14.8 Seeds per pod

Ten pods of each of randomly selected 10 plants were considered and then seeds per pod were counted from all the pods and the average data were taken as number of seeds per pod.

3.14.9 Weight of individual pod

Pod weight was measured by Electric Precision Balance in milligram (mg). Ten randomly selected fruits from each of the treatment were weighted and then divided by ten to get single individual pod weight.

3.14.10 Weight of seeds per plant

Seed weight per plant (g) was collected from each plant and weight per plant was measured by Electric Balance in gram (g). Seed was measured from ten randomly selected plants and mean value was calculated.

3.14.11 1000-seed weight

Thousand seed weight was measured by Electric Balance in gram (g). Thousand seed from each treatment were counted then weighed.

3.14.12 Weight of straw per plot

After seed collection all plant of each unit plot were dried in the sun. Then total plants of each unit plot were weighed to get weight of straw $plot^{-1}$.

3.14.13 Seed yield per plot

All seeds were collected from each replication of each treatment combination. Seed weight per plot was measured by an electric balance and then average was expressed as seed yield per plot in gram.

3.14.14 Seed yield

Seed yield per plot (g) was converted to per hectare yield and it was expressed in ton.

3.14.15 Germination

The number of sprouted and germinated seeds (Seedling emergence) was counted daily commencing. Germination was recorded at 24 hours interval and continued up to 10^{th}. More than 2 mm long plumule and radicle was considered as germinated seed.

Germination test was done after harvest. The germination rate (seedling emergence) was calculated using the following formula:

$$\text{Rate of germination (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total seed placed for germination}} \times 100$$

3.14.16 Shoot length

The shoot length of five seedlings from each sample was measured finally at 10 DAS. Measurement was done using the unit centimeter (cm) by a meter scale.

3.14.17 Root length

The Root length of five seedlings from each sample was recorded finally at 10 DAS. Measurement was done using a meter scale and unit was expressed in centimeter (cm).

3.14.18 Vigor index

The vigor index (VI) of the seedlings can be estimated as suggested by Abdul-Baki and Anderson (1973):

$VI = RL + SL \times GP$

Where,

RL = root length (cm)

SL = shoot length (cm) and

GP = germination percentage

3.15 Statistical analysis

The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by Gomez and Gomez (1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to observe the effect of sowing date and phosphorus on growth, seed yield and quality of fenugreek under the soil and agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. Data on different growth and yield parameters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix (IV-X). This chapter comprises of the presentation and discussion of the results obtained from the present study. The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

4.1 Plant height

Statistically significant variation was observed on plant height due to different sowing dates at 35, 50, 65 and 80 DAS under the present experiment (Appendix XI). At 80 DAS, the highest plant height (58.05 cm) was observed from S_1 (01 November) treatment where the lowest plant height (49.88 cm) was revealed from S_3 (30 November) treatment (Fig. 2). The results of the experiment was in coincided with the findings of Kauser *et al.* (2018), Nandre *et al.* (2011) who reported that the vegetative growth in terms of plant height, number of branches and number of leaves, were increased due to an early sowing (1 November).

Different levels of phosphorus showed significant influence on plant height of fenugreek at 35, 50, 65 and 80 DAS under the present study (Appendix XI). It was revealed that at 80 DAS, the highest plant height (58.83 cm) was observed from P_3 (55 kg ha^{-1}) treatment. On the other hand the lowest plant height (48.77 cm) was observed from P_0 (control) treatment (Fig. 3). Similar trends of result was observed by Godara *et al.* (2013) who reported that growth parameters such as plant height, number of leaves and yield of dried leaves of the crop increased almost linearly with increasing levels of phosphorus. Jagdale and Dalve (2010) found the similar result of present investigation indicated that the vegetative growth in terms of plant height, number of leaves and number of branches was increased due to an application of nitrogen and phosphorus per hectare.

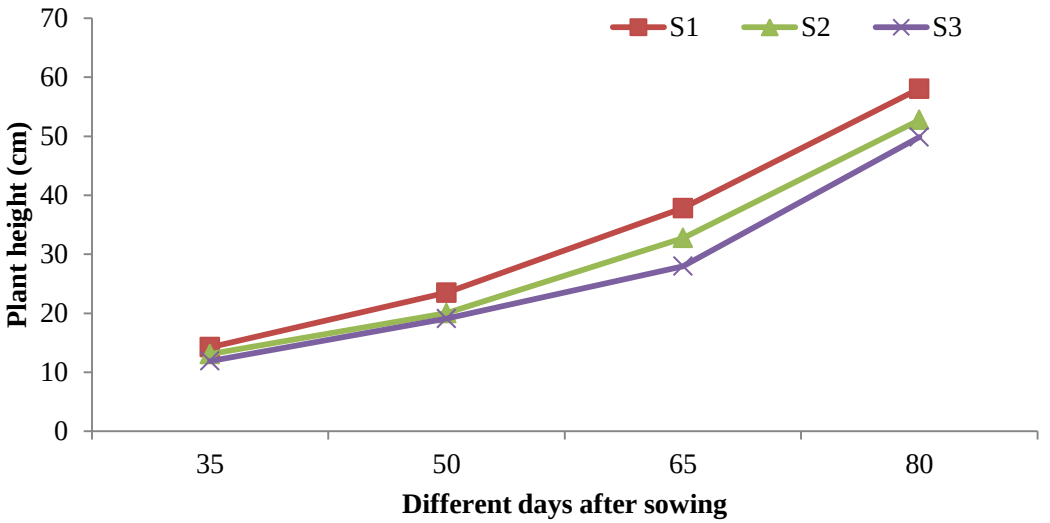


Fig. 2. Effect of sowing date on plant height at different days after sowing (DAS) of fenugreek

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

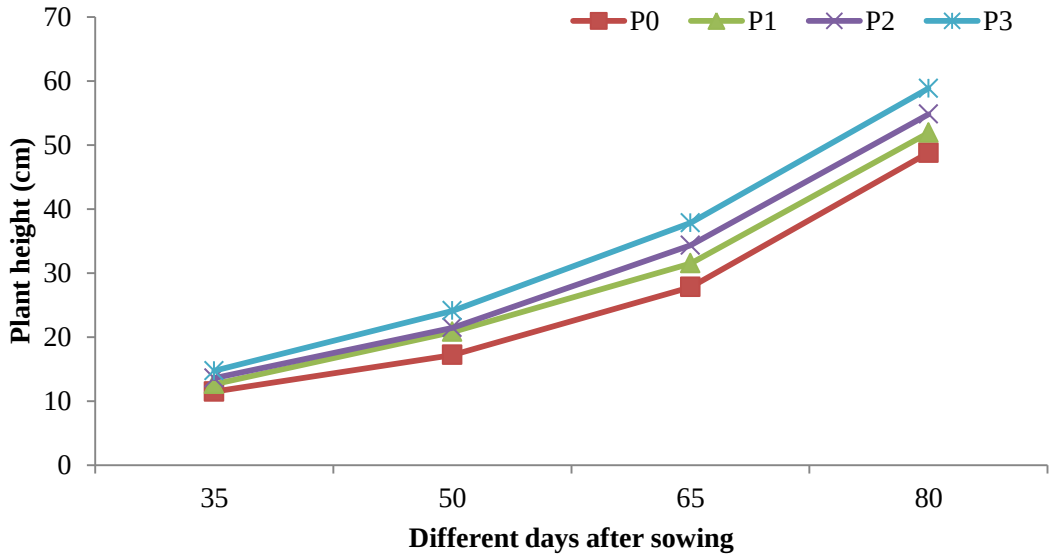


Fig. 3. Effect of phosphorus on plant height at different days after sowing (DAS) of fenugreek

Here, P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Significant influence was observed on plant height of fenugreek due to the combined effect of different sowing dates at 35, 50, 65 and 80 DAS and phosphorus (Appendix IV). From the results of the experiment showed that the highest plant height at 80 DAS (63.71 cm) was observed from S_1P_3 (1 November with 55 kg P ha^{-1}) treatment combination. On the other hand the lowest plant height at 80 DAS (45.15 cm) was revealed from S_3P_0 (30 November with control) treatment combination (Table 1).

Table 1. Combined effect of sowing date and phosphorus on plant height at different days after sowing (DAS) of fenugreek

Treatment combinations	Plant height (cm) at different days after sowing (DAS)			
	35	**50**	**65**	**80**
S_1P_0	12.71 de	18.31 de	30.76 def	52.33 ef
S_1P_1	13.45 cd	23.24 b	36.41 c	56.12 cd
S_1P_2	14.94 ab	25.63 a	40.56 b	60.04 b
S_1P_3	15.95 a	26.81 a	43.57 a	63.71 a
S_2P_0	11.44 ef	17.83 e	28.18 fg	48.82 g
S_2P_1	13.21 d	20.11 c	31.81 de	51.15 fg
S_2P_2	13.10 d	19.42 cd	33.11 d	53.20 ef
S_2P_3	14.62 bc	22.71 b	37.92 bc	57.96 bc
S_3P_0	10.24 f	15.38 f	24.46 h	45.15 h
S_3P_1	11.23 f	19.00 cde	26.21 gh	48.42 g
S_3P_2	12.67 de	19.28 cd	29.32 ef	51.12 fg
S_3P_3	13.58 cd	22.74 b	31.95 de	54.81 de
$LSD_{(0.05)}$	**1.3287**	**1.3141**	**2.9915**	**2.9059**
CV%	**5.71**	**3.79**	**4.94**	**3.23**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.2 Number of compound leaves per plant

Significant variation was noticed on number of compound leaves per plant of fenugreek due to different sowing dates at 35, 50, 65 and 80 DAS under the experiment (Appendix V). From the results of the experiment showed that at 80 DAS, the maximum number of compound leaves per plant (103.81) from S_1 (01 November) treatment where the minimum number of compound leaves per plant (90.26) was revealed from S_3 (30 November) treatment (Table 2). The results of the experiment was coincided with the findings of Nandre *et al.* (2011) reported that the vegetative growth in terms of plant height, number of branches and number of leaves, were increased due to an early sowing (1 November).

Statistically different levels of phosphorus exerted significant influence on number of compound leaves per plant of fenugreek at 35, 50, 65 and 80 DAS under the experiment (Appendix V). It was revealed that at 80 DAS, the maximum number of compound leaves per plant (115.53, respectively) was noted from P_3 (55 kg ha^{-1}) treatment. On the other hand the minimum number of compound leaves per plant (78.12) was observed from P_0 (control) treatment (Table 2). Similar findings were also found by Jagdale and Dalve (2010) who stated that the vegetative growth in terms of plant height, number of leaves and number of branches was increased due to an application of nitrogen and phosphorus.

Table 2. Effect of different sowing date and phosphorus on number of compound leaves per plant at different days after sowing (DAS) of fenugreek

Treatments	Number of compound leaves per plant at			
	35 DAS	50 DAS	65 DAS	80 DAS
Sowing date				
S_1	16.60 a	44.39 a	84.36 a	103.81 a
S_2	15.48 b	41.52 b	79.02 b	96.30 b
S_3	14.39 c	38.08 c	73.25 c	90.26 c
$LSD_{(0.05)}$	0.7962	1.4892	1.6750	1.7201
CV%	6.19	4.20	2.58	2.08
Phosphorus level				
P_0	12.54 d	31.08 d	63.45 d	78.12 d
P_1	15.03 c	41.05 c	79.13 c	94.90 c
P_2	16.44 b	43.35 b	81.36 b	98.61 b
P_3	17.96 a	49.84 a	91.56 a	115.53 a
$LSD_{(0.05)}$	0.9194	1.7196	1.9342	1.9862
CV%	6.19	4.20	2.58	2.08

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

There was marked influence was observed on number of compound leaves per plant at 35, 50, 65 and 80 DAS of fenugreek due to the combined effect of different sowing dates and phosphorus fertilizer (Appendix V). From the results of the experiment showed that the maximum number of compound leaves per plant of fenugreek at 80 DAS (121.63) was observed from S_1P_3 (01 November with 55 kg P ha^{-1}) treatment combination. On the other hand the minimum number of compound leaves per plant

of fenugreek at 80 DAS (73.56) was observed from S_3P_0 (30 November with control) treatment combination (Table 3).

Table 3. Combined effect of sowing date and phosphorus on number of compound leaves per plant at different days after sowing (DAS) of fenugreek

Treatment combinations	Number of compound leaves per plant at			
	35 DAS	50 DAS	65 DAS	80 DAS
S_1P_0	13.32 f	33.52 h	69.30 f	85.90 g
S_1P_1	15.80 d	42.21 f	81.29 d	97.21 e
S_1P_2	17.54 bc	48.30 bc	88.50 bc	110.50 c
S_1P_3	19.75 a	53.51 a	98.34 a	121.63 a
S_2P_0	12.76 fg	30.51 i	63.72 g	74.91 h
S_2P_1	15.19 de	46.72 cd	85.54 c	104.43 d
S_2P_2	16.07 cd	38.14 g	76.25 e	90.22 f
S_2P_3	17.91 b	50.71 ab	90.56 b	115.63 b
S_3P_0	11.53 g	29.21 i	57.34 h	73.56 h
S_3P_1	14.09 ef	34.21 h	70.56 f	83.07 g
S_3P_2	15.70 d	43.61 ef	79.32 de	95.10 e
S_3P_3	16.23 cd	45.29 de	85.78 c	109.32 c
$LSD_{(0.05)}$	**1.5924**	**2.9784**	**3.3501**	**3.4402**
CV%	**6.19**	**4.20**	**2.58**	**2.08**

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.3 Spreading of plant

Statistically significant variation was observed on spreading of plant at 35, 50, 65 and 80 DAS due to different sowing dates under the present experiment (Appendix VI). Results from the experiment showed that at 80 DAS, the highest plant spreading (24.62 cm) was observed from S_1 (01 November) treatment where the lowest plant spreading (20.77 cm) was revealed from S_3 (30 November) treatment (Table 4). Similar results was also observed by Kauser *et al.* (2018) who reported that sowing dates significantly affected on maximum plant spreading.

Different levels of phosphorus showed significant influence on plant spreading of fenugreek at 35, 50, 65 and 80 DAS under the present study (Appendix VI). It was revealed that at 80 DAS, the highest plant spreading (25.69 cm) was observed from P_3 (55 kg ha^{-1}) treatment. On the other hand the lowest plant spreading (19.39 cm) was observed from P_0 (control) treatment (Table 4).

Table 4. Effect of different sowing date on spreading of plant at different days after sowing (DAS) of fenugreek

Treatments	Plant spread (cm) at			
	35 DAS	50 DAS	65 DAS	80 DAS
Sowing date				
S_1	6.78 a	9.57 a	16.09 a	24.62 a
S_2	6.20 b	8.11 b	14.54 b	21.55 b
S_3	5.52 c	7.25 c	13.95 c	20.77 c
$LSD_{(0.05)}$	0.5045	0.5078	0.5072	0.4986
CV%	6.26	4.97	3.57	4.16
Phosphorus level				
P_0	4.98 c	6.38 d	10.49 d	19.39 d
P_1	6.20 b	8.12 c	12.74 c	21.64 c
P_2	6.33 b	8.89 b	17.66 b	22.53 b
P_3	7.15 a	9.86 a	18.54 a	25.69 a
$LSD_{(0.05)}$	0.5825	0.5864	0.5856	0.5757
CV%	6.26	4.97	3.57	4.16

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

There was marked influence observed on plant spreading of fenugreek at 35, 50, 65 and 80 DAS due to the combined effect of different sowing dates and phosphorus (Appendix VI). From the results of the experiment showed that the highest plant spreading at 80 DAS (28.95 cm) was observed from S_1P_3 (1 November with 55 kg P ha^{-1}) treatment combination. On the other hand the lowest plant spreading at 80 DAS (18.48 cm) was revealed from S_3P_0 (30 November with control) treatment combination (Table 5).

Table 5. Combined effect of different sowing date and phosphorus level on spreading of plant at different days after sowing (DAS) of fenugreek

Treatment combinations	Plant spread (cm) at			
	35 DAS	**50 DAS**	**65 DAS**	**80 DAS**
S_1P_0	5.61 cde	7.32 fg	11.81 f	20.20 fg
S_1P_1	7.15 ab	8.91 cd	13.92 e	23.41 d
S_1P_2	6.51 bc	11.44 a	18.80 b	25.93 b
S_1P_3	7.85 a	10.62 ab	19.83 a	28.95 a
S_2P_0	5.02 ef	6.56 g	10.72 g	19.50 g
S_2P_1	6.19 bcd	8.34 de	12.41 f	21.10 f
S_2P_2	6.59 bc	7.70 ef	16.99 d	22.20 e
S_2P_3	7.00 ab	9.85 bc	18.02 bc	23.40 d
S_3P_0	4.31 f	5.26 h	8.95 h	18.48 h
S_3P_1	5.26 def	7.12 fg	11.88 f	20.42 fg
S_3P_2	5.90 cde	7.52 efg	17.20 cd	19.46 gh
S_3P_3	6.61 bc	9.10 cd	17.76 cd	24.72 c
$LSD_{(0.05)}$	**1.0089**	**1.0156**	**1.0144**	**0.9972**
CV%	**6.26**	**4.97**	**3.57**	**4.16**

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November;

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.4 Branches per plant

Branches per plant showed significant difference due to different sowing dates under the present experiment (Appendix VII). Results from the experiment showed that the maximum number of branches per plant (6.74) was recorded from S_1 (1 November) treatment where the minimum number of branches per plant (5.55) was revealed from S_3 (30 November) treatment (Table 6). Similar result was found by Kauser *et al.* (2018) who stated that earlier sowing increases the branches per plant of fenugreek. Nandre *et al.* (2011) found the similar result. They revealed that number of branches and number of leaves, were increased due to an early sowing (1 November).

Significant influence was noticed on number of branches per plant of fenugreek due to different levels of phosphorus under the present study (Appendix VII). It was

revealed that the maximum number of branches per plant (7.02) was observed from P_3 (55 kg ha^{-1}) treatment which was statistically identical with P_2 (45 kg ha^{-1}) treatment. On the other hand the minimum number of branches per plant (5.20) was observed from P_0 (control) treatment (Table 6). The result of the experiment was coincided with the findings of Jagdale and Dalve (2010) who reported that the vegetative growth in terms of plant height, number of leaves and number of branches was increased due to an application of nitrogen and phosphorus. Similar trends was also found by Sharma *et al.* (2014) who reported that branches per plant increases with the application of phosphorus.

Statistically significant influence was observed on number of branches per plant of fenugreek due to the combined effect of different sowing dates and phosphorus (Appendix VII). From the results of the experiment showed that the maximum number of branches per plant (7.57) was observed from S_1P_3 (1 November with 55 kg P ha^{-1}) treatment combination which was statistically similar with S_1P_2 (1 November with 45 kg P ha^{-1}) and S_2P_3 (15 November with 55 kg P ha^{-1}) treatment combination. On the other hand the minimum number of branches per plant (4.55) was revealed from S_3P_0 (30 November with control) treatment combination which was statistically similar with S_3P_1 (30 November with 35 kg P ha^{-1}) and S_2P_0 (15 November with control) treatment combination (Table 6).

4.5 Days to 50% flowerings

Days to 50% flowerings showed significant variation due to different sowing dates (Appendix VII). Results from the experiment showed that the maximum days to 50% flowerings (50.01) was recorded from S_2 (15 November) treatment where the minimum days to 50% flowerings (46.60) was revealed from S_3 (30 November) treatment (Table 6). The findings of the experiment was coincided with the findings of Bhutia and Sharangi (2016) who reported that to obtain higher seed yield, fenugreek should be sown earlier November and irrigation should be given in all the major growth phases at seedling, branching, flowering, pod formation and pod development stages.

There was marked variation was noticed on days to 50% flowerings of fenugreek due to different levels of phosphorus (Appendix VII). It was revealed that the maximum days to 50% flowerings (50.28) were observed from P_2 (45 kg ha^{-1}) treatment. On the

other hand the minimum days to 50% flowerings (46.31) were observed from P_0 (control) treatment (Table 6). Result from the experiment was in coincided with the findings of Sharma *et al.* (2014). Similar result was observed by Jagdale and Dalve (2010) who reported that the maturity parameters like number of days required for first flower initiation, days required for 50% flowering, first pod formation, 50% pod formation and maturity of seed crop were found to be delayed with an increased level of nitrogen and phosphorus.

Days to 50% flowerings were observed significant influence due to combined effect of different sowing dates and phosphorus (Appendix VII). From the results of the experiment showed that the maximum days to 50% flowerings (51.91) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination which was statistically similar with S_2P_3 (15 November with 55 kg P ha^{-1}) treatment combination. On the other hand the minimum days to 50% flowerings (45.11) was revealed from S_3P_0 (30 November with control) treatment combination which was statistically similar with S_3P_1 (30 November with 35 kg P ha^{-1}) treatment combination (Table 7).

4.6 Pods per plant

Significant difference on number of pods per plant was noticed due to different sowing dates (Appendix VII). Results from the experiment showed that the maximum number of pods per plant (43.15) was recorded from S_2 (15 November) treatment where the minimum number of pods per plant (36.55) was revealed from S_3 (30 November) treatment (Table 6). Kauser *et al.* (2018) observed the similar results.

Number of pods per plant showed significant difference due to different levels of phosphorus (Appendix VII). It was revealed that the maximum number of pods per plant (46.66) was observed from P_2 (45 kg ha^{-1}) treatment while the minimum number of pods per plant (33.13) was observed from P_0 (control) treatment (Table 6). The findings of the present study was in coincided with the findings of Aditi *et al.* (2020) who reported that the yield parameters in respect to number of pods per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare and test weight were observed significantly maximum due to judicious P application.

Marked influence was exerted on number of pods per plant of fenugreek due to the combined effect of different sowing dates and phosphorus (Appendix VII). From the results of the experiment showed that the maximum number of pods per plant (52.61) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination. On the other hand the minimum number of pods per plant (30.25) was revealed from S_3P_0 (30 November with control) treatment combination (Table 7).

4.7 Pod length

Statistically non-significant variation on pod length was noticed due to different sowing dates during the present study (Appendix VIII). But results from the experiment showed that the maximum pod length (9.57 cm) was recorded from S_2 (15 November) treatment where the minimum length of single pod (9.22 cm) was revealed from S_3 (30 November) treatment (Table 6). Kauser *et al.* (2018) found the dissimilar result and stated that length of pod statistically influenced due to varied sowing dates.

Pod length significantly influenced by different levels of phosphorus during the experimentation (Appendix VIII). It was revealed that the maximum pod length (10.03 cm) was observed from P_2 (45 kg ha^{-1}) treatment while the minimum pod length (8.63 cm) was recorded from P_0 (control) treatment (Table 6). Tuncturk (2011) observed the dissimilar result of the experiment and stated that phosphorus fertilizer applications positively affected all the traits examined except for pod length.

Marked variation was observed on pod length of fenugreek due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix VIII). The maximum pod length (10.62 cm) was obtained from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination which was statistically similar with S_2P_3 (15 November with 55 kg P ha^{-1}) treatment combination. On the other hand the minimum pod length (8.02 cm) was revealed from S_3P_0 (30 November with control) treatment combination which were statistically similar with S_1P_0 (1 November with control) treatment combination (Table 7).

Table 6. Effect of different sowing date and phosphorus level on branches per plant, days to 50% flowerings, pods per plant and pod length of fenugreek

Treatments	Branches per plant	Days to 50% flowerings	Pods per plant	Pod length (cm)
Different sowing date				
S_1	6.74 a	48.50 b	41.31 b	9.27
S_2	6.17 b	50.01 a	43.15 a	9.57
S_3	5.55 c	46.60 c	36.55 c	9.22
$LSD_{(0.05)}$	0.4723	0.4750	1.2885	0.3956^{NS}
CV%	7.96	3.06	3.30	5.04
Different level of phosphorus				
P_0	5.20 c	46.31 d	33.13 d	8.63 c
P_1	5.87 b	47.85 c	38.40 c	9.33 b
P_2	6.51 a	50.28 a	46.66 a	10.03 a
P_3	7.017 a	49.04 b	43.18 b	9.43 b
$LSD_{(0.05)}$	0.5453	0.5485	1.4878	0.4568
CV%	7.96	3.06	3.30	5.04

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November;

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Table 7. Combined effect of different sowing date and phosphorus level on branches per plant, days to 50% flowerings, pods per plant and pod length of fenugreek

Treatment combinations	Branches per plant	Days to 50% flowerings	Pods per plant	Pod length (cm)
S_1P_0	5.80 de	46.35 ij	35.21 g	8.75 de
S_1P_1	6.42 bcd	48.11 fg	43.35 cd	9.49 bcd
S_1P_2	7.15 ab	50.32 bc	45.46 c	9.23 cd
S_1P_3	7.57 a	49.23 de	41.23 de	9.61 bc
S_2P_0	5.26 ef	47.46 gh	33.93 g	9.12 cd
S_2P_1	5.97 cde	49.71 cd	37.82 f	9.55 bc
S_2P_2	6.53 bcd	51.91 a	52.61 a	10.62 a
S_2P_3	6.90 abc	50.96 ab	48.25 b	9.00 cd
S_3P_0	4.55 f	45.11 k	30.25 h	8.02 e
S_3P_1	5.22 ef	45.72 jk	34.00 g	8.96 cd
S_3P_2	5.86 de	48.62 ef	41.90 de	10.24 ab
S_3P_3	6.58 bcd	46.93 hi	40.05 ef	9.67 bc
$LSD_{(0.05)}$	**0.9445**	**0.9500**	**2.5770**	**0.7912**
CV%	**7.96**	**3.06**	**3.30**	**5.04**

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.8 Seeds per pod

Significant influence on number of seeds per pod was noticed due to different sowing dates during the present study (Appendix VII). Results from the experiment showed that the maximum number of seeds per pod (11.81) was recorded from S_2 (15 November) treatment where the minimum number of seeds per pod (9.92) was revealed from S_3 (30 November) treatment (Table 8). Similar result was found by Kauser *et al.* (2018). Nandre *et al.* (2011) revealed the similar trends who stated that number of pods, number of seeds per pod, weight of seeds per pod, seed yield per plot and seed yield per hectare were found to be the maximum with an early sowing (1 November).

Seeds per pod showed significant variation due to different levels of phosphorus during the experimentation (Appendix VII). It was revealed that the maximum number of seeds per pod (11.94) was observed from P_2 (45 kg ha^{-1}) treatment while the minimum number of seeds per pod (9.77) was noted from P_0 (control) treatment (Table 8). Aditi *et al.* (2020) found the similar trends of the experiment who reported that yield parameters in respect to number of pods per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare and test weight were observed significantly maximum due to judicious P application.

Number of seeds per pod of fenugreek showed significant influence due to the combined effect of different sowing dates and phosphorus (Appendix VII). The maximum number of seeds per pod (12.87) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination which was statistically similar with S_2P_3 (15 November with 55 kg P ha^{-1}) and S_1P_2 (1 November with 45 kg P ha^{-1}) treatment combination. On the other hand the minimum number of seeds per pod (9.11) was observed from S_3P_0 (30 November with control) treatment combination which was statistically similar with S_3P_1 (30 November with 35 kg P ha^{-1}) treatment combination (Table 9).

4.9 Weight of individual pod

Marked variation on weight of individual pod was observed due to different sowing dates during the present study (Appendix VIII). Results from the experiment showed that the maximum weight of individual pod (119.99 mg) was recorded from S_2 (15 November) treatment where the minimum weight of individual pod (106.42 mg) was revealed from S_3 (30 November) treatment (Table 8). Similar result was observed by Parmar *et al.* (2020).

Weight of individual pod significantly influence by different levels of phosphorus during the experimentation (Appendix VIII). It was revealed that the maximum weight of individual pod (133.43 mg) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum weight of individual pod (98.53 mg) was recorded from P_0 (control) treatment (Table 8). The result of the experiment was in coincided with the findings of Nandre *et al.* (2011) also found the similar trends.

Statistically significant variation was noticed on weight of individual pod of fenugreek due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix VIII). From the results of the experiment showed that the maximum weight of individual pod (147.11 mg) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum weight of individual pod (92.63 mg) was revealed from S_3P_0 (30 November with control) treatment combination (Table 9).

4.10 Weight of seeds per plant

Weight of seeds per plant revealed marked variation due to different sowing dates during the present experiment (Appendix VIII). Results from the experiment showed that the maximum weight of seeds per plant (5.40 g) was obtained from S_2 (15 November) treatment which was statistically similar with S_1 (1 November) treatment where the minimum weight of seeds per plant (4.89 g) was noted from S_3 (30 November) treatment (Table 8). Sowmya *et al.* (2017) found the similar trends and stated that weight of pod, number of seeds pod^{-1}, weight of seeds pod^{-1} and thousand seed weight was higher when early sowing.

Significant influence was observed on weight of seeds per plant due to different levels of phosphorus during the experimentation (Appendix VIII). It was revealed that the maximum weight of seeds per plant (6.91 g) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum weight of seeds per plant (3.05 g) was recorded from P_0 (control) treatment (Table 8). Aditi *et al.* (2020) observed the similar trends and revealed that yield parameters in respect to number of pods per plant, seeds per pod, seed yield per plant, seed yield per plot, seed yield per hectare and test weight were observed significantly maximum when judicious application of phosphorus.

Weight of seeds per plant of fenugreek revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix VIII). From the results of the experiment showed that the maximum weight of seeds per plant (7.67 g) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum weight of seeds per plant (2.70 g) was obtained from S_3P_0 (30 November with control) treatment combination (Table 9).

Table 8. Effect of different sowing date and phosphorus level on length of single pod, weight of individual pod and weight of seeds per plant of fenugreek

Treatments	Seeds per pod	Weight of individual pod (mg)	Weight of seeds/plant (g)
Different sowing date			
S_1	10.97 b	115.88 b	5.17 ab
S_2	11.81 a	119.99 a	5.40 a
S_3	9.92 c	106.42 c	4.89 b
$LSD_{(0.05)}$	0.4884	3.1093	0.4250
CV%	3.64	3.12	9.74
Different level of phosphorus			
P_0	9.77 d	98.53 d	3.05 d
P_1	10.61 c	106.87 c	4.72 c
P_2	11.94 a	133.43 a	6.91 a
P_3	11.29 b	117.56 b	5.94 b
$LSD_{(0.05)}$	0.5639	3.5903	0.4907
CV%	3.64	3.12	9.74

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November;

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Table 9. Combined effect of different sowing date and phosphorus level on length of single pod, weight of single pod and weight of seeds per plant of fenugreek

Treatment combinations	Seeds per pod	Weight of individual pod (mg)	Weight of seeds/plant (g)
S_1P_0	9.81 ghi	103.38 fgh	3.61 gh
S_1P_1	10.77 defg	110.48 e	5.04 def
S_1P_2	11.96 abc	130.82 b	6.41 bc
S_1P_3	11.35 cde	118.86 d	5.62 cd
S_2P_0	10.40 efgh	99.59 h	2.84 hi
S_2P_1	11.59 bcd	107.93 efg	4.36 fg
S_2P_2	12.87 a	147.11 a	7.67 a
S_2P_3	12.37 ab	125.32 bc	6.74 b
S_3P_0	9.11 i	92.63 i	2.70 i
S_3P_1	9.46 hi	102.21 gh	4.76 ef
S_3P_2	10.98 def	122.36 cd	6.66 b
S_3P_3	10.14 fgh	108.50 ef	5.46 de
$LSD_{(0.05)}$	**0.9768**	**6.2186**	**0.85**
CV%	**3.64**	**3.12**	**9.74**

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.11 Weight of 1000-seed

Weight of 1000-seed revealed marked variation due to different sowing dates during the present experiment (Appendix XII). Results from the experiment showed that the maximum weight of 1000-seed (12.58 g) was revealed from S_2 (15 November) treatment where the minimum weight of 1000-seed (10.22 g) was noted from S_3 (30 November) treatment (Fig. 4). The result of the experiment was in coincided with the findings of Sowmya *et al.* (2017) who reported that thousand seed weight, seed yield, straw yield, biological yield and harvest index were statistically influenced due to different sowing dates.

Significant influence was observed on weight of 1000-seed due to different levels of phosphorus during the experimentation (Appendix XII). It was revealed that the maximum weight of 1000-seed (12.75 g) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum weight of 1000-seed (10.03 g) was recorded from P_0 (control) treatment (Fig. 5). Similar result was observed by Bairagi (2014).Khan *et al.* (2005) revealed that phosphorus application improved the performance of fenugreek plants for number of seeds per plant, 1000 seed weight, biological yield, seed yield and harvest index of fenugreek.

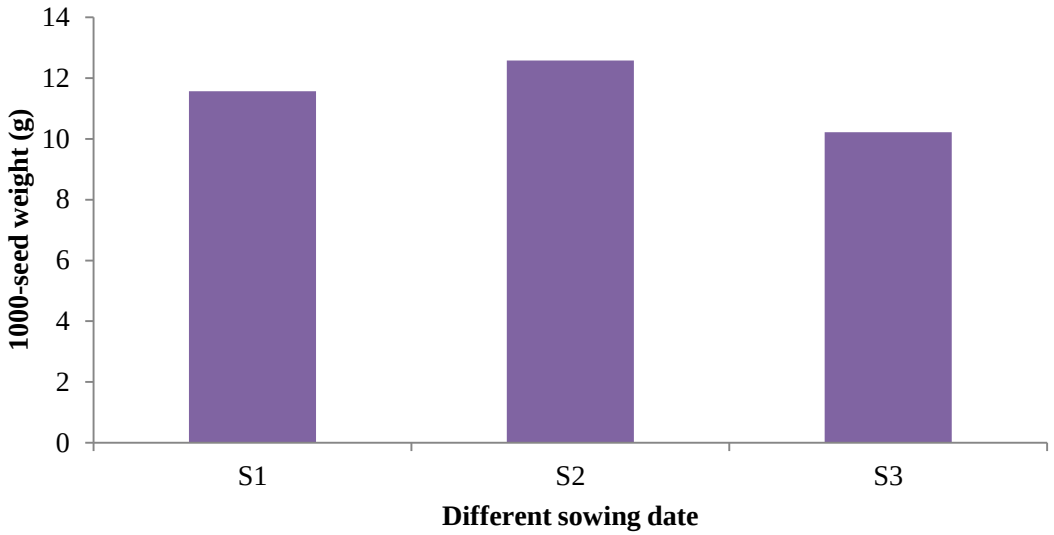


Fig. 4. Effect of sowing date on 1000-seed weight of fenugreek

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

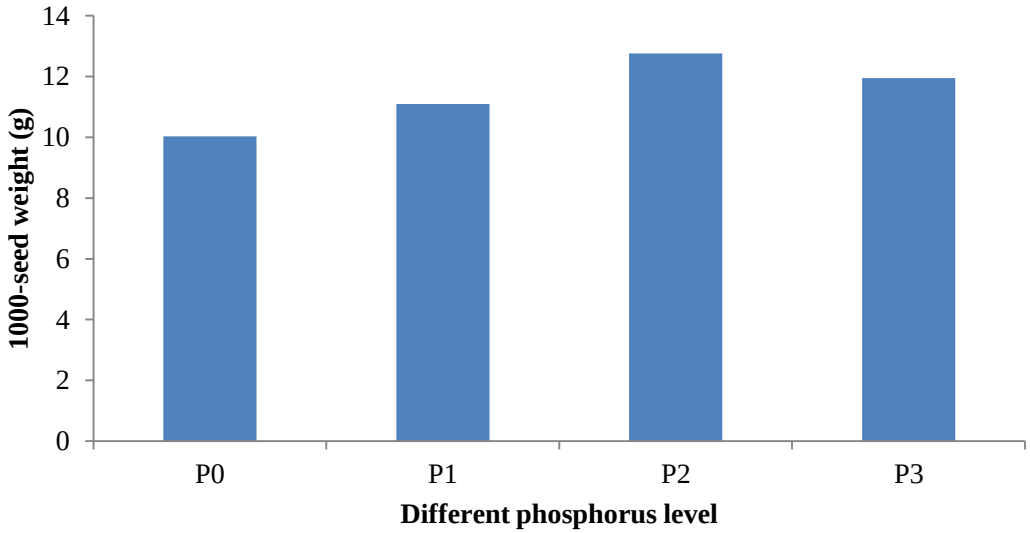


Fig. 5. Effect of different phosphorus level on 1000-seed weight of fenugreek

Here, P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Weight of 1000-seed of fenugreek revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix IX). From the results of the experiment showed that the maximum weight of 1000-seed (13.86 g) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination which was statistically similar with S_2P_3 (15 November with 55 kg P ha^{-1}) treatment combination while the minimum weight of 1000-seed (9.17 g) was revealed from S_3P_0 (30 November with control) treatment combination which was statistically similar to S_3P_1 (30 November with 35 kg P ha^{-1}) treatment combination (Table 10).

4.12 Weight of straw per plot

Weight of straw per plot revealed marked variation due to different sowing dates during the present experiment (Appendix XII). Results from the experiment showed that the maximum weight of straw per plot (355.43 g) was revealed from S_1 (1 November) treatment where the minimum weight of straw per plot (326.22 g) was noted from S_3 (30 November) treatment (Fig. 6). The result of the experiment was in coincided with the findings of Sowmya *et al.* (2017) who reported that treatment with early sowing recorded maximum number of pods $plant^{-1}$, pod length, weight of pod, number of seeds pod^{-1}, weight of seeds pod^{-1}, thousand seed weight, seed yield, straw yield, biological yield, harvest index, chlorophyll content, germination %, seedling vigour index, protein%, galactomannon content.

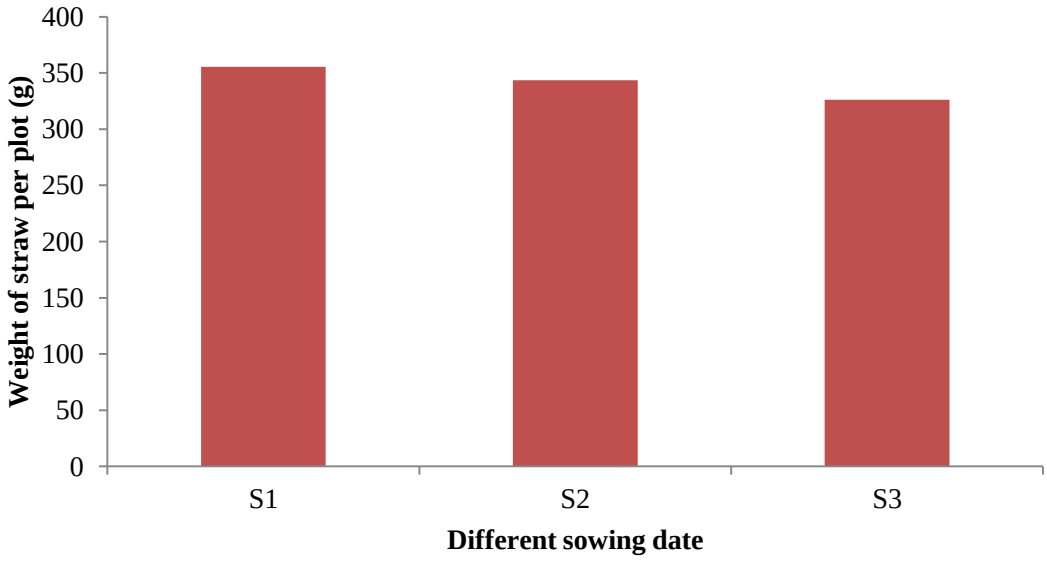


Fig. 6. Effect of different sowing date on weight of straw per plot of fenugreek

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

Significant influence was observed on weight of straw per plot due to different levels of phosphorus during the experimentation (Appendix XII). It was revealed that the maximum weight of straw per plot (390.58 g) was observed from P_3 (55 kg P ha^{-1}) treatment while the minimum weight of straw per plot (284.00 g) was recorded from P_0 (control) treatment (Fig. 7). Similar trends was observed by Sharma *et al.* (2014) who revealed that The application of phosphorus up to 40 kg P_2O_5 ha^{-1} resulted in significantly higher number of branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield over their respective preceding levels (0 and 20 kg P_2O_5 ha^{-1}) but it was found at par with 60 kg P_2O_5 ha^{-1} in respect to branches per plant, chlorophyll content at flowering stage, nodules per plant, pods per plant, seeds per pod, seed and straw yield of fenugreek. Nehara *et al.* (2006) revealed that an increase in P level significantly increased the yield-attributing characters; the seed, straw and biological yields; and the net returns of fenugreek.

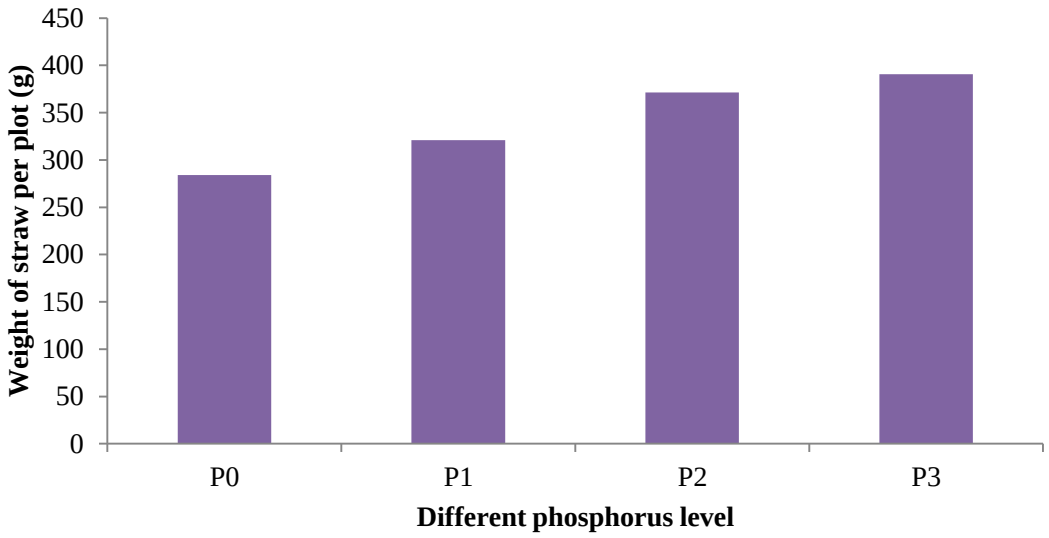


Fig. 7. Effect of different phosphorus level on weight of straw per plot of fenugreek

Here, P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Weight of straw per plot of fenugreek revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix IX). From the results of the experiment showed that the maximum weight of straw per plot (420.94 g) was observed from S_1P_3 (01 November with 55 kg P ha^{-1}) treatment combination while the minimum weight of straw per plot

(272.61 g) was revealed from S_3P_0 (30 November with control) treatment combination (Table 10).

4.13 Seed yield per plot

Significant variation was revealed on seed yield per plot due to different sowing dates during the present experiment (Appendix XII). Results from the experiment showed that the maximum seed yield per plot (216.12 g) was revealed from S_2 (15 November) treatment which was statistically similar with S_1 (1 November) treatment where the minimum seed yield per plot (195.84 g) was noted from S_3 (30 November) treatment (Fig. 8). Similar trends were observed by Nandre *et al.* (2011) who reported that seed yield per plot and seed yield per hectare were found to be the maximum with an early sowing (1 November). Kauser *et al.* (2018) revealed the similar types of result and stated that seed yield per plot were maximum sowing on 1 November.

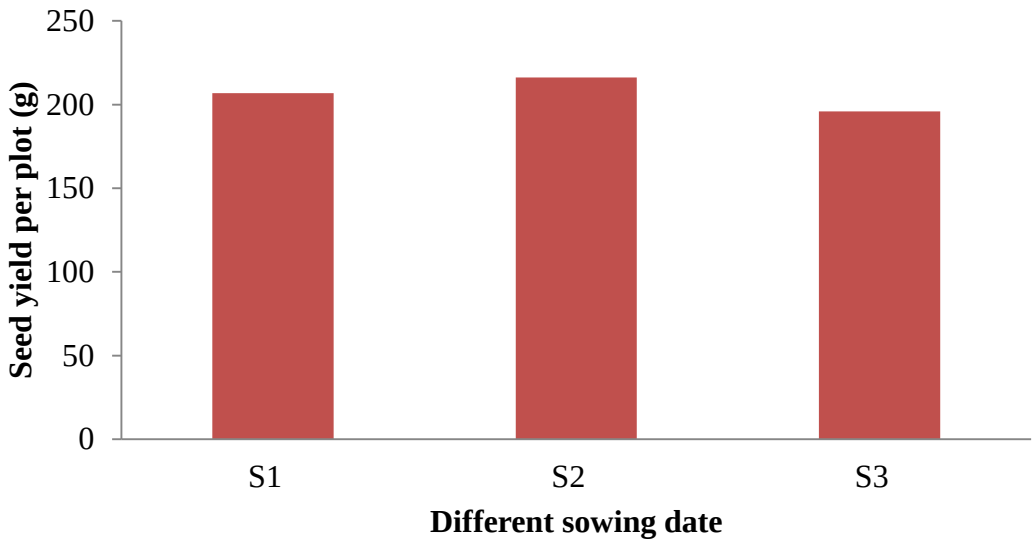


Fig. 8. Effect of different sowing date on seed yield per plot of fenugreek

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

Significant influence was observed on seed yield per plot due to different levels of phosphorus during the experimentation (Appendix XII). It was revealed that the maximum seed yield per plot (276.48 g) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum seed yield per plot (122.08 g) was recorded from P_0 (control) treatment (Fig. 9). Nandre *et al.* (2011) revealed that seed yield per plot were maximum with judicious phosphorus application. Tuncturk (2011) reported that phosphorus fertilizer applications positively affected all the traits examined except for

pod length. Similar result was observed by Nehara *et al.* (2006) who stated that an increase in P level and sulphur level significantly increased the yield-attributing characters; the seed, straw and biological yields; and the net returns of fenugreek.

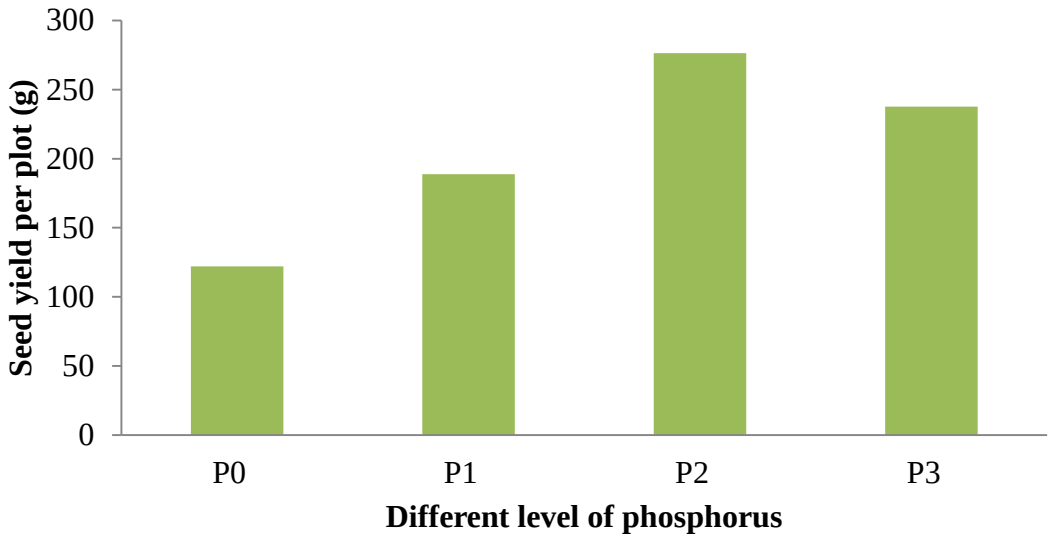


Fig. 9. Effect of different phosphorus level on seed yield per plot of fenugreek

Here, P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Seed yield per plot of fenugreek revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix IX). From the results of the experiment showed that the maximum seed yield per plot (306.72 g) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum seed yield per plot (108.00 g) was revealed from S_3P_0 (30 November with control) treatment combination (Table 10).

4.14 Seed yield per hectare

Significant variation was revealed on seed yield per hectare due to different sowing dates during the present experiment (Appendix XII). Results from the experiment showed that the maximum seed yield per hectare (1.50 t) was revealed from S_2 (15 November) treatment which was statistically similar with S_1 (1 November) treatment where the minimum seed yield per hectare (1.36 t) was noted from S_3 (30 November) treatment (Fig. 10). The result of the experiment was coincided with the findings of Kauser *et al.* (2018) who stated that seed yield were maximum when sowing on early November. Nandre *et al.* (2011) revealed that seed yield per hectare were found to be the maximum with an early sowing (1 November). Similar trends were found by

Meena *et al.* (2018) who reported that maximum seed yield was observed when sown on 15 November. Sultana *et al.* (2016) reported that sowing date had significant effects on seed yield and its components. The results obtained from the study showed a significant variation with different dates of sowing. Projected seed yield per hectare was maximum (1.4 t ha^{-1}) on 2nd November. It was evident from the results that the date of sowing had a significant influence on phenology, growth, and yield of fenugreek. It may be concluded from the results that to obtain higher seed yield fenugreek should be sown earlier at 2nd November. Bhutia and Sharangi (2016) revealed that sowing date had significant effects on seed yield and its components. It may be concluded that to obtain higher seed yield fenugreek should be sown earlier at 2nd November and to obtain maximum seed yield irrigation should be given at seedling, branching, flowering, pod formation, pod development stages.

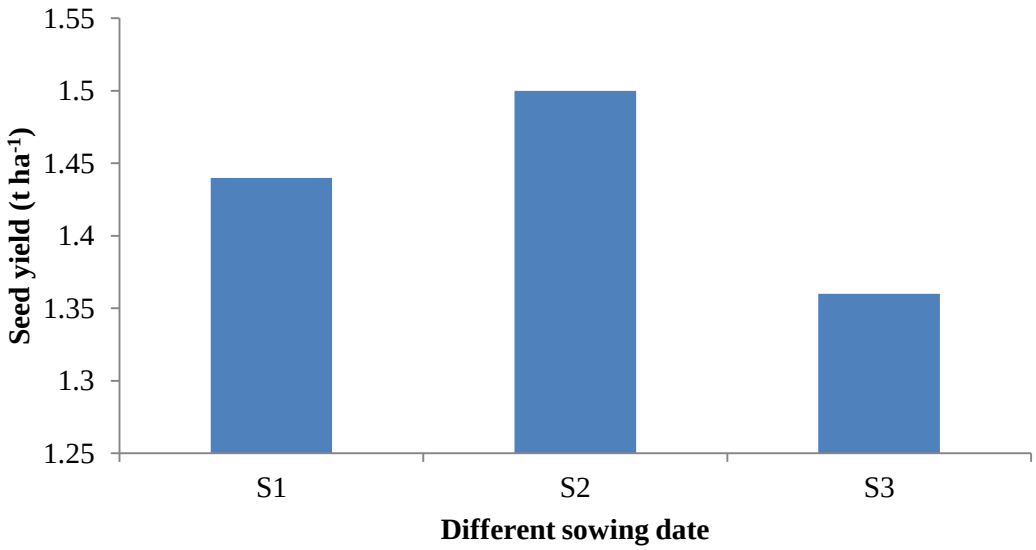


Fig. 10. Effect of different sowing date on seed yield of fenugreek

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

Significant influence was exerted on seed yield per hectare due to different levels of phosphorus during the experimentation (Appendix XII). It was revealed that the maximum seed yield per hectare (1.92 t) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum seed yield per hectare (0.85 t) was recorded from P_0 (control) treatment (Fig. 11). The result of the experiment was in coincided with the findings of Aditi *et al.* (2020) who reported that seed yield per hectare was observed significantly maximum in judicious application of phosphorus. Sharma *et al.* (2014) revealed that maximum seed yield recorded with phosphorus application. Bairagi

(2014) reported that seed yield was observed with the application of phosphorus coupled with a row spacing of 30 cm was found to be most suitable for obtaining highest yield of good quality fenugreek seed in North Indian conditions. Khan *et al.* (2005) found the similar trends and reported that significant increased seed yield of fenugreek was obtained for the crop raised with 60 kg P_2O_5 ha^{-1} but was statistically at par with 45 kg P_2O_5 ha^{-1}. It is concluded that optimum dose of phosphorus for fenugreek crop is 45 kg P_2O_5 ha^{-1}. It is also suggested that further research should be done on planting geometry of fenugreek under different environmental conditions.

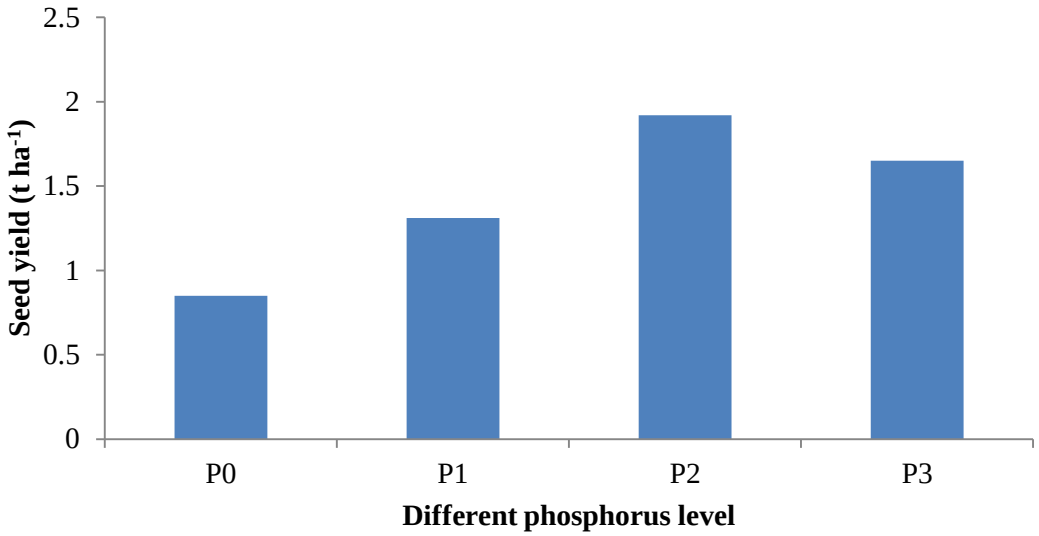


Fig. 11. Effect of different phosphorus level on seed yield of fenugreek

Here, P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Seed yield per hectare of fenugreek revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix IX). From the results of the experiment showed that the maximum seed yield per hectare (2.13 t) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum seed yield per hectare (0.75 t) was obtained from S_3P_0 (30 November with control) treatment combination (Table 10).

Table 10. Combined effect of different sowing date and phosphorus level on 1000-seed weight, weight of straw per plot, seed yield per plot and seed yield of fenugreek

Treatment combinations	1000-seed weight (g)	Weight of straw/plot (g)	Seed yield/plot (g)	Seed yield (t/ha)
S_1P_0	10.08 hij	295.23 fg	144.48 gh	1.00 gh
S_1P_1	11.27 efg	335.52 de	201.6 def	1.40 def
S_1P_2	12.79 bc	370.65 bc	256.32 bc	1.78 bc
S_1P_3	12.11 cde	420.94 a	224.64 cd	1.56 cd
S_2P_0	10.84 fgh	284.15 gh	113.76 hi	0.79 hi
S_2P_1	12.39 bcd	321.72 e	174.24 fg	1.21 fg
S_2P_2	13.86 a	362.21 c	306.72 a	2.13 a
S_2P_3	13.22 ab	405.92 b	269.76 b	1.87 b
S_3P_0	9.17 j	272.61 h	108.00 i	0.75 i
S_3P_1	9.61 ij	305.57 f	190.56 ef	1.32 ef
S_3P_2	11.60 def	381.23 b	266.40 b	1.85 b
S_3P_3	10.49 ghi	345.48 d	218.40 de	1.52 de
$LSD_{(0.05)}$	0.9719	14.992	33.99	0.2361
CV%	3.53	2.59	9.74	9.74

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

4.15 Germination percentage

Non-significant variation was revealed on germination percentage due to different sowing dates during the present experiment (Appendix X). But results from the experiment showed that the maximum germination percentage (92.83) was revealed from S_1 (01 November) treatment where the minimum germination percentage (91.25) was noted from S_3 (30 November) treatment (Table 11). Parmar *et al.* (2020) reported that November sowing in shade net compared to open field and germination, plant height, leaf yield were found to be best and also polyhouse is best compared to shade net.

Non-significant influence was exerted on germination percentage due to different levels of phosphorus during the experimentation (Appendix X). It was revealed that the maximum germination percentage (93.67) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum germination percentage (89.89) was recorded from P_0 (control) treatment (Table 11). Aditi *et al.* (2020) revealed that better seed quality parameters *viz.*, germination percentage, chlorophyll content, seedling vigour index was recorded significantly with judicious phosphorus application and protein content was recorded significantly superior with judicious phosphorus application.

Germination percentage of fenugreek revealed statistically non-significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix X). From the results of the experiment showed that the maximum germination percentage (93.33) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum germination percentage (88.67) was revealed from S_3P_0 (30 November with control) treatment combination (Table 12).

4.16 Shoot length

Non-significant variation was revealed on shoot length due to different sowing dates during the present experiment (Appendix X). But results from the experiment showed that the maximum shoot length (3.00 cm) was revealed from S_2 (15 November) treatment where the minimum shoot length (2.90 cm) was noted from S_3 (30 November) treatment (Table 11).

Non-significant influence was observed on shoot length due to different levels of phosphorus during the experimentation (Appendix X). It was revealed that the maximum shoot length (3.18 cm) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum shoot length (2.71 cm) was recorded from P_0 (control) treatment (Table 11).

Shoot length of fenugreek revealed statistically non-significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix X). From the results of the experiment showed that the maximum shoot length (3.21 cm) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment

combination while the minimum shoot length (2.60 cm) was revealed from S_3P_0 (30 November with control) treatment combination (Table 12).

4.17 Root length

Non-significant influence was revealed on root length due to different sowing dates during the present experiment (Appendix X). But results from the experiment showed that the maximum root length (2.76 cm) was revealed from S_2 (15 November) treatment where the minimum root length (2.59 cm) was noted from S_3 (30 November) treatment (Table 11).

Non-significant influence was noticed on root length due to different levels of phosphorus during the experimentation (Appendix X). It was revealed that the maximum root length (2.71 cm) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum root length (2.59 cm) was recorded from P_0 (control) treatment (Table 11).

Root length of fenugreek revealed statistically non-significant influence due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix X). From the results of the experiment showed that the maximum root length (2.90 cm) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum root length (2.52 cm) was revealed from S_3P_0 (30 November with control) treatment combination (Table 12).

4.18 Vigor index

Significant variation was observed on vigor index due to different sowing dates during the present experiment (Appendix X). Results from the experiment showed that the maximum vigor index (529.07) was revealed from S_2 (15 November) treatment where the minimum vigor index (501.85) was noted from S_3 (30 November) treatment (Table 11). Similar trends were also observed by Sowmya *et al.* (2017).

Significant influence was marked on vigor index due to different levels of phosphorus during the experimentation (Appendix X). It was revealed that the maximum vigor index (552.36) was observed from the treatment P_2 (45 kg P ha^{-1}) while the minimum vigor index (480.45) was recorded from P_0 (control) treatment (Table 11). Aditi *et al.* (2020) found the similar trends of result and they stated that better seed quality

parameters *viz.*, germination percentage, chlorophyll content, seedling vigour index was recorded significantly with phosphorus application.

Vigor index revealed statistically significant variation due to the combined effect of different sowing dates and phosphorus during the experimentation (Appendix X). From the results of the experiment showed that the maximum vigor index (570.27) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum vigor index (453.99) was revealed from S_3P_0 (30 November with control) treatment combination (Table 12).

Table 11. Effect of different sowing date and phosphorus level on germination, shoot length, root length and vigor index of fenugreek

Treatments	Germination %	Shoot length (cm)	Root length (cm)	Vigor index
Different sowing date				
S_1	92.83	2.94	2.65	521.86 b
S_2	91.83	3.00	2.76	529.07 a
S_3	91.25	2.90	2.59	501.85 c
$LSD_{(0.05)}$	6.2250 ^{NS}	0.4889 ^{NS}	0.3646 ^{NS}	3.7335
CV%	7.99	9.60	16.14	7.87
Different level of phosphorus				
P_0	89.89	2.71	2.59	480.45 d
P_1	92.56	2.98	2.71	527.20 b
P_2	93.67	3.18	2.71	552.36 a
P_3	91.78	2.91	2.65	510.36 c
$LSD_{(0.05)}$	7.1880 ^{NS}	0.5646 ^{NS}	0.4210 ^{NS}	4.3111
CV%	7.99	9.60	16.14	7.87

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November;

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Table 12. Combined effect of different sowing date and phosphorus level on germination, shoot length, root length and vigor index of fenugreek

Treatment combinations	Germination %	Shoot length (cm)	Root length (cm)	Vigor index
S_1P_0	90.33	2.71	2.61	490.49 gh
S_1P_1	93.33	3.13	2.73	546.93 cd
S_1P_2	95.67	3.18	2.67	559.66 b
S_1P_3	92.00	2.75	2.58	490.36 gh
S_2P_0	90.67	2.83	2.65	496.87 fg
S_2P_1	93.00	3.15	2.75	548.70 c
S_2P_2	93.33	3.21	2.90	570.27 a
S_2P_3	90.33	2.79	2.75	500.43 f
S_3P_0	88.67	2.60	2.52	453.99 i
S_3P_1	91.33	2.67	2.65	485.97 h
S_3P_2	92.00	3.16	2.57	527.16 e
S_3P_3	93.00	3.18	2.63	540.30 d
$LSD_{(0.05)}$	12.450^{NS}	0.9779^{NS}	0.7291^{NS}	7.4670
CV%	7.99	9.60	16.14	7.87

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during 10 October 2020 to April 2021 to study the effect of sowing date and phosphorus on growth, seed yield and quality of fenugreek. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Madhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors. Factor A: Three sowing date *viz*., S_1= 01 November, S_2= 15 November and S_3= 30 November and Factor B: Four phosphorus fertilizer level *viz.*, P_0= Control, P_1= 35 kg P ha^{-1}, P_2= 45 kg P ha^{-1} and P_3= 55 kg P ha^{-1}. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 1.44 m^2 (1.2 m × 1.2 m) and row to row distance maintained 30 cm. Data on different growth, yield contributing characters and yield were recorded to find out the best sowing date and optimum phosphorus fertilization for the potential seed yield of fenugreek.

Different yield contributing characters and yield were significantly influenced due to varied sowing date. Results from the experiment showed that at 80 DAS, the highest plant height (58.05 cm), number of compound leaves per plant (103.81), highest plant spreading (24.62 cm), branches per plant (6.74) was scored by S_1 (01 November) treatment where the lowest plant height (49.88 cm), minimum number of compound leaves per plant at 80 DAS (90.26), the lowest plant spreading at 80 DAS (20.77 cm) and minimum branches per plant (5.55) was obtained from S_3 (30 November) treatment. The maximum days to 50% flowerings (50.01) was recorded from S_2 (15 November) treatment where the minimum days to 50% flowerings (46.60) was revealed from S_3 (30 November) treatment. The maximum pods per plant (43.15), seeds per pod (11.81), weight of individual pod (119.99 mg), weight of seeds per plant (5.40 g), maximum weight of 1000-seed (12.58 g) was recorded from S_2 (15 November) treatment. On the other hand the minimum pods per plant (36.55), seeds per pod (9.92), weight of individual pod (106.42 mg), weight of seeds per plant (4.89 g) and weight of 1000-seed (10.22 g) was revealed from S_3 (30 November) treatment. The maximum weight of straw per plot (355.43 g) was revealed from S_1 (01

November) treatment where the minimum weight of straw per plot (326.22 g) was noted from S_3 (30 November) treatment. The maximum seed yield per plot (216.12 g), seed yield per hectare (1.50 t) and vigor index (529.07) was revealed from S_2 (15 November) treatment where the minimum seed yield per plot (195.84 g), seed yield per hectare (1.36 t) and vigor index (501.85) was noted from S_3 (30 November) treatment.

Different yield contributing characters and yield were significantly influenced due to varied phosphorus fertilization. Results from the experiment showed that at 80 DAS, the highest plant height (58.83 cm), number of compound leaves per plant (115.53), plant spreading (25.69 cm) and branches per plant (7.02) was observed from P_3 (55 kg P ha^{-1}) treatment. On the other hand the lowest plant height (48.77 cm), minimum number of compound leaves per plant (78.12), lowest plant spreading (19.39 cm) and branches per plant (5.20) was observed from P_0 (control) treatment. The maximum days to 50% flowerings (50.28) were observed from P_2 (45 kg P ha^{-1}) treatment. On the other hand the minimum days to 50% flowerings (46.31) were observed from P_0 (control) treatment. The maximum pods per plant (46.66), seeds per pod (11.94), pod length (10.03 cm), weight of individual pod (133.43 mg), weight of seeds per plant (6.91 g) and weight of 1000-seed (12.75 g) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum pods per plant (33.13), seeds per pod (9.77), pod length (8.63 cm), weight of individual pod (98.53 mg), weight of seeds per plant (3.05 g) and weight of 1000-seed (10.03 g) was recorded from P_0 (control) treatment. The maximum weight of straw per plot (390.58 g) was observed from P_3 (55 kg P ha^{-1}) treatment while the minimum weight of straw per plot (284.00 g) was recorded from P_0 (control) treatment. The maximum seed yield per plot (276.48 g), seed yield per hectare (1.92 t) and vigor index (552.36) was observed from P_2 (45 kg P ha^{-1}) treatment while the minimum seed yield per plot (122.08 g), seed yield per hectare (0.85 t) and vigor index (480.45) was recorded from P_0 (control) treatment.

Different yield contributing characters and yield were significantly influenced due to combined effect of sowing date and phosphorus fertilization. From the results of the experiment showed that at 80 DAS, the highest plant height (63.71 cm), number of compound leaves per plant (121.63), plant spreading (28.95 cm) and branches per plant (7.57) was observed from S_1P_3 (01 November with 55 kg P ha^{-1}) treatment combination. On the other hand, the lowest plant height (45.15 cm), number of

compound leaves per plant of fenugreek (73.56), plant spreading (18.48 cm) and branches per plant (4.55) was revealed from S_3P_0 (30 November with control) treatment combination. The maximum days to 50% flowerings (51.91) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum days to 50% flowerings (45.11) was revealed from S_3P_0 (30 November with control) treatment combination. The maximum pods per plant (52.61), seeds per pod (12.87), pod length (10.62 cm), weight of individual pod (147.11 mg), weight of seeds per plant (7.67 g) and weight of 1000-seed (13.86 g) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination. On the other hand the minimum pods per plant (30.25), seeds per pod (9.11), pod length (8.02 cm), weight of individual pod (92.63 mg), weight of seeds per plant (2.70 g) and weight of 1000-seed (9.17 g) was revealed from S_3P_0 (30 November with control) treatment combination. The maximum weight of straw per plot (420.94 g) was observed from S_1P_3 (01 November with 55 kg P ha^{-1}) treatment combination while the minimum weight of straw per plot (272.61 g) was revealed from S_3P_0 (30 November with control) treatment combination. The maximum seed yield per plot (306.72 g), seed yield per hectare (2.13 t) and vigor index (570.27) was observed from S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination while the minimum seed yield per plot (108.00 g), seed yield per hectare (0.75 t) and vigor index (453.99) was obtained from S_3P_0 (30 November with control) treatment combination.

CONCLUSION

This study revealed that sowing date and application of phosphorus fertilizer have a positive effect on growth and seed yield of fenugreek. In case of seed yield of fenugreek, the combination of sowing date S_2 (15 November) along with phosphorus application P_2 (45 kg P ha^{-1}) were given the better performance of all the yield contributing parameters and seed yield of fenugreek. So, S_2P_2 (15 November with 45 kg P ha^{-1}) treatment combination can be repeated in different agro ecological zones of Bangladesh.

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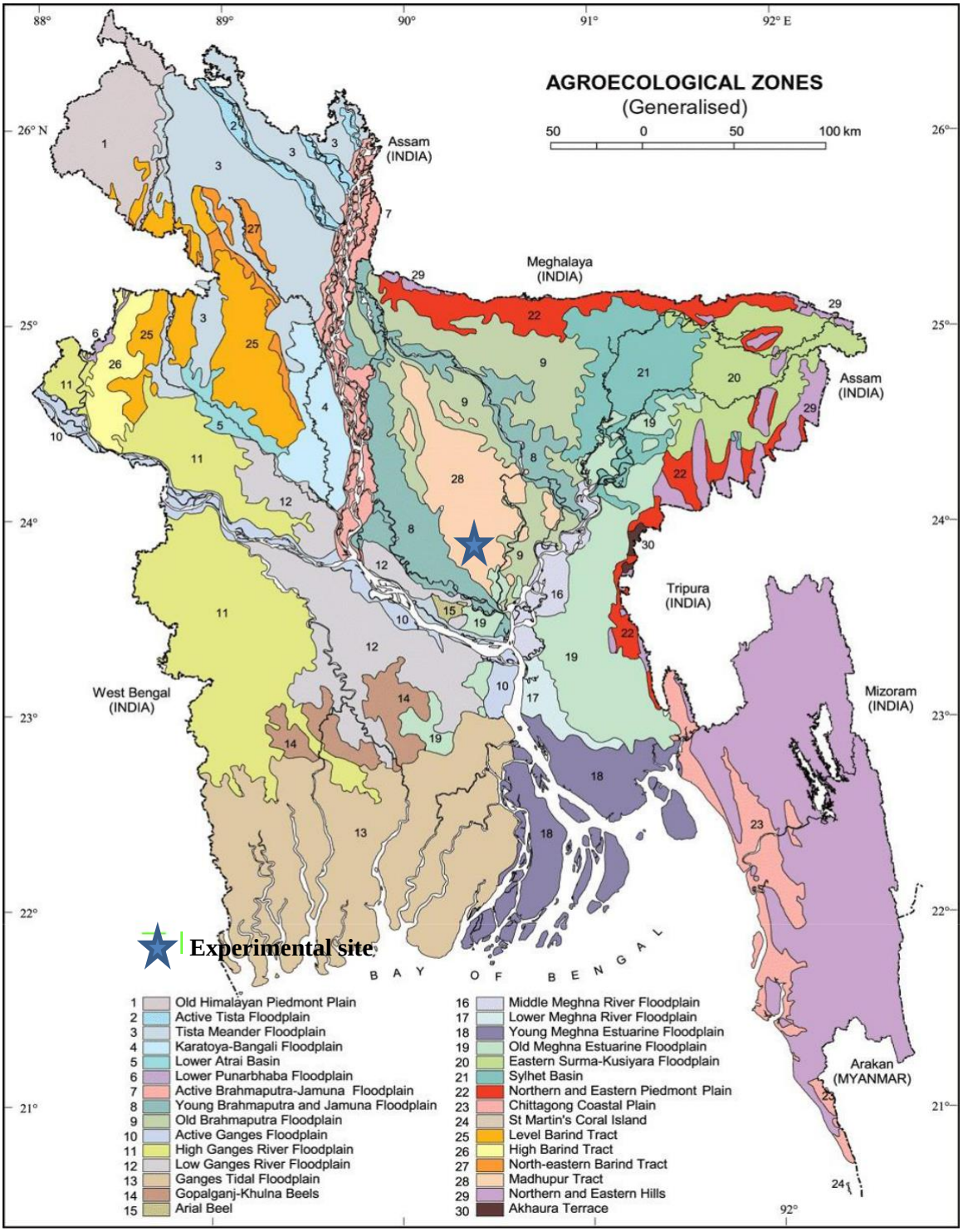
APPENDICES

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2020 to March 2021

Month and year	RH (%)	Air temperature (°C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
November, 2020	56.25	28.70	8.62	18.66	14.5
December, 2020	51.75	26.50	9.25	17.87	12.0
January, 2021	46.20	23.70	11.55	17.62	0.0
February, 2021	37.95	22.85	14.15	18.50	0.0
March, 2021	35.75	21.55	15.25	18.40	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University, Dhaka
AEZ	Modhupur 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
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam
pH	6.2
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Mean square values of plant height at different days after sowing of fenugreek growing under the experiment

Sources of variation	Degrees of freedom	Mean square of plant height at			
		35 DAS	50 DAS	65 DAS	80 DAS
Replication	2	1.3027	0.4045	8.814	2.714
Factor A (sowing date)	2	16.3334**	64.5542**	290.567**	206.106**
Factor B (phosphorus)	3	17.2096**	72.9962**	162.641**	164.963**
A × B	6	0.4364**	4.4959**	5.734**	1.592**
Error	22	0.5598	0.6266	2.637	2.997

* significant at 5% level of significance
** significant at 1% level of significance

Appendix V. Mean square values of number of compound leaves per plant at different days after sowing of fenugreek growing during experimentation

Sources of variation	Degrees of freedom	Mean square of number of compound leaves plant^{-1} at			
		35 DAS	50 DAS	65 DAS	80 DAS
Replication	2	0.5910	4.348	1.73	5.57
Factor A (sowing date)	2	14.7083**	119.590**	370.31**	552.79**
Factor B (phosphorus)	3	47.8481**	544.760**	1214.88**	2119.10**
A × B	6	0.7306**	48.486**	52.79**	129.54**
Error	22	0.9203	3.012	4.15	4.04

* significant at 5% level of significance
** significant at 1% level of significance

Appendix VI. Mean square values of plant spread at different days after sowing of fenugreek growing during experimentation

Sources of variation	Degrees of freedom	Mean square of plant spread at			
		35 DAS	50 DAS	65 DAS	80 DAS
Replication	2	6.85331	7.1974	12.033	17.1412
Factor A (sowing date)	2	4.77280**	17.0485**	14.707**	50.4491**
Factor B (phosphorus)	3	7.23173**	19.8156**	134.859**	53.1515**
A × B	6	0.27033**	1.7177**	0.553**	7.1136**
Error	22	0.14893	0.1686	0.281	0.8476

* significant at 5% level of significance
** significant at 1% level of significance

Appendix VII. Mean square values of branches per plant, days to 50% flowerings, pods per plant and seeds per pod of fenugreek growing during experimentation

Sources of variation	Degrees of freedom	Mean square of			
		Branches per plant	Days to 50% flowerings	Pods per plant	Seeds per pod
Replication	2	7.86137	15.3283	8.511	6.2692
Factor A (sowing date)	2	4.81551**	35.1467**	139.206**	10.7299**
Factor B (phosphorus)	3	5.84753**	25.9229**	311.162**	7.5158**
A × B	6	0.07131**	0.4928**	31.686**	0.1413**
Error	22	0.24284	0.2605	1.777	0.1580

* significant at 5% level of significance

** significant at 1% level of significance

Appendix VIII. Mean square values of pod length, weight of seed/pod, weight of seed/plant and 1000 seed weight of fenugreek growing during experimentation

Sources of variation	Degrees of freedom	Mean square of			
		Pod length	Weight of seed/pod	Weight of seed/plant	1000 seed weight
Replication	2	0.20375	23.99	0.0044	6.4489
Factor A (sowing date)	2	0.43385 ^{NS}	580.53**	7.8607**	16.8177**
Factor B (phosphorus)	3	2.96090**	2040.44**	20.5176**	12.2282**
A × B	6	0.92676**	84.40**	1.4255**	0.2126**
Error	22	0.22193	12.68	0.1850	0.1638

* significant at 5% level of significance

** significant at 1% level of significance

Appendix IX. Mean square values of weight of straw/plot, seed yield/plot and seed yield of fenugreek growing during experimentation

Sources of variation	Degrees of freedom	Mean square of		
		Weight of straw/plot	Seed yield/plot	Seed yield
Replication	2	83.9	117.3	0.00366
Factor A (sowing date)	2	2588.7**	10371.6**	0.50017**
Factor B (phosphorus)	3	21089.9**	42993.3**	2.07337**
A × B	6	1158.1**	1846.4**	0.08904**
Error	22	78.4	99.2	0.00465

* significant at 5% level of significance

** significant at 1% level of significance

Appendix X. Mean square values of germination percentage, shoot length, root length and vigor index of fenugreek growing under the experiment

Sources of variation	Degrees of freedom	Mean square of			
		Germination percentage	Shoot length	Root length	Vigor index
Replication	2	13.0278	0.25343	0.30698	3.4
Factor A (sowing date)	2	7.6944 ^{NS}	0.02582 ^{NS}	0.09030 ^{NS}	163.6**
Factor B (phosphorus)	3	22.7685 ^{NS}	0.34201 ^{NS}	0.02883 ^{NS}	12619.8**
A × B	6	4.9907 ^{NS}	0.13593 ^{NS}	0.01340 ^{NS}	2168.7**
Error	22	54.0581	0.33349	0.18540	20.8

* significant at 5% level of significance
** significant at 1% level of significance

Appendix XI. Effect of sowing date and phosphorus on plant height (cm) at different days after sowing (DAS) of fenugreek

Treatment	Plant height at 35 DAS	Plant height at 50 DAS	Plant height at 65 DAS	Plant height at 80 DAS
Different sowing date				
S_1	14.26 a	23.50 a	37.83 a	58.05 a
S_2	13.09 b	20.02 b	32.76 b	52.78 b
S_3	11.93 c	19.10 c	27.99 c	49.88 c
$LSD_{(0.05)}$	0.6644	0.6571	1.4958	1.4530
CV%	5.71	3.79	4.94	3.23
Different level of phosphorus				
P_0	11.46 d	17.18 c	27.80 d	48.77 d
P_1	12.63 c	20.78 b	31.48 c	51.90 c
P_2	13.57 b	21.44 b	34.33 b	54.79 b
P_3	14.72 a	24.09 a	37.81 a	58.83 a
$LSD_{(0.05)}$	0.7671	0.7587	1.7271	1.6777
CV%	5.71	3.79	4.94	3.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

Appendix XII. Effect of different sowing date and phosphorus level on 1000-seed weight, weight of straw per plot, seed yield per plot and seed yield of fenugreek

Treatments	1000-seed weight (g)	Weight of straw/plot (g)	Seed yield/plot (g)	Seed yield (t/ha)
Different sowing date				
S_1	11.56 b	355.43 a	206.76 ab	1.44 ab
S_2	12.58 a	343.50 b	216.12 a	1.50 a
S_3	10.22 c	326.22 c	195.84 b	1.36 b
$LSD_{(0.05)}$	0.4859	7.4958	17.00	0.1181
CV%	3.53	2.59	9.74	9.74
Different level of phosphorus				
P_0	10.03 d	284.00 d	122.08 d	0.85 d
P_1	11.09 c	320.94 c	188.80 c	1.31 c
P_2	12.75 a	371.36 b	276.48 a	1.92 a
P_3	11.94 b	390.58 a	237.60 b	1.65 b
$LSD_{(0.05)}$	0.5611	8.6554	19.6389	0.1363
CV%	3.53	2.59	9.74	9.74

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, S_1: 01 November, S_2: 15 November and S_3: 30 November

P_0: Control, P_1: 35 kg P ha^{-1}, P_2: 45 kg P ha^{-1} and P_3: 55 kg P ha^{-1}

SOME PICTORIAL VIEW DURING EXPERIMENT

Vegetative stage of fenugreek plant

Flower

Pod

Mature pod in the field

Plate 1. Different stages of fenugreek plant in the field

Plate 2. Harvested seed of fenugreek

Plate 3. Seedlings of fenugreek with shoot and root in germination test