EFFECT OF NITROGEN AND PHOSPHOROUS ON THE GROWTH AND YIELD OF FENUGREEK (METHI)

(*Trigonella foenum-graecum L.)*

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DHAKA-1207

JUNE-2020

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BY

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A Thesis
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
IN
SOIL SCIENCE

SEMESTER: JANUARY- JUNE, 2018

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF NITROGEN AND PHOSPHOROUS ON THE GROWTH AND YIELD OF FENUGREEK (METHI) (*Trigonella foenum-graecum* L.)"** 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** in **SOIL SCIENCE,** embodies the result of a piece of bona fide research work carried out by **POOJA DEBNATH** Registration No.**13-05266** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Dr. Alok Kumar Paul)

Supervisor

ACKNOWLEDGEMENTS

All *praises are due to the God, who kindly enabled the author to complete the research work and the thesis leading to Master of Science* in Soil Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

I would like to express my deepest respect, and gratitude to my supervisor, Professor **Dr. Alok Kumar Paul**, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, for his sincere guidance, supervision, constructive criticism, extending generous help and inspiration throughout the course and in preparation of the manuscript of thesis.

I express my sincere respect to my Co-supervisor, **Dr. Md. Ashraf Hossain,** chief scientific officer, Head of the Department of Soil Science, BARI, Joydevpur, Gajipur, for his co-operation, constructive suggestion to conduct the research work as well as preparation of the manuscript of thesis.

I express my sincere appreciation and gratitude to my all the respected teachers of soil science department of Sher-e-Bangla Agricultural University, for their valuable teaching, advice, encouragement, and cooperation during the whole study period.

I express my profound tributes, sincere gratitude and heartfelt thankfulness from my core of heart to my parents, and my husband, whose blessing, inspiration, sacrifice, and support opened the gate and paved to way of my higher study and completion of my research.

I feel much pleasure to convey the profound thanks to my friends, well-wishers for their help, encouragement, and inspiration.

Pooja Debnath

List of abbreviation

AD	Anno Domini
AEZ	Agro Ecological Zone
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BCR	Benefit cost ratio
CGR	Crop growth rate
cv.	Cultivar
C.V.	Coefficient of variation
DAS	Days after sowing
DMRT	Duncan's multiple range test
DV	Daily values
DMA	Dry matter accumulation per plant
et al.	*et alibi* (and others)
etc.	*et cetra* (and so on)
IJIRST	International journal for innovation research in science and technology
LSD	Least significant difference
NAR	Net assimilation rate
PSB	Phosphate solubilizing bacteria
RGR	Relative growth rate
RCBD	Randomized complete block design
SAU	Sher-e-Bangla Agricultural University
Viz.	Videlicet (Namely)

Unit

%	Percentage
Cm	Centimeter
G	Gram
Ha	Hectare
Kg	Kilogram

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EFFECT OF NITROGEN AND PHOSPHOROUS ON THE GROWTH AND YIELD OF FENUGREEK (METHI)

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ABSTRACT

This study was conducted to observe the effect of nitrogen and phosphorous on growth and yield of fenugreek. Furthermore, to investigate the optimum dose to maximize the growth and yield of fenugreek. Experimental plot was in Sher-e-bangla Agricultural University research field, Dhaka, Bangladesh. Study was done in Robi season (mid-November 2018 to early March 2019). Field trials were designed in Complete Randomized Block Design with three replications. Here, four level of nitrogen (0, 30,60,90 kg/ha), three level of phosphorous (0,20,40 kg/ha) and potassium (60 kg/ha) as common dose were applied. In study plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, length of pods, number of seeds pod^{-1}, weight of 1000 seeds(g) and seed yield(kg/ha) were determined. It was noticed that nitrogen has significant effect on all the parameters. All the plant parameters except 1000 seeds weight increased with the increased of phosphorous level. Maximum value of Plant height (37.90 cm), number of branches (4.27) and yield (727.67kg/ha) was recorded in combine application of 90kg/ha nitrogen and 40kg/ha phosphorous. Maximum value of number of pods, length of the pod and seeds/pods was recorded in both $N_{90}P_{40}$ and $N_{90}P_{20}$ combination. In conclusion, combine application of 90kg/ha Nitrogen and 40kg/ha Phosphorous provided highest yield of fenugreek. Application of 90kg/ha Nitrogen combine with 40kg/ha Phosphorous, or 90kg/ha nitrogen coupled with 20 kg/ha phosphorous gave the reasonable yield of fenugreek. Application of Nitrogen and Phosphorous fertilizer had no effect on soil parameters.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is a diploid, annual, self-pollinating plant that is strongly scented. It is locally known as "methi" and belongs to the family Fabaceae. The English name derives via Middle French fenugrec from Latin faenugraecum, faenum Graecum meaning "Greek hay". It was also named "*Trigonella"* from Latin language that means "Little triangle" due to its yellowish-white triangular flower (Flammang *et al*.,2004). It is widely used as spice and condiment to add flavor in various foods. Fenugreek is believed to have been brought into cultivation in the Near East. It is uncertain which wild strain of the genus *Trigonella* gave rise to domesticated fenugreek. In one first-century A.D. recipe, the Romans flavored wine with fenugreek. In the 1st century AD, in Galilee, it was grown as a staple food, as Josephus mentions it in his book, the Wars of the Jews. This crop is native to an area extending from Iran to northern India and widely cultivated in China, India, Egypt, Ethiopia, Morocco, Ukraine, Greece, Turkey, etc. with 80 species (Danesh-Talab *et al*., 2014). India is a major producer, with fenugreek production in India derived from numerous states. Rajasthan accounts for over 80% of India's output.

Fenugreek is used as an herb (dried or fresh leaves), spice (seeds), and vegetable (fresh leaves, sprouts, and microgreens). "Sotolon" is the chemical responsible for fenugreek's distinctive sharp smell (NIH, 2019). Fenugreek seeds (per 100 g) are a rich source of protein (46% DV), dietary fiber, B vitamins, and dietary minerals, particularly manganese (59% DV) and iron (262% DV) (USDA, 2019). Fenugreek 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). Fenugreek has a long history of medicinal uses in Ayurveda. It is well-known as traditional medicine for diabetes, indigestion, elevation of lipids and edema (fluid retention) of the legs. Fenugreek is also good source of dietary protein for human and animals. Its seeds have a strong aroma and somewhat bitter in taste. Seeds of fenugreek are used as yellow dye in cosmetics and medicinal purposes. Fenugreek is a good soil renovator and is widely used as a green manure (Abdelgani *et al*., 1999). This plant is used in therapy atherosclerosis (Nandini *et al*., 2007), rheumatism (Vyas *et al*., 2010), sugar lowering (Gupta *et al*., 2001), blood lipids lowering (Xue *et al*., 2007), appetizer (Max, 2007) and contain antioxidant activity (Birjees *et al*., 2008). Fenugreek has a high proportion of protein as well as amino acid, 4-hydroxyisoleucine, which has high potential for insulin-stimulating activity. The advantage of fenugreek cultivation is that being a legume crop, it is capable of fixing nitrogen from the atmosphere.

Nitrogen is a common plant nutrition which promotes vegetative developments in plants. This plant nutrient is also important for producing herb, folium and seed yields in medicinal and spice plants (Ceylan,1995). Nitrogen plays a central role in the synthesis of chlorophyll. Nitrogen is an essential constituent of compounds like amino acid, proteins, nucleic acids, prophyrin, flavin, pyridines, nucleotides, enzymes, coenzymes and alkaloids which contributes to the growth of plant.

Phosphorous imparts hardiness to shoot, improves grain quality, regulates the photosynthesis, governs physic-bio-chemical processes and helps root enlargement and nitrogen fixation. Phosphorous is critical in plant metabolism which play an important role in cellular energy transfer, respiration, photosynthesis and it is a key structural component of nucleic acids coenzymes, phosphor-proteins and phospholipids. Plant growth and seed yield was increased in fenugreek when phosphorus was applied @ 26kgP (60 kg P_2O_5) ha-1(Bhairagi, 2014; Purbey and Sen, 2005). Sharma et al. (2014) obtained maximum number of primary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, seed yield from 17.6 kg P (40 kg P_2O_5) ha^{-1}.

Considering the above facts, the experiment was conducted with following objectives:

I. To observe the effect of Nitrogen and phosphorous on the growth and yield of fenugreek;
II. To find out the Nitrogen and Phosphorous dose to maximize the yield of Fenugreek and
III. To investigate the interaction effect of Nitrogen and Phosphorous on the growth and yield of Fenugreek.

REVIEW OF LITERATURE

Research work on Fenugreek is limited in Bangladesh. However, a good number of Some the studies so far were reviewed and described under the following paragraphs.

Mehta *et al*. (2011) carried out a field experiment with the aim to study the effect of nitrogen, phosphorus and biofertilizer on growth dynamics, productivity and nutrient uptake of fenugreek. The experiment consisting of sixteen treatment combinations with two levels each of nitrogen (N) (10 and 20 kg N/ha) and P_2O_5 (20 and 40 kg P_2O_5/ha) and four levels of seed inoculation with bio-fertilizers (no seed inoculation (control), seed inoculation with Rhizobium alone, seed inoculation with phosphate solubilizing bacteria (PSB) alone and seed inoculation with both Rhizobium+ PSB). Significant increase of dry matter accumulation per plant (DMA), crop growth rate(CGR), relative growth rate (RGR) and net assimilation rate (NAR) at all the growth stages as well as seed yield, straw yield, net return, benefit cost ratio (BCR) were reported when treated with 20 kg N and 40 kg P_2O_5/ha. Inoculation of seed with both *Rhizobium* and PSB gave the highest DMA, CGR, RGR and NAR over their sole application as well as control.

Kumar *et al*. (2016) was conducted an experiment at Horticultural Research Centre, SVPUAT, Meerut to assess the impact of nitrogen, phosphorus and cutting management on flowering and yield of green leaves of fenugreek (Trigonella foenum-graecum L.). Three treatments of nitrogen (0, 20 and 40 kg ha-1), three treatments of phosphorus (0, 30 and 60 kg ha-1) and three cutting management (No cutting, one cutting at 20 DAS and two cutting at 20 and 40 DAS, factors were used. The plant height, number of green leaves plant^{-1}, number of branches/ plant, length of longest branch, days taken to flowering, fresh weight of biomass plant^{-1}, dry matter accumulation plant^{-1} and yield of green leaves (q ha^{-1}) were significantly higher with 40 kg nitrogen ha^{-1}, 60 kg phosphorus ha^{-1} and two cutting management at 20 and 40 DAS than zero kg N and Phosphorus ha^{-1} and no cutting management.

Jasim *et al.* (2016) did an experiment in Babylon during the growing season 2013 – 2014 to study the effect of 5 soil fertilization treatments [control, 200 kg ha-1 of NPK (18-18-0), 4 and 8 tha^{-1} of compost of poultry], and its interaction with 4 treatments of foliar fertilizers [control, spray urea 1 g/liter, spraying humic acid 2 ml l^{-1} and spray polimet 2 ml l^{-1}] on growth and yield of fenugreek. Soil fertilizers were added as side dressing and the foliar fertilizers were added twice. The results showed that chemical fertilizer was superior significantly compared to other treatment in plant height, number of leaves, leaf area and wet and dry weight, while poultry (8 t ha^{-1}) was superior compared to control in branches number and wet weight. Urea spray was superior in plant height, leaves no. and

soft weight. Polimet spray was superior compared to control in branches plant^{-1}. The interaction between the soil and spraying fertilizers had a significant effect in increasing plant height, branches no., leaves no., leaf area and wet and dry weight.

Malav *et al*. (2018) was undertaken A field experiment on the standardization of organic module for production of fenugreek was conducted during *rabi* season of 2007-08 and 2008-09 (two years). The experiment comprising of absolute control and varying proportion of organic and inorganic sources viz., 100 % Recommended Dose of N through FYM, 100 % RDN through castor cake, Rhizobium treatment, PSB treatment, Rhizobium + PSB treatment, 50 % Recommended Dose of N through FYM + Rhizobium, 50 % Recommended Dose of N through CC + Rhizobium, 50 % RDN through FYM +Rhizobium+ PSB, 50 % Recommended Dose of N through CC + Rhizobium+ PSB) and Recommended dose of fertilizer was laid out in randomized block design with four replications. It was found that RDF and varying combinations of organic sources produced significantly higher grain yield over absolute control. The seed and straw yield of fenugreek was found significant due to different treatments, wherein integrated use of organic sources of nitrogen (50 % RDN through castor cake + Rhizobium + PSB) recorded significantly higher seed and straw yield of fenugreek as compared to their individual use. Different treatments were failed to produce significant effect on nutrient content in seed and straw of fenugreek, but it was found significant with respect to nutrients uptake, wherein higher removal of nutrients by seed and straw were noticed under integrated use of organic sources of nitrogen as well as chemical fertilizer. The organic carbon and available phosphorus was also found significant due to different treatments, whereas the maximum amount of organic carbon was registered under 100 % RDN through FYM/castor cake. The maximum available phosphorus was recorded with the use of PSB and available potassium was found non-significant due to different treatments. Thus, it can be inferred that application of 50 % RDN through CC + Rhizobium+ PSB is better for realizing good soil health and sustainable higher yield levels.

Vedpathak and Chavan (2016) were carried out a field experiment to study the effects of organic and chemical fertilizer on growth and yield of Fenugreek in outdoor nursery of School of Earth Sciences, Solapur University, agricultural farm in district of Solapur, Maharashtra. Fenugreek local seeds were treated with different fertilizer treatments in field including vermicompost (T1) @ 0.6 kg/plot (@ 0.3 kg/sq. m), NADEP compost (T2) @1.25 kg/plot (@ 0.625 kg/sq. m), pit compost (T3) @ 1.25 kg/plot (@ 0.625 kg/sq. m), chemical fertilizer (T4) @ 80:40:40 Kg of NPK/ha according to RDF and control (T5). The results showed that the growth parameters viz., plant height (28.75cm), fresh and dry weight per plant were improved after 60th day with application of vermicompost treatment (T1). Number of pods per plant (2.66) were higher in control treatment (T5). Total weight of pods per plant (0.78 gm/plant) and mean weight per pods per plant (0.30gm/pod/plant) was more with application of straight chemical fertilizers (T4). Application of chemical

fertilizer is better and sustainable for higher yield of Fenugreek vegetable per plot than the other remaining fertilizer treatments.

Tunçtürk, R. *et al.* (2011) was conducted a study to determine the effects of Nitrogen and Sulphur applications on the yield and quality of fenugreek in Van, Turkey in 2006 and 2007 growing seasons. In the study, plant height (cm), the number of branches (branch plant^{-1}), first pod height (cm), the number of pods (pod plant^{-1}), the number of seeds in the pod (seed pod^{-1}), pod length (cm), thousand-seed weight (g), seed yield (kg ha^{-1}), protein content (%) and protein yield (kg ha^{-1}) were determined. The all growth and yield parameters except for thousand seed weight were significantly affected by nitrogen fertilization. The highest seed yields (853.0 and 815 kg ha^{-1}) were obtained from 90 kg N ha^{-1} and 20 kg S ha^{-1}applications in 2006 and 2007, respectively. The highest protein content (24.2 %) was obtained from 90 kg N ha^{-1} and 40 kg S ha^{-1} applications in both experimental years.

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 under different levels of phosphorus (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_5ha^{-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, 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.

Godara *et al*. (2012) was conducted a field experiment on effect of different combinations of organic and inorganic nutrient sources on productivity and profitability of fenugreek was laid out during *rabi* season of 2010-11. The experiment comprising of absolute control and varying proportion of organic and inorganic sources viz., recommended dose of nutrient through fertilizers (40:45:0),100 % poultry manure, 100% vermicompost, 50% RDF+50%poultry manure, 50% RDF+50%vermicompost, 25%RDF+75% poultry manure and 25%RDF+75% vermicompost. The organic sources and fertilizers were applied before sowing and as per standard practices, respectively. It was found that RDF and varying combinations of organic and inorganic sources produced significantly higher grain yield over absolute control. Recommended dose of nutrients produced significant higher yield over organic manures (vermicompost and poultry manures). Application of recommended dose of nutrients supplied through chemical fertilizers resulted in highest grain yield (27.75 q/ha), gross return (Rs 69375/ha), net return (Rs 50150/ha) and BCR (3.60) closely followed by 50% RDF + 50 % vermicompost /poultry manure. Thus, it can be inferred that

application of 50% RDF along with 50% vermicompost /poultry manure is better for realizing good soil health and sustainable higher yield levels.

Rahman *et al*. (2017) was carried out an experiment at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2016 to march 2017 to investigate the effect of four levels of phosphorous viz., 0, 20, 30, 40 kg P ha-1 and three levels of Sulphur viz., 0, 10 and 20 kg S ha^{-1} on vegetative growth of fenugreek (cv. BARI Methi-1). On his experiment he found highest plant height (26.73cm at 30 DAS and 32.47cm at 60 DAS), when applied with Phosphorous 40 kg/ha. The maximum number of primary branches $plant^{-1}$ (4.60 at 30 DAS and 5.73 at 60 DAS) was obtained from the application of 40 kg P ha^{-1} and 20 kg S ha^{-1}. The above-mentioned doses help to obtain maximum seed yield. Therefore, application of P-S (40+10) kg ha^{-1} with a blanket dose of N-K (80+67) kg ha^{-1} + 5.0 tons cowdung might be considered as suitable fertilizer dose for production of fenugreek.

Datta *et al.* (2017) was undertaken an experiment with the aim to standardize the dose of NPK on fenugreek variety Hissar Sonali. The experiment was carried out at West Bengal, India during the year 2013-14 and 2014-15. Three levels of nitrogen (40, 60 and 80 kg/ha), phosphorus (60, 80 and 100 kg/ha) and two levels of potassium (20 and 40 kg/ha) were included in this investigation. The maximum plant height (75.74 cm) was recorded with $N_{80}P_{80}K_{40}$ at 75 DAS. Maximum number of secondary branches (15.94) per plant recorded in $N_{60}P_{80}K_{40}$ combination, the minimum days required for 50% flowering was noticed in $N_{40}P_{60}K_{20}$ (49.36 days) and test weight (15.24 g) was observed in $N_{60}P_{80}K_{40}$ combination. Maximum projected yield (17.20 q/ha) was recorded in $N_{60}P_{80}K_{40}$ followed by $N_{40}P_{80}K_{40}$ (16.31 q/ha) and $N_{60}P_{100}K_{40}$ (15.80 q/ha) as compared to lowest yield of 11.70 q/ha under $N_{40}P_{60}K_{20}$ combination. From yield maximization point of view, the most effective treatment was NPK @60:80:40 kg/ha followed by NPK @ 40:80:40 kg/ha and NPK @ 60:100:40 kg/ha.

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh. The period was from November 2018 to March 2019. The aim of the experiment was to find out the optimum nitrogen and phosphorous fertilizer dose on the growth and yield of fenugreek. This chapter briefly describes the experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data collection and data analysis under the following headings and sub-headings.

3.1 Experimental site and soil

The experimental filed was situated at 23°24′N latitude and 90°22′E longitude at height of 8.6m above the mean sea level. It belongs to the AEZ 28, Modhupur tract (Banglapedia, 2015). The general soil type is Deep Red Brown Terrace Soil. Topsoil is silty clay loam in texture. Organic matter content is very low (1.34%). The land is above flood level and well drained. The initial morphological, physical, and chemical characteristics of soil are presented in table 1 and 2.

Table 1. Morphological characteristics of experimental field

Morphological features	characteristics
Location	Sher-e-Bangla Agricultural University farm, Dhaka
AEZ No. and Name	AEZ-28 (Modhupur Tract)
General soil type	Deep Red Brown Terrace soil
Soil series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Table 2. Physical and Chemical properties of experimental field

Soil properties	Value
A. Physical properties	
1. **Particle size of soil** • **% sand** • **% silt** • **% clay**	 • 16 • 56 • 28
2. **Soil texture**	Silty Clay Loam
B. Chemical properties	
• **Soil pH** • **Particle density** • **Organic Carbon (%)** • **Organic Matter (%)** • **Total N (%)** • **Available P (ppm)** • **Available S (ppm)** • **Exchangeable K (meq/100g soil)**	• 6.5 - 6.8 • 2.37 • 0.75 • 1.29 • 0.0725 • 22.67 • 15 • 0.15

3.2 Climate

The experimental site was located under Sub-tropical climate; usually rain fall is heavy during *Kharif* season (April to September) and scanty in *Rabi* season (October to March). Generally, temperature is low in *Rabi* season and plenty of sunshine in this season. The temperature tends to increase from February as the season proceeds towers to *Kharif* season. The experiment was conducted under Sub-tropical climate and *Rabi* season extended from mid-November to early March.

3.3 Seed

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

3.4 Treatments

Combination of four levels of Nitrogen, three levels of phosphorous was applied in the experiment, where Potassium @60 kg/ha was common dose.

Here,

Factor 1. Four Nitrogen levels are-

I. 0 kg/ha (N_0)
II. 30 kg/ha (N_{30})
III. 60 kg/ha (N_{60})
IV. 90 kg/ha (N_{90})

Factor 2. Three Phosphorous levels are-

I. 0 kg/ha (P_0)
II. 20 kg/ha (P_{20})
III. 40 kg/ha (P_{40})

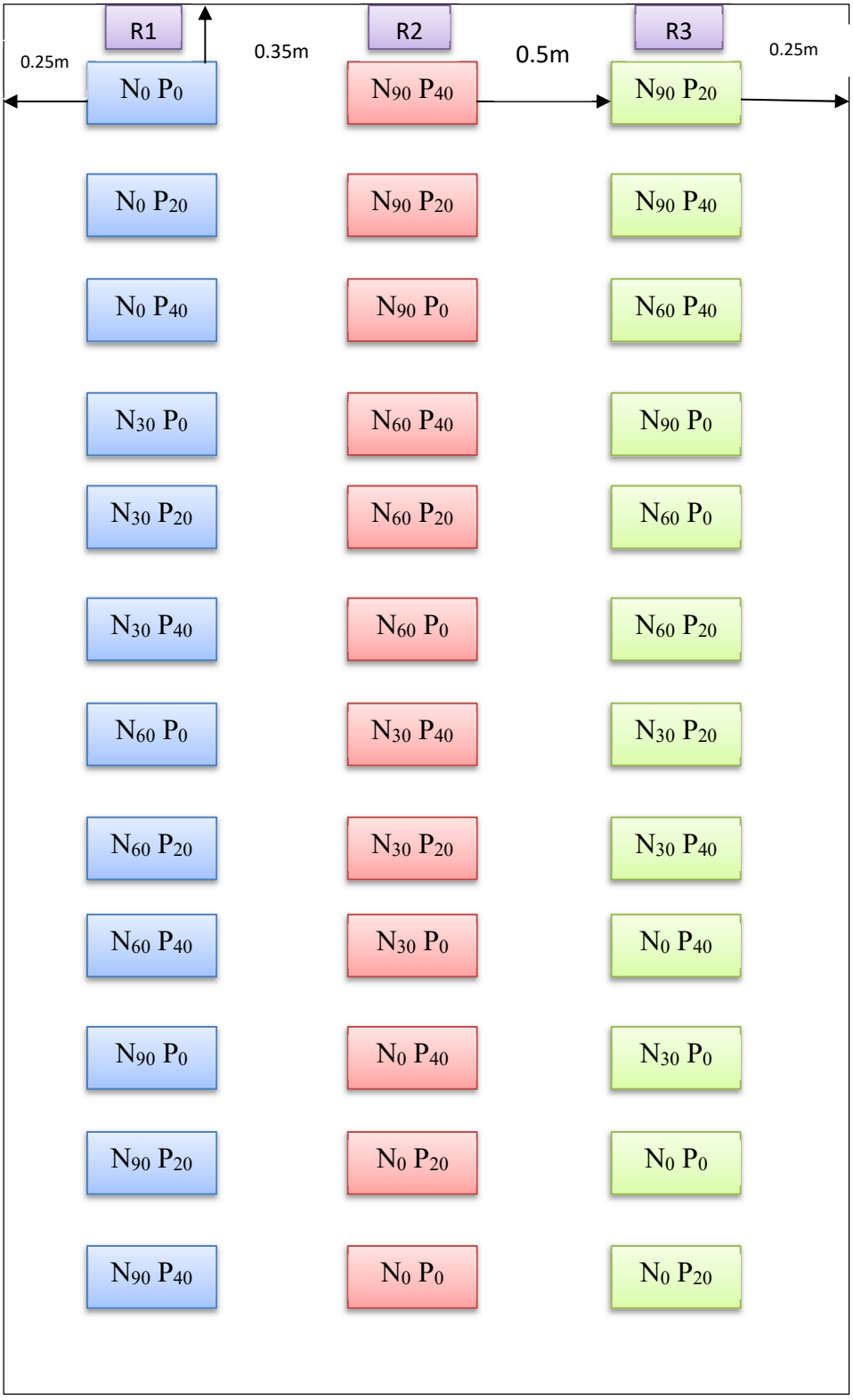
Here, Total number of treatment combination is 12 (Table 3).

Table 3: Treatment combination of Nitrogen and phosphorous

$N_0 P_0$	$N_{30} P_0$	$N_{60} P_0$	$N_{90} P_0$
$N_0 P_{20}$	$N_{30} P_{20}$	$N_{60} P_{20}$	$N_{90} P_{20}$
$N_0 P_{40}$	$N_{30} P_{40}$	$N_{60} P_{40}$	$N_{90} P_{40}$

3.5 Design and layout of the experiment

The layout of the experiment was based on randomized complete block design (RCBD) with 3 replications. The area of unit plot was 2.5m × 1.5m. The total number of plots were 36.



Factor A:
Nitrogen level
N_0= 0 kg/ha
N_{30}=30 kg/ha
N_{60}= 60 kg/ha

Factor B:
Phosphorous level
P_0 = 0 kg/ha
P_{20} = 20 kg/ha
P_{40} = 40 kg/ha

Figure 1: Layout of experimental field and treatment combination

3.6 Land preparation

Before the 15 days of sowing land was prepared by ploughing. To have the good tilth laddering and harrowing was also done. Removal of weeds and stubbles of previous crop was also done during land preparation. Soil clods was broken, and plots was prepared. To provide good drainage system plots was raised up to 15cm, that helps to germinate seed easily.

3.7 Application of fertilizers

Fertilizers were applied at the following doses

Fertilizer	Dose	Fertilizer applied
Nitrogen	As per treatment	Urea
Phosphorous	As per treatment	TSP
Potassium	60 kg/ha	MoP

The entire amount of phosphorous, potassium and one-third of nitrogen fertilizer was applied during the final land preparation. The rest of the nitrogen fertilizer was top dressed in two equal splits during the vegetative growth stage and reproductive growth stage of plant.

3.8 Sowing

Fenugreek seeds were soaked in water for 7 to 8 hours to enhance the germination process. Seeds were sown in rows 25 cm apart continuously by hand @15kg/ha. Seeds were covered with good pulverized soil and gently pressed by hand. Sowing was done on November 16, 2018. Slight watering was applied to supply sufficient moisture that required for quick germination.

3.9 Intercultural operations

Plant thinning was done to get the desire population density. Moreover, irrigation, weeding and other plant protection measures were taken for better crop establishment and plant growth.

3.9.1 Thinning

After 25 days of sowing thinning was done to maintain 10 cm intra-spacing (plant to plant distance).

3.9.2 weeding

Several times hand weeding was done to keep field free from weeds. First weeding was done after 25 days of sowing followed by thinning. Second and third weeding was done after 35 and 50 DAS respectively.

3.9.3 Irrigation

For germination water was given to the plots by water cane with fine nozzle every two days till germination. After that three irrigations were given at 30,60 and 90 DAS.

3.10 Harvesting

Harvesting was done on March 7, 2019, when the color of seeds turned into yellowish brown. Plant was uprooted in early morning to avoid shattering of seeds. After that the stalks with seeds were dried in sun. Seeds were separated by beating with sticks and cleaned by winnowing. Before storage seeds were dried properly.

3.11 Data collection

Ten plants from each plot were collected randomly and tagged for data collection. All data was collected at harvesting stage. The sample plats uprooted prior to the harvest and sundried properly. Data was collected on the following parameters:

1. Plant height (cm)
2. Number of branches plant^{-1}
3. Number of pods plant^{-1}
4. Length of pods
5. Number of seeds pod^{-1}
6. Weight of 1000 seeds (g)
7. Seed yield (kgha^{-1})

3.11.1 Plant height

Plant height was measured at the time of harvest. Scale was used to measure the distance from soil surface to plant tip of the randomly ten selected plants and the mean value was calculated for each treatment.

3.11.2 Number of branches plant^{-1}

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

3.11.3 Number of pods plant^{-1}

Pods number of ten randomly selected plants were counted and the average number of fruits for each plant was determined.

3.11.4 Length of pod

Length of the pod was measured by scale. Randomly 10 plants was selected and measurement was taken after that mean value was calculated.

3.11.5 Number of seeds pod^{-1}

Number of the seeds was counted from randomly selected pods and mean value was taken.

3.11.6 Weight of 1000 seeds

From each treatment 1000 seeds counted and then weighted them by electric balance.

3.11.7 Seed yield

Seed yield plot^{-1} was converted to per hectare yield.

3.12 Chemical Analysis of Soil sample

Soil sample was collected from the field after harvest of crop. Both the physical and Chemical properties of soil was analyzed at the laboratory of the department of soil science, Sher-e-Bangla Agricultural University. Following properties of the soil was analyzed:

3.12.1 Soil Particle Density

Soil particle density was determined by volumetric flask method. First weight of 100ml volumetric flask was taken then 20g oven dry soil was taken in the flask. After that weight of the flask with soil was taken and 30ml of distilled water added on the flask. It boil for 30 minutes in water bath and cooled in room temperature. Further water added up to the mark. Weight was taken after making the volume of 100ml and temperature was recorded and calculation was done.

Particle density = (soil mass ÷ volume of soil solid)

3.12.3 Soil pH

In 25 ml water 10g soil was taken and stir for half hour and then soil PH was measured by electrical pH meter.

3.12.4 Organic carbon content (%)

Organic carbon in soil was determined by WalkIey and Black's (1934) wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$.

3.12.5 Organic Matter (%)

Soil organic matter was calculated from the value of organic carbon by using following equation. Here 1.724 is Van Bemmelen factor, described by Piper (1942).

% organic matter = % organic carbon ×1.724

3.12.6 Total N (%)

Total nitrogen was measured by the kjeldahl method. Soil was digested with 30% H_2O_2. and cone. H_2SO_4. The catalyst use here were K_2SO_4, $CuSO_4.5H_2O$ and Se powder in ratio of 100:10:1. Nitrogen in the digest was estimated by distillation with 40 % NaOH followed by titrations of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4. (Bremner and Mulvancy, 1982).

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H2SO4

B = Blank titration (ml) value of standard H2SO4

N = Strength of H2SO4

S = Sample weight (g)

3.12.7 Available P (ppm)

Available P was extracted from soil by shaking with 0.5 M $NaHO_3$ solution of pH 8.5 (Olsen *et at* 1954). The Phosphorus in the extract was then determined by developing blue color using ascorbic acid reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 nm wavelength by spectrophotometer and available P was calculated with the help of standard curve.

3.13 Statistical analysis

To observe that the effect of different fertilizer doses on the parameters is significant or not ANOVA test was done. Among post hoc test Duncun's multiple range test (DMRT) and Least Significant Difference (LSD) test was done by using R statistic (R studio -Version 4.0.2).

RESULTS AND DISCUSSION

4.1. The effect of nitrogen and phosphorus fertilizer application on different plant parameters:

4.1.1. Plant height

Nitrogen fertilizer has significant effect on the plant height of fenugreek. Plant height increase with the increase of fertilizer doses. The value of plant height was increased from 38.53 cm to 55.14 cm with the increasing of nitrogen fertilizer level N_0 to N_{90} (Table 4).

Plant height was also increased from 45.95cm to 48.70 cm with the dose of Phosphorous, that is from P_0 to P_{40} (Table 5).

Highest plant height (56.19 cm**)** was found when the combination of fertilizer was $N_{90}P_{40}$ and lowest was (37.90 cm) recorded in control (N_0P_0) treatment (Table 6).

4.1.2. Number of branches

From this experiment it is found that both Nitrogen and phosphorous has significant effect on the number of branches. Here, highest number of branches was recorded at level N_{90} and P_{40}, the number of branches was 3.84 and 3.54 respectively (Table 4 and 5).

Number of branches found 1.77 when treated with N_0P_0, which is the lowest recorded value. On the other hand, highest value (4.27) of number of branches was recorded when treatment was $N_{90}P_{40}$ (Table 6).

Table 4. Individual effect of nitrogen on plant height and number of branches of fenugreek

Treatments	Plant height (cm)	Number of branches plant^{-1}
N_0	38.53 d	2.18 d
N_{30}	42.56 c	3.05 c
N_{60}	52.43 b	3.58 b
N_{90}	55.14 a	3.84 a
LSD (0.05)	0.541	0.202

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha

Table 5. Individual effect of phosphorus on plant height and number of branches of fenugreek

Treatments	Plant height (cm)	Number of branches plant^{-1}
P_0	45.97 c	2.73 c
P_{20}	46.84 b	3.22 b
P_{40}	48.70 a	3.54 a
LSD (0.05)	0.469	0.175

Means with uncommon letter(s) are significantly different at 5% level by DMRT
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

Table 6. Interaction effect of nitrogen and phosphorus on plant height and number of branches of fenugreek

Treatments	Plant height (cm)	Number of branches plant^{-1}
N_0P_0	37.90 j	1.77 h
N_0P_{20}	38.47 ij	2.23 g
N_0P_{40}	39.23 i	2.53 fg
$N_{30}P_0$	40.43 h	2.83 ef
$N_{30}P_{20}$	41.42 g	3.00 de
$N_{30}P_{40}$	45.83 f	3.33 cd
$N_{60}P_0$	51.35 e	2.90 ef
$N_{60}P_{20}$	52.40 d	3.80 b
$N_{60}P_{40}$	53.54 c	3.33 c
$N_{90}P_0$	54.18 bc	3.43 c
$N_{90}P_{20}$	55.06 b	3.83 b
$N_{90}P_{40}$	**56.19** a	**4.27** a
CV%	1.177	6.546
LSD (0.05)	0.92	0.445

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

4.1.3. Number of pods

In individual effect, maximum number of pods was observed under N_{90} (22.37) and P_{40} (19.65) that refers, both nitrogen and phosphorous has positive effect on the number of pod development (Table 7 and 8).

Among combine effect, $N_{90}P_{40}$ (24.47) showed best effect, followed by $N_{90}P_{20}$ (22.94) on number of pods of fenugreek. Where, lowest number of pods was recorded under N_0P_{20} (7.87) combination (Table 9).

4.1.4. Length of pod

Length of pod increased from 11.03 cm to 13.22 cm with the increased of nitrogen dose N_{30} to N_{90} (Table 7). In respect of phosphorus, the similar trend also noticed. The pod length increased from 11.97 to 12.06 with the increasing level of phosphorus from 20 kg/ha to 40 kg/ha (Table 8).

Maximum length of the pod was noticed with $N_{90}P_{40}$ (13.863 cm) combination, followed by $N_{90}P_{20}$ (13.513 cm) combination (Table 9).

4.1.5. Seeds per pod

Number of seeds per pod increased with the increase of the both Nitrogen and phosphorous. In individual effect, highest number of seeds (16.592) was observed at nitrogen level $N_{90.}$ In respect of phosphorous at level P_{40} (15.548) highest result was recorded (Table 7 and 8).

Maximum number of seeds was observed both at $N_{90}P_{20}$ (16.81) and $N_{90}P_{40}$ (16.80) level of interaction (Table 9).

Table 7. Individual effect of nitrogen on number of pods, length of pod and seeds per pod of fenugreek

Treatments	Number of pods plant^{-1}	L**ength** of pod (cm)	Number of Seeds pod^{-1}
N_0	11.40 d	10.21 d	12.696 d
N_{30}	13.91 c	11.03 c	14.228 c
N_{60}	18.95 b	12.39 b	15.611 b
N_{90}	22.37 a	13.22 a	16.592 a
LSD (0.05)	0.257	0.344	0.28

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha

Table 8. Individual effect of phosphorus on number of pods, length of pod and seeds per pod of fenugreek

Treatments	Number of pods plant^{-1}	Length of pod (cm)	Number of Seeds pod^{-1}
P_0	14.89 c	11.12 c	13.963 c
P_{20}	15.44 b	11.97 b	14.834 b
P_{40}	19.65 a	12.06 a	15.548 a
LSD (0.05)	0.223	0.298	0.24

Means with uncommon letter(s) are significantly different at 5% level by DMRT
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

Table 9. Interaction effect of nitrogen and phosphorus on number of pods, length of pod and seeds per pod of fenugreek

Treatments	Number of pods plant^{-1}	L**ength** of pod (cm)	Number of Seeds pod^{-1}
N_0P_0	10.63 g	9.433 e	11.60 g
N_0P_{20}	7.87 h	10.583 d	12.02 g
N_0P_{40}	15.70 e	10.583 d	14.47 e
$N_{30}P_0$	10.87 g	10.733 d	12.80 f
$N_{30}P_{20}$	12.20 f	11.217 d	14.82 de
$N_{30}P_{40}$	18.67 d	11.143 d	15.06 d
$N_{60}P_0$	18.37 d	12.017 c	15.28 cd
$N_{60}P_{20}$	18.73 d	12.487 bc	15.68 bc
$N_{60}P_{40}$	19.77 c	12.667 b	15.86 b
$N_{90}P_0$	19.70 c	12.293 bc	16.17 b
$N_{90}P_{20}$	22.94 b	13.513 a	16.81 a
$N_{90}P_{40}$	24.47 a	13.863 a	16.80 a
CV%	1.584	3.011	1.95
LSD (0.05)	0.45	0.596	0.49

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

Table 10. Individual effect of nitrogen on weight of 1000 seed and yield of fenugreek

Treatments	Weight of 1000 seed (g)	Yield (kg/ha)
N_0	10.58 c	294.93 d
N_{30}	10.72 c	377.67 c
N_{60}	11.22 b	575.40 b
N_{90}	11.6 a	670.69 a
LSD (0.05)	0.19	8.33

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha

Table 11. Individual effect of phosphorus on weight of 1000 seed and yield of fenugreek

Treatments	Weight of 1000 seed (g)	Yield (kg/ha)
P_0	10.46 c	450.17 b
P_{20}	11.14 b	493.23 a
P_{40}	11.49 a	495.62 a
LSD (0.05)	0.16	7.21

Means with uncommon letter(s) are significantly different at 5% level by DMRT
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

4.1.6. Weight of 1000 seed

It is recoded that Nitrogen had slightly positive effect on weight of thousand seed, where phosphorous had no effect on it (table10 and 11).

However, at $N_{90}P_{40}$ combination weight of seed was reported 12.36g, which was the highest value. Where at N_0P_0 value was 9.03g, weight of thousand seed found 11.8g and 11.33g at N_0P_{20} and N_0P_{40} interaction level (Table 12). This illustrate that weight of thousand seed increase little if nitrogen and phosphorous fertilizer apply, compare to the condition without fertilizer. However, weight of the thousand seeds do not increase with the increase of nitrogen and phosphorous fertilizer dose.

4.1.7. Yield

In sole effect the maximum yield of 670.69 kg/ha was recorded with N at the rate of 90 kg/ha (Table 10). In respect of phosphorus the maximum yield of 495.62 kg/ha was observed with 40 kg/ha (Table 11).

Among the interactions, the maximum projected yield was recorded with $N_{90}P_{40}$ (727.67kg/ha) followed by $N_{90}P_{20}$ (717.06kg/ha) and lowest yield (285.87kg/ha) was under N_0P_0 combination (Table 12).

Table 12. Interaction effect of nitrogen and phosphorus on weight of 1000 seed and yield of fenugreek

Treatments	Weight of 1000 seed (g)	Yield (kg/ha)
N_0P_0	9.03 h	285.87 e
N_0P_{20}	11.8 b	303.27 d
N_0P_{40}	11.33 de	295.67 de
$N_{30}P_0$	10.07 g	373.53 c
$N_{30}P_{20}$	10.10 g	377.93 c
$N_{30}P_{40}$	11.56 bcd	381.53 c
$N_{60}P_0$	11.70 bc	573.93 b
$N_{60}P_{20}$	11.26 de	574.67 b
$N_{60}P_{40}$	10.70 f	577.60 b
$N_{90}P_0$	11.03 ef	567.33 b
$N_{90}P_{20}$	11.40 cd	717.06 ab
$N_{90}P_{40}$	12.36 a	727.67 a
CV%	1.8	1.78
LSD (0.05)	0.335	14.43

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

4.2. The effect of nitrogen and phosphorus fertilizer application on postharvest soil parameters:

To find out the effect of nitrogen and phosphorous fertilizer several tests were done and observed the changes of soil parameters.

4.2.1. Soil pH

There was no significant effect of Nitrogen fertilizer on soil pH was observed. Soil treated with level of N_{90} pH recorded **6.7** while soil without application of nitrogen fertilizer value of pH found 6.8 (Table 13).

It is noticed from the experiment that Phosphorous also has no effect on soil pH (Table 14).

In respect of combine application of both fertilizers soil pH value varies from 6.8 to 6.1, refers that both fertilizers has no significant effect on soil pH (Table 15).

4.2.2. Organic carbon content

In individual effect, soil organic carbon content varied from 0.71% to 0.77%, with the variation of level N_0 to N_{60} respectively (Table 13).

In respect of phosphorous soil showed irregular pattern. Here soil organic carbon decreased at level P_{20} (0.70 %) and value remain same at level of P_0 and P_{40} (Table 14).

In respect of combine interaction soil carbon content showed irregular pattern (Table 15).

4.2.3. Organic matter content

Maximum organic matter found at nitrogen level of N_{60} (1.31%), however this value decreased to 1.26 % at N_{90} level (Table 13).

In respect of phosphorous, organic matter content of soil treated with phosphorous level P_{20} (1.2%) decreased compare to the soil with P_0 treatment (1.31%). However, value increased (1.28%) at level P_{40} (Table 14).

In combine effect, highest value found at level of $N_{30}P_0$ (1.44%), followed by $N_{60}P_0$ and $N_{90}P_{40}$, value are 1.36 % and 1.39 % respectively (Table 15).

Table 13. Individual effect of nitrogen on soil pH, organic carbon and organic matter

Treatments	Soil pH	Organic carbon (%)	Organic matter (%)
N_0	6.8	0.71	1.20
N_{30}	6.6	0.71	1.22
N_{60}	6.5	0.77	1.29
N_{90}	6.7	0.73	1.26
LSD (0.05)	NS	NS	NS

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha

Table 14. Individual effect of phosphorus on soil pH, organic carbon and organic matter

Treatments	Soil pH	Organic carbon (%)	Organic matter (%)
P_0	6.7	0.76	1.31
P_{20}	6.54	0.70	1.29
P_{40}	6.59	0.75	1.28
LSD (0.05)	NS	NS	NS

Means with uncommon letter(s) are significantly different at 5% level by DMRT
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

Table 15. Interaction effect of nitrogen and phosphorus on soil pH, organic carbon and organic matter

Treatments	Soil pH	Organic carbon (%)	Organic matter (%)
N_0P_0	6.7	0.75	1.29
N_0P_{20}	6.1	0.74	1.26
N_0P_{40}	6.8	0.7	1.22
$N_{30}P_0$	6.7	0.84	1.44
$N_{30}P_{20}$	6.67	0.59	0.96
$N_{30}P_{40}$	6.8	0.72	1.27
$N_{60}P_0$	6.6	0.8	1.36
$N_{60}P_{20}$	6.5	0.8	1.33
$N_{60}P_{40}$	6.5	0.77	1.23
$N_{90}P_0$	6.67	0.67	1.15
$N_{90}P_{20}$	6.77	0.72	1.25
$N_{90}P_{40}$	6.8	0.8	1.39
LSD (0.05)	NS	NS	NS

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

4.2.4. Particle density

There was no noticeable effect of nitrogen and phosphorous was observed on particle density of soil. Particle density of soil remain almost same with increase of nitrogen and phosphorous doses (Table 16 and 17).

4.2.5. Total nitrogen

From the experiment, there was no significant variation found in total N% of post-harvest soil. Total N% varies from 0.02360% to 0.02260% (Table 18).

Highest N% (0.67 %) was observed at level N_{60}. In respect of sole effect of phosphorous maximum N% was 0.0646% at level of P_{40} (Table 16 and 17)

4.2.6. Available phosphorous

There was no significant variation observed on the available Phosphorous of post-harvest soil. Different level of nitrogen and phosphorous had no effect on the availability of phosphorous on post-harvest soil. Available phosphorous rage was recorded 21.1 to 22.87 ppm (Table 16 ,17 and 18).

Table 16. Individual effect of nitrogen on particle density, total Nitrogen and available Phosphorous

Treatments	Particle density (g/cc)	Total Nitrogen (%)	Available Phosphorous (ppm)
N_0	2.5	0.0627	22.1
N_{30}	2.37	0.0603	22.2
N_{60}	2.35	0.0671	22.4
N_{90}	2.34	0.0629	22.7
LSD (0.05)	**NS**	**NS**	**NS**

Means with uncommon letter(s) are significantly different at 5% level by DMRT
N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha

Table 17. Individual effect of phosphorus on particle density, total Nitrogen and available Phosphorous

Treatments	Particle density (g/cc)	Total Nitrogen (%)	Available Phosphorous (ppm)
P_0	2.36	0.06457	22.5
P_{20}	2.35	0.0606	22.8
P_{40}	2.47	0.0646	22.5
LSD (0.05)	**NS**	NS	NS

Means with uncommon letter(s) are significantly different at 5% level by DMRT
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

Table 18. Interaction effect of nitrogen and phosphorus on particle density, total Nitrogen and available Phosphorous

Treatments	Particle density (g/cc)	Total Nitrogen (%)	Available Phosphorous (ppm)
N_0P_0	2.37	0.02370	22
N_0P_{20}	2.26	0.02260	21.2
N_0P_{40}	2.87	0.02870	21.78
$N_{30}P_0$	2.38	0.02383	22.1
$N_{30}P_{20}$	2.36	0.02360	22.4
$N_{30}P_{40}$	2.38	0.02380	22.2
$N_{60}P_0$	2.31	0.02313	21.9
$N_{60}P_{20}$	2.44	0.02440	21.5
$N_{60}P_{40}$	2.3	0.02300	21.8
$N_{90}P_0$	2.37	0.02370	22
$N_{90}P_{20}$	2.34	0.02340	21.77
$N_{90}P_{40}$	2.32	0.02320	21.87
LSD (0.05)	**NS**	**NS**	**NS**

N_0 = 0.0 kg/ha (control), N_{30} = 30kg/ha, N_{60} = 60kg/ha and N_{90} = 90 kg/ha
P_0 = 0.0 kg/ha (control), P_{20} = 20kg/ha and P_{40} = 40kg/ha

SUMMARY AND CONCLUSION

Study was conducted on Sher-e-bangla Agricultural University research field, during the period of November, 2018 to March, 2019. The aim of the study was to observe the effect of nitrogen and phosphorous fertilizer on growth and yield of fenugreek seed. Work was done on Methi (cv. BARI Methi I). Four level of nitrogen *viz*. 0,30,60,90 kg/ha and three level of phosphorous *viz*. 0,20,40 kg/ha were used.

Different growth parameters and seed yield attributes were observed. Statistical data analysis was done by using R statistics. Significance test was done by ANOVA table and to observe the mean difference postdoc test DMRT was done.

The highest value of Plant height (55.14 cm), number of branches (3.84), number of pods (22.37 plant^{-1}), length of pod (13.22 cm), number of seeds per pod (16.592) and yield (670.69 kg/ha) was observed when applied 90 kg/ha nitrogen fertilizer.

In respect of sole effect of P, the highest value of parameters such as, plant height (48.70 cm), number of branches (3.54), number of pods (19.65 plant^{-1}), length of pod (12.06 cm), number of seeds per pod (15.548) and yield (495.62kg/ha) was observed when applied 40 kg/ha phosphorous fertilizer.

However, in case of 1000 seeds weight nitrogen had slightly positive effect where phosphorous had no effect. $N_{90}P_{40}$ combination weight of seed was reported 12.36g, which was the highest value.

In combine application of 90kg/ha nitrogen and 40kg/ha phosphorous, maximum value of Plant height (37.90 cm), number of branches (4.27), number of plants (474700.7 ha^{-1}) and yield (727.67kg/ha) was recorded.
Where highest value of number of seeds/pods was observed both at $N_{90}P_{20}$ (16.81) and $N_{90}P_{40}$ (16.80) level of interaction. Maximum height of the pod was noticed with $N_{90}P_{40}$ (13.863 cm) combination, followed by $N_{90}P_{20}$ (13.513 cm) combination. Highest number of pods per plant was recorded at $N_{90}P_{40}$ (24.47) and $N_{90}P_{20}$ (22.94) combination.

Application of nitrogen and phosphorous fertilizer had no effect on soil particle density, soil pH, organic carbon (%), organic matter (%) total nitrogen (%) and available phosphorous (ppm) of post-harvest soil.

The study concluded as, combine application of 90kg/ha Nitrogen and 40kg/ha Phosphorous provided highest yield of fenugreek. Application of 90kg/ha Nitrogen combine with 40kg/ha Phosphorous, or 90kg/ha nitrogen coupled with 20 kg/ha phosphorous gave the reasonable yield of fenugreek. Application of Nitrogen and Phosphorous fertilizer had no effect on soil parameters.

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APPENDICES

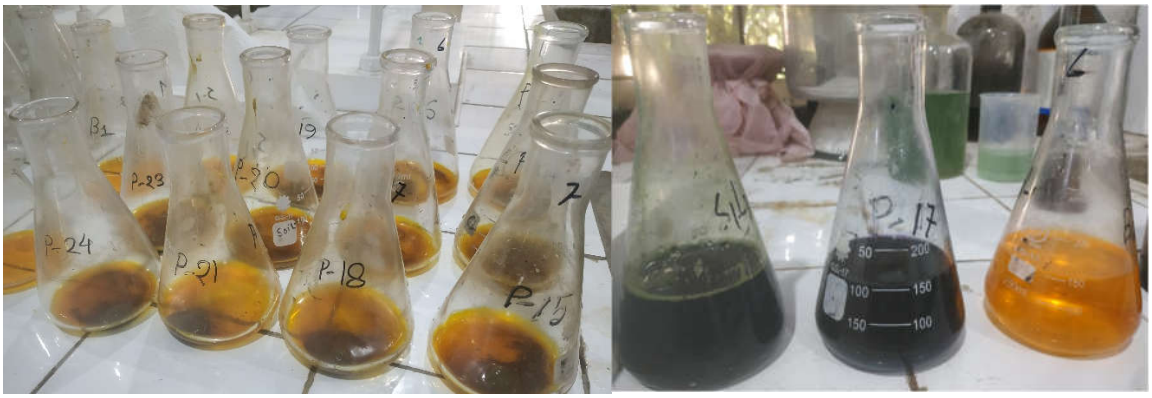
Appendix I: Sowing of fenugreek seeds

Appendix II: Irrigation of experimental filed

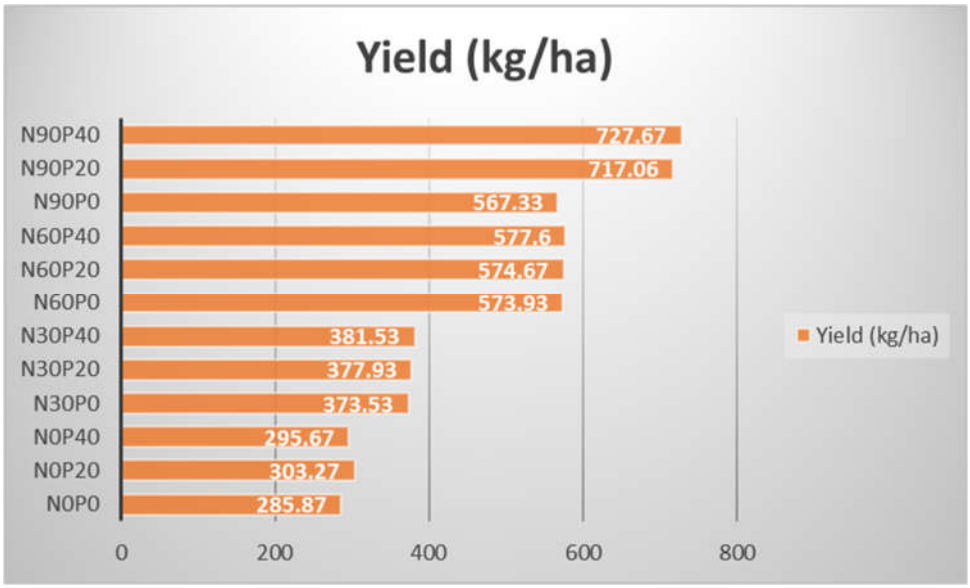
Appendix III: Flowing (Left) and Podding (Right) of Fenugreek

Appendix IV: Harvesting (Left) and data collection (Right) of plant parameters.

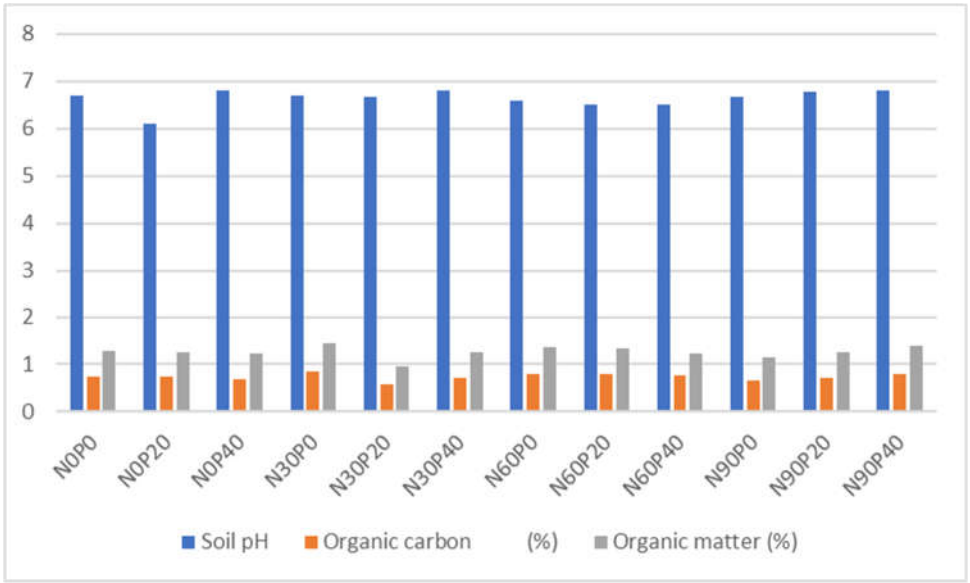
Appendix V: Water bath(left) and measuring cylinder (right)



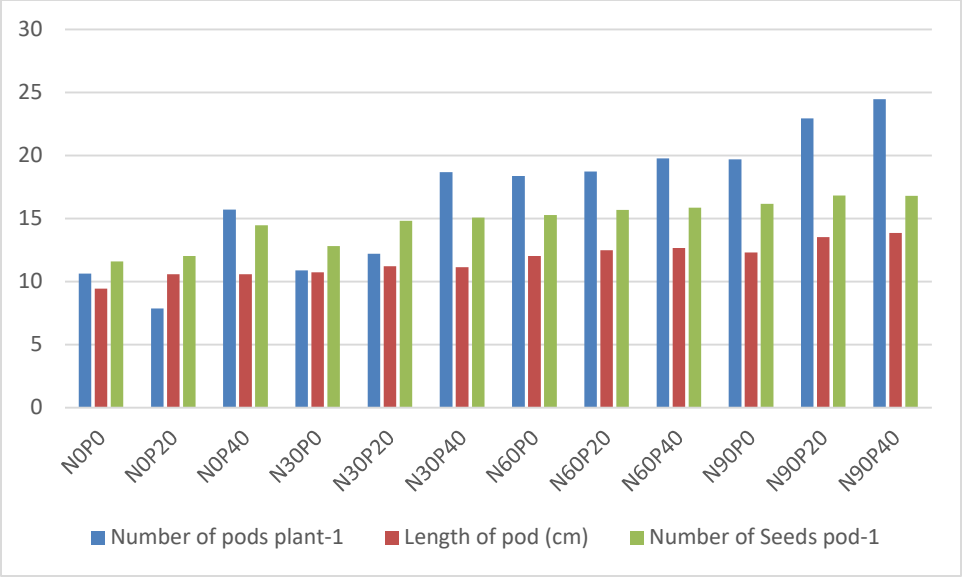
Appendix VI: Wet oxidation of soil organic matter (Walkley-Black method)



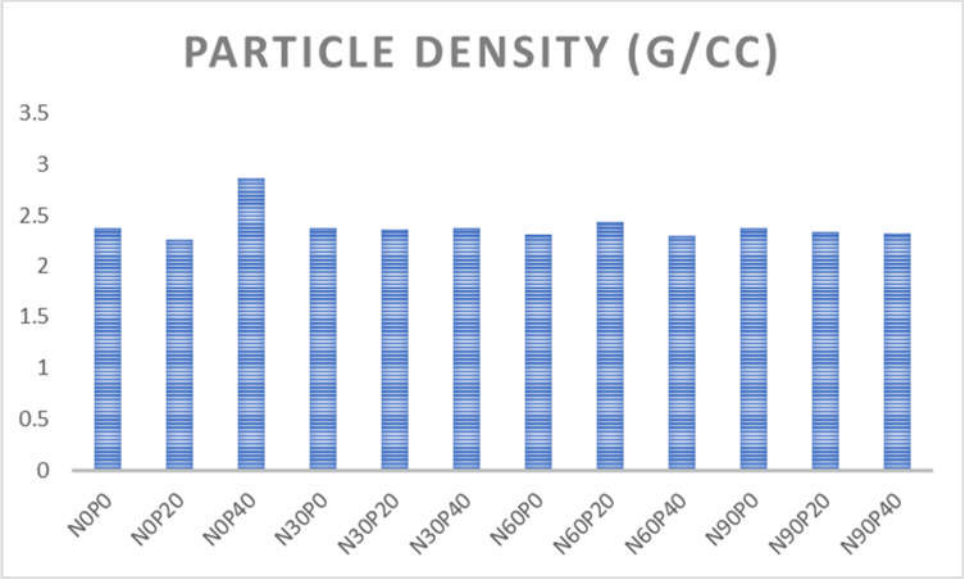
Appendix VII: Effect of nitrogen and phosphorous fertilizer on the yield of fenugreek seeds



Appendix VIII: Effect of nitrogen and phosphorous fertilizer on soil pH, organic carbon (%) and organic matter (%) of post-harvest soil



Appendix IX: Effect of nitrogen and phosphorous on Number of pods plant^{-1}, pod length and number of seeds pod^{-1}



Appendix X: Effect of nitrogen and phosphorous fertilizer on soil particle density of post-harvest soil