RESPONSE OF NITROGEN AND SPACING ON YIELD ATTRIBUTES AND YIELD OF FENUGREEK

***(Trigonella foenum-graecum* L.)**

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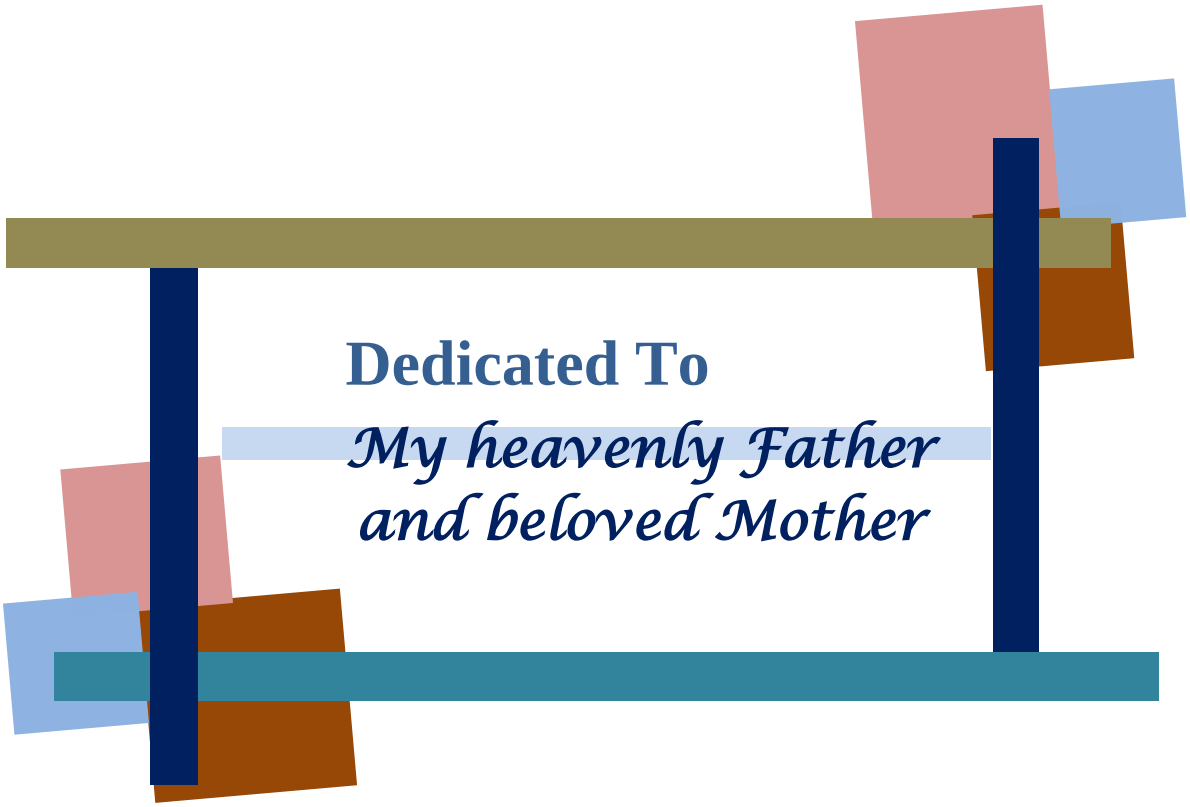

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*This is to certify that the thesis entitled '**RESPONSE OF NITROGEN AND SPACING ON YIELD ATTRIBUTES AND YIELD OF FENUGREEK (Trigonella foenum-graecum L.)** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **MD. AHASAN HABIB**, Registration No. **08-02850** 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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The Author

EFFECT OF NITROGEN LEVELS AND SPACING ON YIELD ATTRIBUTES AND YIELD OF FENUGREEK
(Trigonella foenum-graecum L.*)*

BY

Md. Ahasan Habib

Abstract

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University (SAU), Dhaka during the *rabi* season of 2014-2015, to find out the optimum nitrogen fertilizer dose and suitable spacing for higher seed yield of fenugreek (var. BARI Methi 1). Four nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}) and three spacings (20 cm x 10 cm, 25 cm x 10 cm and 30 cm x 10 cm) were considered as treatments. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Nitrogen fertilization doses, spacings and their combinations exerted significant influence on yield attributes and seed yield of fenugreek. Application of 120 kg N ha^{-1} and the spacing of 30 cm x 10 cm, independently provided the maximum plant height (36.22 cm and 32.7 cm at 80 days after sowing (DAS)), number of leaves $plant^{-1}$(260.6 and 256.9 at 80 DAS), plant spread (26.14 cm and 22.65 cm at 80 DAS), number of primary (4.70 and 4.10) and secondary branches (3.70 and 3.44) $plant^{-1}$, number of pods $plant^{-1}$(14.0 and 13.5), weight of individual pod (4.54 g and 4.6 g), number of seeds pod^{-1}(14.0 and 13.50), weight of seeds pod^{-1}(100.9 mg and 99.0 mg),1000-seed weight (7.7 g and 7.69 g) and seed yield $plot^{-1}$ (284.1 g and 238.7g). Application of 120 kg N ha^{-1} and 30 cm x 10 cm spacing independently also produced maximum seed yield ha^{-1} (789.0 kg ha^{-1} and 663.3 kg ha^{-1}). Application of nitrogen @ 120 kg ha^{-1} in combination with the spacing of 30 cm x 10 cm gave maximum yield attributes and thus gave the highest seed yield (801.7 kg ha^{-1}) identical with 25 cm x 10 cm spacing with the same nitrogen level (787.9 kg ha^{-1}).

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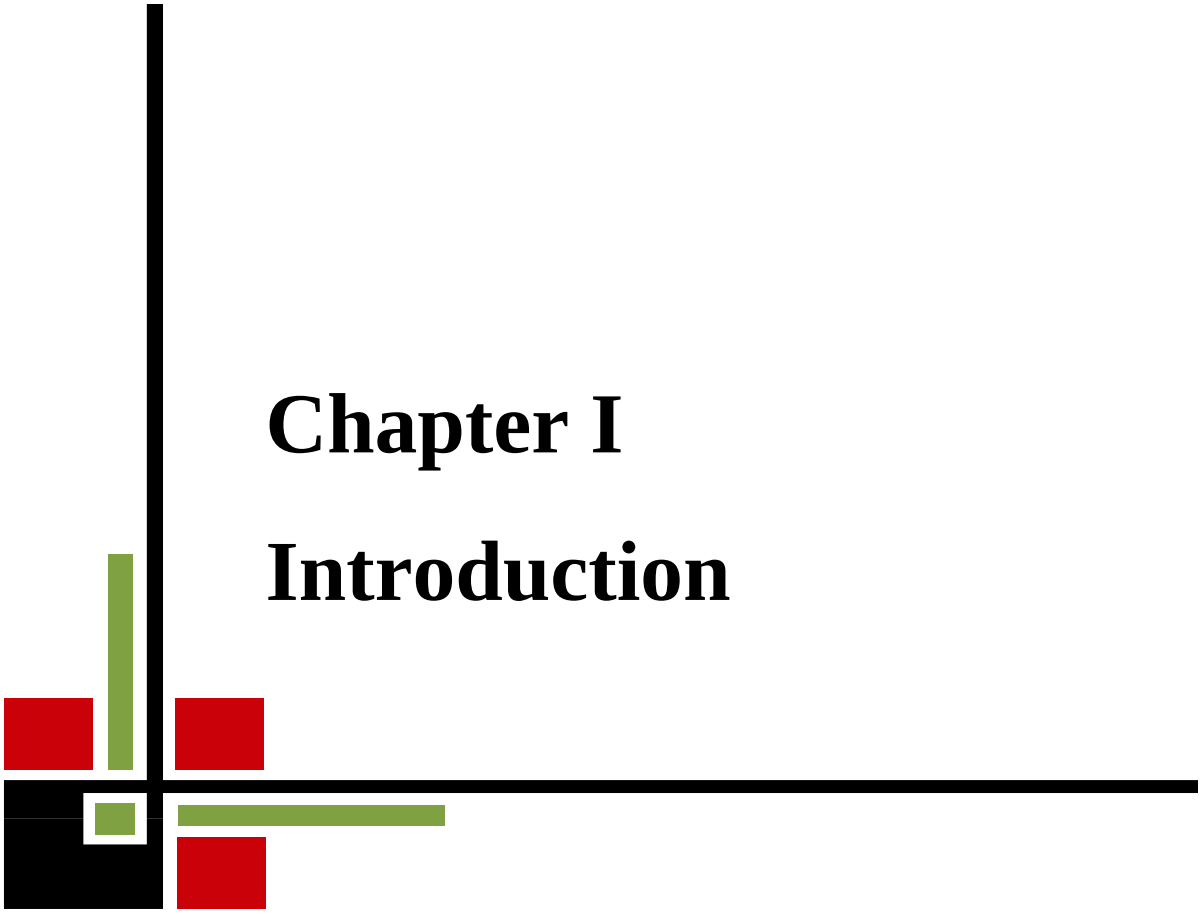
ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zones
ANOVA	=	Analysis of Variance
cm	=	Centimeter
CV	=	Coefficient of Variantion
DAS	=	Days after sowing
et al.,	=	And others
gm	=	gram
hr	=	Hour
ha	=	Hectare
i.e.	=	That is
J.	=	Journal
kg	=	Kilograms
LSD	=	Least Significant Difference
mm	=	Millimeter
mg/L		Milligram per litre
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
Viz.	=	Namely
WUE	=	Water use efficiency
%	=	Percentage
(^{0})	=	Degree



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L) locally known as 'methi' belonging to the family Leguminosae and sub family Papilionaceae is widely used as spice and condiment to add flavor in various foods. 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).

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). Some studies have shown that fenugreek contains nicotinic acid or niacin (vitamin B_3). Vitamin B_3 prevents (Najafpoor ,1994). These plants are used for blood lipids and sugar decreasing in diabetic and non diabetic peoples and have antioxidant and antibacterial activity. This plant decreases body fats and is effective on obesity. This plant is used in therapy atherosclerosis (Nandini *et al*., 2007), rheumatism (Vyas Amit *et al*., 2010), sugar lowering (Gupta *et al*., 2001), blood lipids lowering (Xue *et al*., 2007), appetizer (Max, 2007) and contain antioxidant activity (Birjees Bukhar *et al*., 2008).

Nitrogen is a key element in the structure of many compounds of cells and plays a crucial role in the growth and yield of plants. Moosavi *et al*. (2012) and Shokhmgar (2009) showed that nitrogen fertilization significantly affected fenugreek seed yield, and the highest seed yield was obtained with the application of 150 kg N ha^{-1}. But Zandi *et al*. (2011) and Tuncturk (2011) obtained the maximum seed yield of fenugreek from the application of nitrogen @ 90 kg N ha^{-1} and 75 kg N ha^{-1} respectively.

Plant spacing controls the plant density of the crop and it is well known that establishment of an optimum plant density per unit area is one of the important factors contributing to the increased productivity of a crop. Wider or too low spacing beyond the optimum can affect the yield of crops. There is an optimum plant density for each crop, over which assimilates are more utilized for vegetative growth and respiration increase rather than the reproductive growth. Also, under similar plant density conditions, although single-plant production increased, yield per area unit decreased (Ghanbari and Taheri Mazandarani, 2003). Sharma (2004) indicated that the increase in plant density increased seed yield and decreased 1000-seed weight of fenugreek. Also, Gowda *et al.* (2006) compared the effects of three sowing arrangements (15×15 cm, 15×30 cm and 30×30 cm) on fenugreek and showed that the sowing arrangement of 15×15 cm produced the highest seed yield. Comparing the effect of four plant populations of 10, 20, 30 and 40 plants m^{-2} on fenugreek by Seghatoleslami and Ahmadi Bonakdar (2010) indicated that plant density had no significant effect on 1000-seed weight and harvest index, but as the population was increased from 10 to 40 plants m^{-2}, total biomass increased from 67.3 to 142.8 g m^{-2}. Anonymous (2015) obtained the highest seed yield of fenugreek from 30 cm × 10 cm spacing. However, Mondal *et al*. (2011) recommended spacing of 25 cm × 10 cm for fenugreek cultivation. Keeping the above facts in mind the present experiment was carried out with the following objectives:

i. To study the growth behavior of fenugreek under different nitrogen levels and spacing.
ii. To determine the optimum N fertilization rate and suitable spacing for higher seed yield of fenugreek.
iii. To examine the interaction effect of nitrogen and spacing on yield and yield attributes of fenugreek.

Chapter II

Review of Literature

CHAPTER II
REVIEW OF LITERATURE

Among the spice crops, fenugreek occupies the topmost position for adding flavor in various foods. The proper nitrogen fertilization rate and suitable plant spacing essentially influence its morphological characters, yield attributes and seed yield. Experimental evidences showed that there is a profound influence of nitrogen (N) and spacing (S) on this crop. A brief of the relevant works on fenugreek and other crops performed in the past are presented in this chapter.

2.1 Effect of nitrogen (N) on morphological parameters, yield attributes and seed yield

A. Fenugreek

Moosavi *et al.* (2012) conducted an experiment to determine the effect of irrigation interval, N fertilization and plant density on yield and yield components of fenugreek. N fertilization at three different rates of 0, 75 and 150 kg N ha^{-1} from urea source and plant density levels of 22, 33 and 66 plants m^{-2} respectively. They found that days 50% flowering increased with the increasing of N rates. Application of 150 kg N ha^{-1} had 33.9 and 66.1% higher pod number $plant^{-1}$, 37.5 and 68.1% higher pod number m^{-2}, 31.7 and 67.1% higher seed yield, 31.7 and 65.9% higher single-plant seed yield, 31.1 and 68.9% higher single-plant biomass yield and 30.6 and 67.8% higher biological yield than the application of 75 and 0 kg N ha^{-1}, respectively. Moreover, the results showed that increase in population from 22 to 33 plants m^{-2} decreased single-plant seed and biomass yields by 32.1 and 33.6%, respectively. Conclusively, considering the results of the present study it is recommended to use an irrigation interval of 10 days with the application of 150 kg N ha^{-1} and a population of 66 plants m^{-2} for the cultivation of fenugreek in Darmian, Iran.

Tuncturk (2011) conducted an experiment to determine the effects of nitrogen and sulphur applications on the yield and quality of fenugreek in Van, Turkey. In the study, plant height (cm), the number of branches plant^{-1}, the number of pods pant^{-1}, the number of seeds pod^{-1},pod length (cm), 1000-seed weight (g), and seed yield (kg ha^{-1}) were determined. 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.

Zandi *et al.* (2011**)** conducted a study on agronomic and morphological traits in fenugreek (*Trigonella foenum-graecum* L.) under nitrogen fertilizer and plant density, Four levels of nitrogen (0, 25, 50 and 75 kg ha^{-1}) as the main factor and four levels of plant density (60, 80, 100 and 120 plants m^{-2}) as sub-plots were investigated. The maximum number of pods plant^{-1} and seed yield (1468 kg ha^{-1}) produced by using 75 kg N ha^{-1}.

Jagdale and Dalve (2010) conducted 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.

B. Other crops

Mozaffari *et al.* (2012) carried out a field experiment at Qazvin-Iran during 2009-2010 to assess the effect of different levels of nitrogen at the rate of 0, 75, 150 and 225 kg ha-1 and potassium at the rate of 0, 45, 90 and 135 kg ha^{-1}

on yield and some of the agronomical characteristics in Rapeseed (*Brassica juncea*). The results showed that increased amount of nitrogen and potassium up to 225 kg N ha^{-1} and 135 kg K ha^{-1} respectively had a positive and significant ($p<0.01$) effect on thousand seed weight, seed yield.

A field experiment was conducted by Gupta *et al.* (2011) during the *rabi* season of 2003-2004 and 2004-2005. They reported from their field experiment that higher dose of nitrogen @ 120 kg Nha^{-1} produced maximum seed yield of *Brassica spp*.

Singh *et al.* (2004) reported that nitrogen application increased the seed yield of rapeseed and the maximum seed yield was obtained from 120 kg N ha^{-1} application. The increased nitrogen and sulfur content enhanced the total uptake of nitrogen and sulfur.

Patel *et al.* (2004) carried out a field experiment during the *rabi* season of 1999- 2000 in Gujarat, India to investigate the effects of irrigation schedule, spacing (30 and 40 cm) and N rates (50, 75 and 100 kg/ha) on the growth, yield and quality of Indian Rapeseed cv. GM-2. In combination treatments, 3 irrigation + N at 100 kg ha^{-1} + spacing of 45 cm resulted in a significant increase in yield. Growth, yield attributes and seed yield increased with increasing N levels, while oil content decreased with increasing rates. The highest benefit cost ratio was also obtained N at 100 kg ha^{-1}.

Sinsinwar *et al.* (2004) conducted a field experiment by during the 1999/2000 and 2000/01 *rabi* seasons in Bharatpur, Rajsthan, India to determine the best cropping sequence and N fertilizer application rates (0, 30, 60 and 90 kg ha^{-1}) of Indian Rapeseed cv. RH-30 under brackish water situation. The cropping sequences comprised: pearl millet + black gram followed by Indian Rapeseed : pearl millet + pigeon pea followed by Indian Rapeseed; black gram followed by Indian Rapeseed; cluster bean followed by Indian Rapeseed; and fallow

followed by Indian Rapeseed. The cropping sequences did not affect the growth, yield and yield components (i.e. plant height, number of primary and secondary branches per plant, number of siliquae per plant), 1000-seed weight and seed yield in both years. The see yield of Indian rapeseed significantly increased with each increment of N fertilizer up to 60 kg ha^{-1}, beyond which the increase was marginal. On an average, the increase in seed yield compared to the control was 33.3 and 83.8% with 30 and 60 kg N/ha, respectively. The Indian Rapeseed seed equivalent yield was significantly highest in pearl millet + black gram followed by Indian Rapeseed (3190 kg ha^{-1}) cropping sequence during 1999/2000. In 2000/01, the Indian Rapeseed equivalent yield of pearl millet + black gram followed by Indian Rapeseed was highest (2435 kg ha^{-1}).

Meena and Sumeriya (2003) carried out a study to evaluate the effect of nitrogen (0, 30, so, 60 and 90 kg/ha) on seed and oil content of rapeseed (*Brassica juncea*). Application of 60 kg N ha^{-1} gave the maximum seed yield and oil content (37.04%) compared to no nitrogen application.

Field experiments were conducted by Abdin *et al.* (2003) in Rajasthan, Haryana and Uttar Pradesh, India to study the effects of S and N on the yield and quality of Indian rapeseed cv. Pusa Jai Kisan (V_1) and rape cv. Pusa Gold (V_2). The treatments comprised: T_1 (SO:N 50 + 50); T_2 (S40:N50 + 50 for V_1 and S40:N50+25 + 25 for V^2); and T_3 (820 + 20:N50 + 50 for V_I and S20 + 10 + 10:N50 + 25 + 25 for V_2). Split application of S and N (T_3) resulted in a significant increase the seed and oil yield of both crops. The average seed yield obtained from the different experimental sites in the three states was 3.89 t/ha for V^1 and 3.06 t ha^{-1} for V_2 under T_3. The average oil yield under T_3 was 1.71 t/ha for V_I and 1.42 t ha^{-1} in V_2. The oil and protein contents in the seeds of V_1 and V_2 also increased with the split application of S and N. It may be concluded from these results that the yield and quality of rapeseed-Rapeseed can be optimized with the split application of 40 kg S ha^{-1} and 100 kg N ha^{-1} during the appropriate phenological stages of crop growth and develo

Khan *et al.* (2003) observed that cycocel at 400 ppm + 60 kg Nitta and ethrel at 200 ppm ± 80 kg N/ha enhanced leaf photosynthetic rate, water use efficiency, leaf area and leaf dry mass 80 days after sowing. The highest stem, pod and plant dry mass of mustard were noted 120 days after sowing. At maturity, pod number and seed yield increased.

Kader *et al.* (2003) observed that the effects of row spacing (30, 45 or 60 cm) and N rate (60, 120 or 180 kg ha^{-1}) on the yield of Indian Rapeseed cv. Basanti were studied. N was applied at sowing (50%) and after the initial irrigation (50%). They found among the N rates, 120 kg ha^{-1} gave the highest seed yield (20.24 quintal ha^{-1}), straw yield (12.22 quintal ha^{-1}), stick yield (43.52 quintal ha^{-1}), and net profit (12975 rupees ha^{-1}).

Kumar and Singh (2003) conducted an experiment during *rabi* season with different levels of nitrogen for Indian Rapeseed (*Brassica juncea*). They reported that the maximum seed yield (24.51 q/ha) was observed with 150 kg N/ha.

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}). He observed that adequate N fertilization is important in increasing siliqua number per plant and 1000-seed weight in summer oilseed rape. He suggested that the rate of 160 kg N ha^{-1} will be adequate for the crop to meet its N requirements.

Prasad *et al.* (2003) stated that N at 30 kg ha^{-1} + P at 20 kg ha^{-1} + Zn at 5 kg ha^{-1}, and N at 60 kg ha^{-1} + P at 30 kg ha^{-1} + S at 20 kg ha^{-1} produced the highest growth, yield and productivity of mustard, and also good cost: benefit ratio.

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N ha^{-1} under irrigated or non-irrigated conditions in a field experiment. They

observed that plant height increased with increasing rate of nitrogen and was higher under irrigated than non- irrigated conditions. Singh et al. (2002) also reported that plant height increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

Singh *et al.* (2004) stated that N at 120 kg ha^{-1} produced 4.51 higher number of branches, 48.03 higher siliqua numbers, 2.09 g siliquae weight, 2.05 g higher seed wt per plant and 2.55 quintal higher seed yield compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the yield and yield attributes significantly. The basis of N application did not significantly affect the performance of the plants.

Singh and Prasad (2003) stated that among the N rates, 120 kg/ha gave the highest seed yield (20.24 quintal ha^{-1}), straw yield (12.22 quintal ha^{-1}), stick yield (43.52 quintal ha^{-1}) of Indian mustard.

Singh and Meena (2003) conducted a field experiment to determine the effect of N fertilizers (20. 40, 60, 80 and 100 kg N ha^{-1}) on seed, the oil and protein yield of Indian Rapeseed cv. Varuna. Results showed that 40 kg N ha^{-1} gave the highest oil content (39.61%).

An experiment was conducted by Tripathi (2003) in Uttar Pradesh, India in 1994- 95 and 1995-96 to investigate the effects of N levels (80, 120, 160 and 200 kg ha^{-1}) on the growth, yield and quality of Indian Rapeseed cv. Varuna. Nitrogen was applied at 3 equal splits, at smiting, at first irrigation and at 60 days after sowing.

Babu and Sarkar (2002) reported that rapeseed cultivars responded to N application up to 80 kg ha" Dry matter yield, N content, N uptake and percent of N by Rapeseed cultivars significantly increased with an increase in the level of fertilizer N. Percent of N significantly increased from 12 at 40 kg N ha^{-1} to

22 at 80 kg N hal in rapeseed yield while in stover the corresponding values ranged from 11 to 20%. Successive levels of N also increased significantly the uptake of soil N by Rapeseed cultivars clearly establishing the 'priming' or 'added nitrogen interaction effect' of applied nitrogen.

Meena *at al.* (2002) revealed that the application of 60 kg N tha registered signiticanth higher seed and stover yield of Rapeseed over control and 30 kg Nib. and found statistically at par with 90 kg Nth& Sharma and Jain (2002) reported that the application of 80 kg N ha^{-1} resulted in the highest number of branches (24.4) and siiiquae (260.9) per plant, number of seeds per siliquae (15.3), 1000-seed weight (5.85 g), and seed yields (1649, 2217, and 1261 kg ha^{-1}).

Sharawat *et al.* (2002) observed that the yield and oil content generally increased with the increase in N and S rate. N at 120 kg ha^{-1} resulted in the highest number of siliquae per plant (397 25), weight of siliquae per plant (33 32 g), number of seeds per siliquae (14.80), seed yield per plant (368.75 g), 1000-grain weight (17.33 g), seed yield per ha (17.33 quintal) and oil content (38.39%) of mustard.

Singh (2002) found that application of N and P increased the length of siliquae, number of siliquae per plant, seeds per siliquae, seed yield and 1000-seed weight of Rapeseed. However. the significant increase in yield and yield components was recorded in 60, 90 and 120 kg N ha^{-1} and 30, 45 and 60 kg P ha^{-1} treatments. The maximum seed yield was recorded from application of 45 kg P ha^{-1} (11.43 and 13.85 q/ha in 1999 and 2000, respectively) and 120 kg N/ha (12.98 and 13.83 q ha^{-1} in 1999 and 2000, respectively). The oil content also increased with the application of N and P, but was not significant.

Shukla *et al.* (2002) conducted an experiment to observe the effect of nitrogen for Indian Rapeseed (*B. juncea*). They found that maximum number of siliquae

per plant, siliquae length, maximum number of seeds per siliquae, maximum 1000- maxi nurrm seed weight and maximum seed yield per hectare was obtained with the application of 120kg N/ha. They also reported that growth characters and length of siliquae increased significantly with successive increase in nitrogen up to 120 kg/ha.

Budzynski and Jankowski (2001) stated that the effects of pre-sowing application of NPK (161 kg ha^{-1}) + S (30 kg ha^{-1}) or Mg (5 kg ha^{-1}) and top dressing of N (0, 30, 25+5 and 60 kg ha^{-1}) on the yield, yield components and morphological features of white rapeseed (*Sinapsis alba*) and Indian Rapeseed seeds were evaluated in an experiment conducted in Poland. N top dressing (30, 25+5 and 60 kg ha^{-1}) increased the height, diameter of stern base and branching of Indian Rapeseed and white Rapeseed stems. Both crops, however, exhibited lodging. The effects of NPKS and NPKMg on the yield potential of white Rapeseed were not dependent on weather conditions N applied at 30 kg ha^{-1} at the start of the flowering period gave the best results among the methods of white Rapeseed top dressing. Splitting this rate to 25 kg N ha^{-1} as a solid fertilizer and 5 kg N ha^{-1} in a solution gave results similar to that of the whole rate of 30 kg N ha^{-1} as a solid N at 60 kg ha^{-1} appeared to be less productive. N applied as a solid fertilizer at a rate of up to 60 kg ha^{-1} increased the seed yield

Sainju *et al.* (2000) conducted an experiment on cover crops can influence soil properties and crop yield they examined the influence of legume and N fertilizer application (0, 90, and 180 kg N ha^{-1}) on the short and long-term effects on soil C and N and tomato yield and N uptake. N uptake similar to that produced by 90 and 180 kg N ha^{-1}. Nitrogen fertilizer application increased PNM and inorganic N after split application and tomato yield and N uptake but decreased organic C and N and PCM.

Sidlauskas (2000) observed that the yield of rapeseed was increased with the increasing rate of nitrogen levels up to 120 kg. Further increase of nitrogen level did not affect the seed yield.

Hossain and Gaffer (1997) conducted an experiment with 5 levels of nitrogen viz, 0, 100, 150, 200, 250 kg ha^{-1} on rapeseed and maximum yield was found 1.73 t ha^{-1} with 250 kg N ha^{-1}.

Islam and Mondal (1997) showed that the maximum plant height of mustard was obtained 93.6 cm at 300 kg N ha^{-1} while applying different levels of nitrogen i.e. 0, 100, 200.300 kg ha^{-1}.

Islam, *et al*. (1997) in a field trial showed that application of four levels of nitrogen 0, 100, 200, 300 kg ha^{-1} yielded 0.69, 1.29, 1.45, 1.21 t ha^{-1} mustard ha^{-1}, respectively.

Kakati and Kalita (1996) found that most of the yield components (branches $plant^{-1}$, Siliqua $plant^{-1}$ seed and stover N content) increase with the increasing rate of N-fertilizer, while oil content of seed decreased, 1000 seed weight and number of seeds siliqua remained unchanged. The mustard cv. Vanilla was found to be highest yielding cultivar.

Mondal *et al.* (1996) reported that the highest seed yield of rapeseed (1.40 tilia) was obtained from fertiflzer levels of 150:90:100:30:4:1 kg/ha of N, P2O5, K_20, S, Zn and B along with 6 tones cowdung.

Patil *et al.* (1996) reported that the effect on growth, yield components and seed yields of *B. juncea* that the branching pattern and number of pods produced on different order of branches, in the two species, were favorable modified by the increasing levels of N apply. Primary and secondary branches contributed to the seed yield to an extent of 80% of the total. Yield without any

significant effect of N on 1000 seed weight B. juncea exhibited significantly higher yield than *B. campestris*. Nitrogen supply up to 120 kg ha^{-1} linearly increased seed yield in both the species.

Tomer *el al.* (1996) reported the highest seed yield of mustard cv Varna (2 t ha^{-1}) and PUSS (2.72 t ha^{-1} with the highest dose of N 160 kg halt' over control.

Tuteja *et al.* (1996) investigated the effect of nitrogen at 60, 90 and 120 kg ha^{-1} on the yield of *Brassica juncea* cv. *Varuna*. Seed yield was the highest (1.12 t/ha) with 120 kg N/ha.

Ali and UlIah (1995) reported maximum plant height of rapeseed with 120 kg N ha^{-1} when different doses of nitrogen 0, 40, 90, 120 kg ha^{-1} were given to the plant.

Shrivastava *et al.* (1988) observed in an experiment conducted with musrard (*Brassica juncea ev. varuna*) that the application of nitrogen at the rate of 90 kg/ha at the Preflowering stage gave highest harvest index.

Shamsuddin *et al.* (1987) working with Rapeseed with five levels of nitrogen (0,30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation observed that plant height of mustard increased progressively with increasing levels of nitrogen application but was not significantly differed with the application of different levels of nitrogen. Nitrogen at the rate of 120 kg ha^{-1} gave taller plant, highest no of primary branches of plant (5 30) and the highest seed yield (830 kg ha^{-1}) over control. Thousand seed weight also increased significantly due to application of nitrogen.

Singh and Saron (1987) set an experiment with *Brassica campestris* var. toria (*Brassica napus* var. *toria*) applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg/ha increased plant height, number of pods $plant^{-1}$

and 1000-seed weight. This dose gave seed yields of 1.20 t ha^{-1} compared to 0.89 t/ha without nitrogen. A further increase in yield with 90 kg N ha^{-1} was not significant.

In a study on the effect of three N fertilization rates (0, 80 and 120 kg N ha^{-1}) on yield of *Nigella sativa*, Khan (1993) reported that the application of 80 kg N ha^{-1} produced the highest number of follicles per plant and seed yield and the application of 120 kg N ha^{-1} produced the highest 1000-seed weight, but the seed number per follicle was not affected by N fertilization. In addition, the application of 80 kg N ha^{-1} increased yield by 91% as compared with no-N fertilization treatment plot.

2.2 Effect of spacing on morphological parameters, yield attributes and seed yield

A. Fenugreek

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) 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) and from 20 cm row spacing in 2014-15 (1.53 t/ha). Plant to plant distance was maintained as 10 cm.

Bairagi (2014) 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) 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.

Mondal *et al*. (2011) recommended spacing of 25 cm x 10 cm spacing for the cultivation of fenugreek.

Tuncturk (2011) conducted an experiment to determine the effects of different row spacing (20, 30 and 40 cm) and phosphorus applications (0, 30, 60 and 90 kg ha ha^{-1}) on the yield and quality of fenugreek in Van-Turkey, in 2006 and 2007 growing seasons. 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. 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. 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.

B. Other crops

Ghobadi and Ghobadi (2010) studied the effect of different coriander plant densities (10, 30, 50 and 70 plant per m^{-2}) and concluded that number of umbels per plant and number of seed per umbel reduced with increasing plant density but no significant difference was observed in 1000-fruit weight.

Khorshidi *et al.* (2009) showed that with increase in inter-plants space significantly increased number of branches per main stem of fennel.

Kumar *et al.* (2007) stated that density of 25 plants m^{-2} had the highest plant height while the highest branch number per main stem of coriander belonged to density of 10 plants m^{-2} treatment.

Akbarinia *et al*. (2006) studied the coriander densities of 20, 30, 40, 50 and 60 plants/m^{-2} and concluded that fruit and essential oil yield were higher in 30 plants/m^{-2} densities.

Okut and Yidrim (2005) studies showed that maximum fruit yield and biological yield of coriander were obtained from 30 cm row spacing.

Masood *et al* (2004) investigated the effect of row spacing (40, 50, 60 and 70 cm) on morphological characters and seed yield of fennel and reported that the greatest plant height, seed yield per umbel, and seed yield per hectare were obtained with the lowest row spacing but the lowest plant height, seed yield per umbel, and seed yield per hectare were obtained with the greatest row spacing.

Arabasi and Bayran (2004) with planting sweet basil in three plant density (20, 40, and 60 plant per m^{-2}) reported that the highest amount of dry matter, percentage and the yield of effective substances produced in 20 plants per m^{-2}.

A field experiment was conducted to determine the effect of crop densities (10, 20 and 40 plant m^{-1}) of amaranth by Abbasdokht *et al.* (2003) in Iran. Yield and yield contributing characters were statistically significant in different density. The density 40 plants m^{-2} gave the minimum yield, whereas 10 plants m^{-1} gave highest single plant yield but the lowest was found in hectare was considered.

Field trials were conducted in South Florida, United state. Between 1996 and 1999 by Santos *et al.* (2003) to determine the extent of yield reduction due to

population density of stem amaranth. They recorded that yield reductions reached 24 % with densities higher than 8 plant/ 6 m row planting.

Mozumder (2003) reported that plant spacing is an important factor for seed production in *Eryngium*. It is cultivated densely for its higher fresh leaf yield but fewer amounts of seeds (80-100 kg seed ha^{-1}) are produced in that way. He recommended that 30 cm x 10 cm spacing for bilati dhonia cultivation

Nahdibadi *et al* (2002) with study of the effect of different plant densities on yield dry material of Thyme (*Thymus vulgaris*) showed that the higher yield of dry material was obtained with 15 cm densities of planting.

Missinga and Currie (2002) conducted an experiment to assess the impact of plant density of amaranth on yield and yield contribution characters and reported that spacing didn't affect the individual plant height but the yield per hectare of gimakalmi was greatly influenced due to plant spacing.

Shareh (1999) reported that increasing of density reduced yield components and harvest index but increased fruit and biological yield of *Pimpinella anisum* per area unit.

Diereichsen (1996) reported that maximum fruit yield of coriander was obtained with density of 50 plants per m^2 and decreasing plant density, the plant to some extent compensates the yield reduction by producing new branches.

Park *et al.* (1993) conducted an experiment on plant spacing the growth and yield of Gimakalmi. From their findings it was clear that 30 cm x 30 cm or 45 cm x 45 cm in consideration of growth and yield of the crop.

Two field experiments was conducted by Norman and Shongwe (1993) on a sandy clay loam soil during the summer season of 1990-1991 and 1991-1992. Amaranth Seeds were sown in for the 1st experiment with 4 spacing (60 x 45, 60 x 60, 90 x 45, 90 x 60 cm). These spacing recorded no significant improvement in shoot, leaf or stem quality.

Verzalova *et al* (1988) reported that row spacing of funnel did not effect on the plant height but number of umbel and seed yield of fennel per plant was increased at the wider spacing.

Ahmed and Haque (1986) studied the effect of row spacing (15, 20, 25 and 30cm) and time of sowing (November 1, November 20, December 10 and December 30) on the yield of black cumin (*Nigella sativa*) in Bangladesh. They found that closer row spacing (15 cm) and early sowing (November 1) was the best for higher seed yield of black cumin.

Koay and Chua (1979) conducted an experiment to study the effect of appropriate planting method and density for economical production of pak-choi (*Brassica Chinensis L.)* in Singapore. The treatment compared were direct seeding, bare root transplanting or ball root transplanting in rows 30 cm apart with inter plant spacing of 10 cm, 20 cm and 30 cm x 30 cm were included in the study. The highest yield was obtained in 15 cm X 15 cm spacing but had no significant difference with 10 cm x 10 cm spacing.

Davey (1965) observed maximum head size in cabbage with a spacing of 25-50 cm in row. However, closer spacing resulted in higher yield per hectare with greater variability in head size. Wider spacing resulted in better growth and rapid development than closer spacing.

Chapter III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from November 2014 to March 2015 to find out the optimum nitrogen fertilization rate and suitable spacing on yield attributes and yield of fenugreek. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout of the experimental design, intercultural operations, data recording and their analyses under the following headings and sub-headings.

3.1 Experimental site and soil

The experimental field is located at 23^0 41' N latitude and 90^o 22' E longitude at a height of 8.6m above the mean sea level. It belongs to the AEZ 28, Modhupur Tract (FAO, 1998). The experimental site was shown in the map of AEZ of Bangladesh.

3.2 Climate

The experimental field was situated under Sub-tropical climate; usually the rainfall is heavy during *kharif* season, (April to September) and scanty in *rabi* season (October to March). In *rabi* season temperature is generally low and there is plenty of sunshine. The temperature tends to increase from February as the season proceeds towards *kharif*. The site where the experiment was conducted had subtropical climate and the *rabi* season extended from October to early March.

3.3 Seed

High yielding variety of fenugreek (cv. BARI Methi 1) 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.

3.4 Treatments

Four levels of nitrogen and three spacing and their combinations were used in the experiment. These were: Factor A: Four Nitrogen levels

i. N_0 = 0 ka ha^{-1}
ii. N_1= 40 ka ha^{-1}
iii. N_2 = 80 ka ha^{-1}
iv. N_3 = 120 ka ha^{-1}

Factor B: Three Spacing

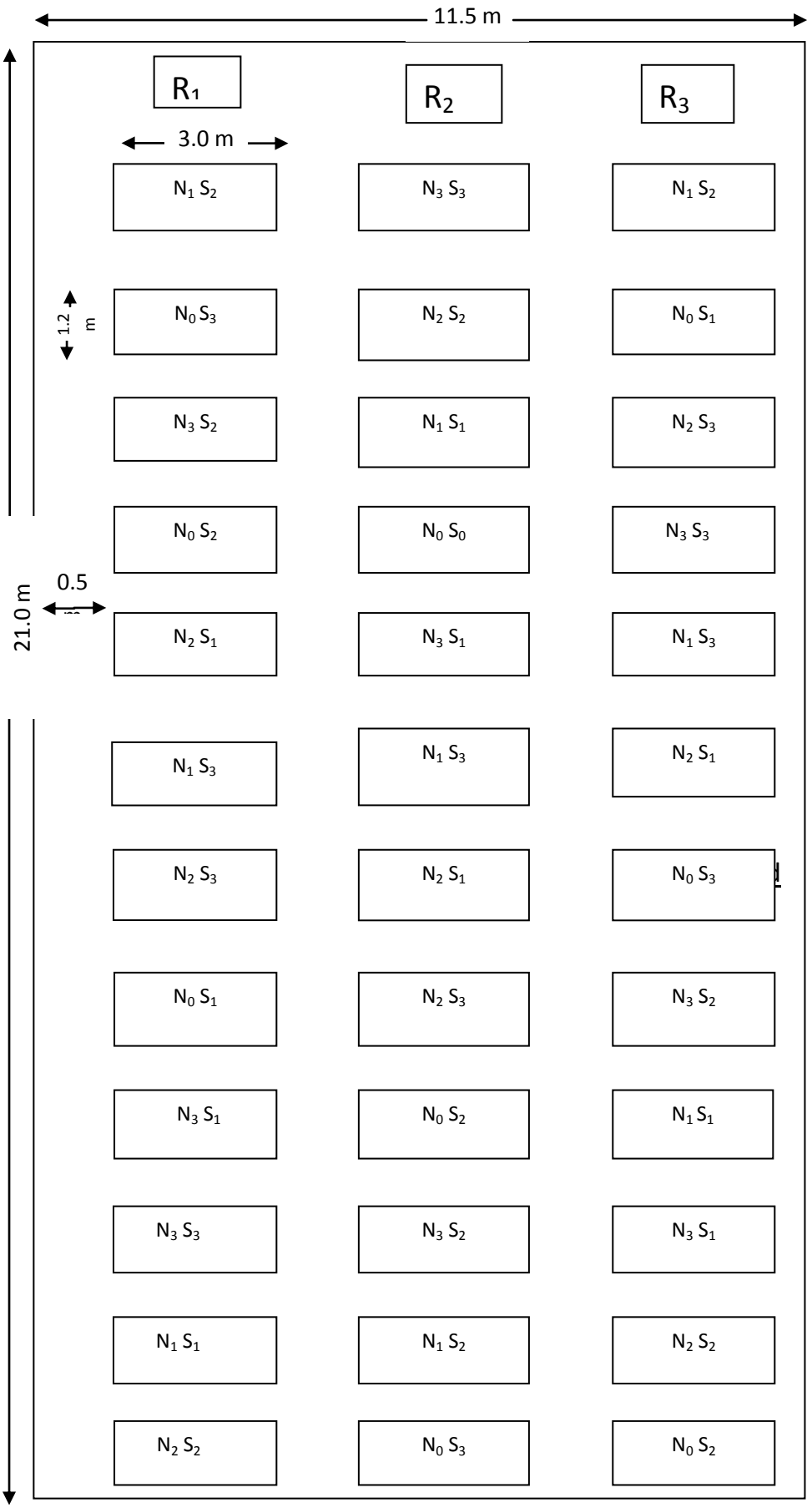
i. S_1 = 20 x 10 cm
ii. S_2 = 25 x 10 cm
iii. S_3 = 30 x 10 cm

A total of 12 treatment combinations are as follows:

N_0 x S_1	N_1 x S_1	N_2 x S_1	N_3 x S_1
N_0 x S_2	N_1 x S_2	N_2 x S_2	N_3 x S_2
N_0 x S_3	N_1 x S_3	N_2 x S_3	N_3 x S_3

3.5 Design and layout of the Experiment

The experiment was laid out in randomized complete block design (RCBD) with 3 replications. The size of unit plot was 3 m x 1.2 m. The total number of treatments was 12 (4 levels of nitrogen × 3 spacing) and the number of plots were 36.



Plot size: 3.0 m × 1.2 m

Factor-A: Nitrogen level

N_0: 0 kg Nha^{-1}

N_1: 40 kg Nha^{-1}

N_2: 80 kg Nha^{-1}

N_3: 120 kg Nha^{-1}

Factor-B: Spacing

S_1: 20 cm x 10 cm

S_2: 25 cm x 10 cm

S_3: 30 cm x 10 cm

Fig. 1. A field layout of the experiment having four nitrogen levels and three spacing

3.6 Land preparation

The land was opened by disc plough 15 days before seeding. 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.

3.7 Fertilizer application

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

Nutrient/Fertilizer	Dose
Cowdung	5 tons ha^{-1}
Nitrogen	treatment wise
Phosphorus	35 kg ha^{-1}
Potassium	67 kg ha^{-1}
Sulphur	20 kg ha^{-1}

The entire amount of cowdung, phosphorus from TSP, and potassium from MP, 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.

3.8 Sowing

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 made as per treatment continuously by hand @ 15 kg/ha (Anon., 2010). To allow uniform sowing in rows seeds were mixed with some loose soil (about four to five 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 on November 25, 2014 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).

3.9 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.

3.9.1 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.

3.9.2 Irrigation

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

3.10 Harvesting

Seeds were harvested when pod colour changed into yellowish brown in colour (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).

3.11 Data collection

Ten (10) plants from each plot were selected as random 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 stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of primary branches plant^{-1}
4. Number of secondary branches plant^{-1}
5. Plant spread (cm)
6. Days to 50% flowering
7. Number of pods plant^{-1}
8. Weight of seed plant^{-1}(g)
9. 1000 seed weight (g)
10. Wight of single pod (g)
11. Number of seeds pod^{-1}
12. Weight seed pod^{-1} (mg)
13. Weight of straw plot^{-1} (kg)
14. Number of plants plot^{-1} at harvest
15. Seed yield plot^{-1} (g)
16. Seed yield (t ha^{-1})

3.11. 1 Plant height (cm)

Plant height was measured five times at 15 days interval such as 35, 50, 65 and 80 days after sowing (DAS). The height of the plant was measured 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.

3.11. 2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted five times at 15 days interval such as 35, 50, 65 and 80 DAS of fenugreek plants. Mean values of data were calculated and recorded.

3.11.3 Number of primary branches plant^{-1}

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

3.11.4 Number of secondary branches plant^{-1}

Average number of branches which were developed from primary branches were calculated and recorded following the same method of 3.11.4.

3.11.5 Plant spread (cm)

At first the measurement was made in centimeter North-South (N-S) direction of the plant canopy of randomly selected ten plants. 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.

3.11.6 Days to 50% flowering

In each plot 10 plants were tagged and dates of first flowering from each tagged ten 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.

3.11.7 Number of pods plant^{-1}

Pods of ten randomly selected plants of each replication were counted and then the average number of fruits for each plant was determined. It was done continued up to final harvesting.

3.11.8 Weight of seeds plant^{-1} (g)

Seed weight plant^{-1}**(g)** was measured by Electric Balance in gram (g). Seeds from ten selected plants from each unit plot were collected and divided by ten to calculate weight of seeds per plant.

3.11.9 1000 seed weight (g)

1000 seed weight was measured by Electric Balance in gram (g). 1000 seed from each treatment were counted then weighed.

3.11.10 Weight of single pod (g)

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

3.11.11 Number of seeds pod^{-1}

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 pod^{-1}.

3.11. 12 Weight of seeds pod^{-1} (g)

Seed weight pod^{-1} was measured by Electric Balance in gram (g). Seeds from each treatment were counted and then weighed.

3.11.13 Weight of straw plot^{-1} (g)

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}.

3.11.14 Number of plant plot^{-1} at harvest

Number of plant was counted during final harvesting of fenugreek plant.

3.11.15 Seed yield plot^{-1} (g)

After maturity seeds of all plants except 10 selected plants were harvested and cleaned. Then seed was measured with electric balance in gram. Then this weight was added to seed weight of 10 selected plants to obtain seed yield plot^{-1}.

3.11.16 Seed yield (kg ha^{-1})

Seed yield plot^{-1} (g) was converted to per hectare yield (t ha^{-1}).

3.12 Statistical analysis

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

Chapter IV

Results and Discussion

CHAPTER IV

RESULT AND DISCUSSION

The result obtained with different levels of nitrogen (N), spacing (S) and their combinations were presented and discussed in this chapter. Data on morphological parameters, yield contributing characters and seed yield of fenugreek were in both Tables and Figures and analyses of variance and corresponding degrees of freedom have been shown in Appendices.

4.1 Plant height (cm)

Different nitrogen (N) levels had significant effect on fenugreek plant height at different days after sowing (DAS) (Fig. 2 and Appendix II). The plant height increased with increasing the age of the plants. The tallest plant (13.3, 18.1, 22.9 and 36.22 cm at 35, 50, 65 and 80 DAS, respectively) was recorded from N_3. In contrast, the smallest plants were recorded from control (N_0) at 35, 50, 65 and 80 DAS and the heights were 8.2, 16.1, 19.1, 27.1 cm, respectively. In previous studies related to fenugreek, Datta *et al.* (2005), Rathore and Manohar (1990), Selverajan and Chezhiyan (2001), Thapa and Maity (2004), Sharma (2000) reported that plant height increased with the increase of nitrogen doses.

Plant height was significantly affected by different plant spacing at DAS (Fig. 3 and Appendix II). Plant height increased with the increase of spacing. The tallest plants (11.3, 17.2, 20.3 and 32.7 cm at 35, 50, 65 and 80 DAS, respectively) were recorded from the wider spacing of S_3 (30 x 10 cm) and the shortest plants (10.3, 16.1, 18.5 and 30 cm at 35, 50, 65 and 80 DAS,

respectively were found in the closer spacing of S_1 (20 x 10 cm). The denser plant population i.e. closer spacing increased the competition for nutrients, space and light that might have resulted in the stunted growth. The plants of wider spacing (30 cm x 10 cm) got optimum nutrients, space and light and hence. the maximum plant height was obtained from this spacing. Verzalova *et al.* (1988) reported that row spacing of fennel did not effect on the plant height. Masood *et al.* (2004) investigated that the maximum plant height were obtained from the lowest row spacing in fennel. But Verzalova *et al.* (1988) reported that row spacing of fennel did not effect on the plant height

Interaction of nitrogen rates and spacing put significant effect on plant height at different DAS (Table 1 and Appendix II).The tallest plants (13.8, 18.9, 23.7 and 37.4 cm at 35, 50, 65 and 80 DAS, respectively) were recorded in N_3S_3 combination. In contrast, the smallest plants were recorded from N_0S_1 combination at 35, 50, 65 and 80 DAS and the plant heights were 7.0, 15.3, 18.5 and 25.5 cm, respectively.

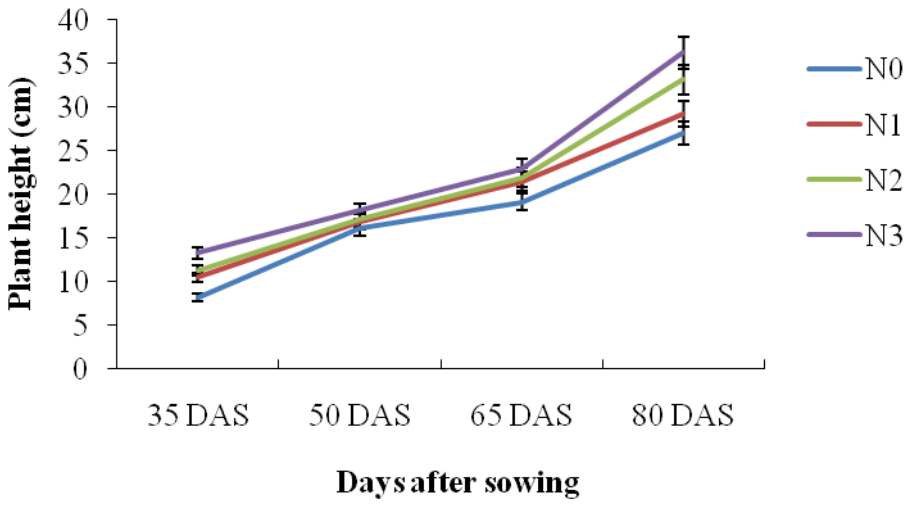


Fig. 2. Effect of different levels of nitrogen at different DAS on the height of fenugreek plant (DAS= Days after sowing, N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, Error bar represents standard deviation).

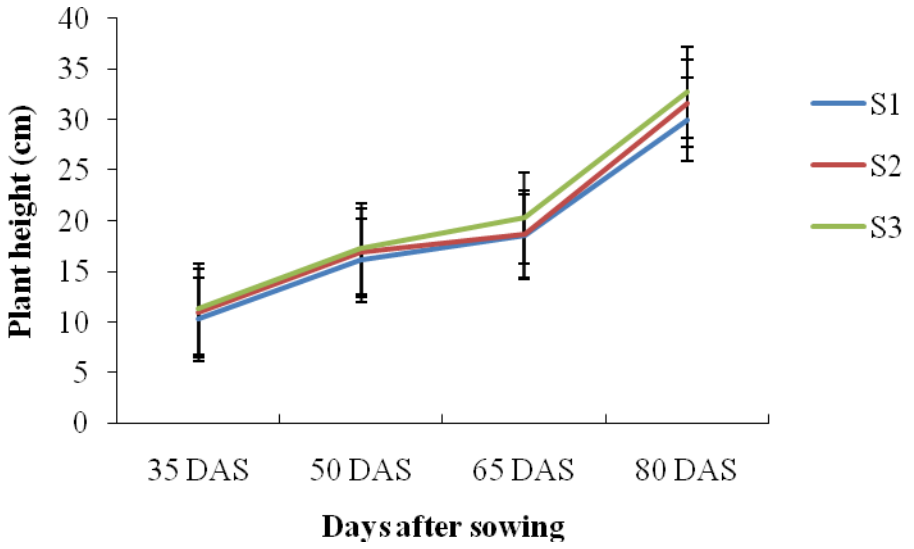


Fig. 3. Effect of different spacing at different DAS on the height of fenugreek plant (DAS = Days after sowing, S_1 = 20 cm x 10 cm, S_2 =25 cm x 10 cm, S_3 = 30 cm x 10 cm, Error bar represents standard deviation).

Table 1. Interaction effect of nitrogen levels and spacing on plant height at different growth stages of fenugreek

Nitrogen levels X Spacing	Plant height (cm) at			
	35 DAS	**50 DAS**	**65 DAS**	**80 DAS**
N_0S_1	7.0 f	15.3 e	18.5 d	25.5 f
N_0S_2	8.3 ef	16.2 de	18.6 d	27.8 e
N_0S_3	9.3 de	16.7 cd	20.3 c	27.8 e
N_1S_1	9.9 cde	16.9 bcd	21.3 bc	27.8 e
N_1S_2	10.3 cd	17.1 bcd	21.2 bc	29.4 de
N_1S_3	11.3 bc	17.0 bcd	21.9 bc	30.6 cd
N_2S_1	11.4 bc	17.6 bc	22.2 ab	31.8 c
N_2S_2	11.7 bc	16.9 bcd	21.5 bc	32.6 c
N_2S_3	10.8 cd	17.2 bcd	21.9 bc	35.0 b
N_3S_1	12.8 ab	17.4 bc	22.6 ab	34.8 b
N_3S_2	13.5 a	17.9 ab	22.6 ab	36.5 ab
N_3S_3	13.8 a	18.9 a	23.7 a	37.4 a
LSD (0.05)	1.80	1.20	1.60	2.16
CV (%)	9.90	4.10	4.50	4.1

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; DAS = Days after sowing

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

4.2 Number of leaves plant^{-1}

The N showed significant variation in the number of leaves per plant at 35, 50, 65 and 80 DAS (F ig. 4 and Appendix III). The maximum number of leaves per plant (24.9, 70.90, 171.2 and 260.6 at 35, 50, 65 and 80 DAS, respectively) was produced by N_3 and not N application produced the lowest number of leaves plant $^{-1}$ (18.56, 54.41, 160.9 and 233.4 at 35, 50, 65 and 80 DAS respectively). It is reported that better growth and development of crop depend on a good number of leaves and producing more foliage in respect of the yield of fenugreek to the seed production and those are linked to use of amount of N fertilizer and suggesting that the greater number of leaf, the greater the photosynthetic area which may result higher seed yield. This is in agreement with the findings of Jagdale and Dalve (2010) who obtained the increased number of leaves in fenugreek plant from the application of 120 kg N ha^{-1}.

Number of leaves per plant was significantly influenced by spacing at 35, 50, 65 and 80 DAS (Fig. 5 and Appendix III). The wider spacing of S_3 (30 x 10 cm) had the highest number of leaves (24.30, 66.98, 170.6 and 256.9 at 35, 50, 65 and 80 DAS, respectively) and the lowest number of leaves plant^{-1} (21.82, 61.53, 158.8 and 228.5 at 35, 50, 65 and 80 DAS, respectively) was obtained from the closer spacing of S_1 (20 x 10 cm). Wider row spacing increased number of leaves plant^{-1} in fenugreek plant because of less competition for food materials. This corroborates the result of Bairagi (2014) who got the maximum number of leaves plant^{-1} from 30 cm row spacing.

Number of leaves plant^{-1} was significantly increased by the interaction between nitrogen levels and spacing (Table 2 and Appendix III). Number of leaves per plant (27.47, 73.80, 177.0 and 255.5 at 35, 50, 65 and 80 DAS, respectively) was found in N3S3 combination closely followed by N^3S^2 combination and the lowest number of leaves plant^{-1} (21.8, 47.20, 154.1 and 208.8 at 35, 50, 65 and 80 DAS, respectively) was recorded inN_0S_1 combination.

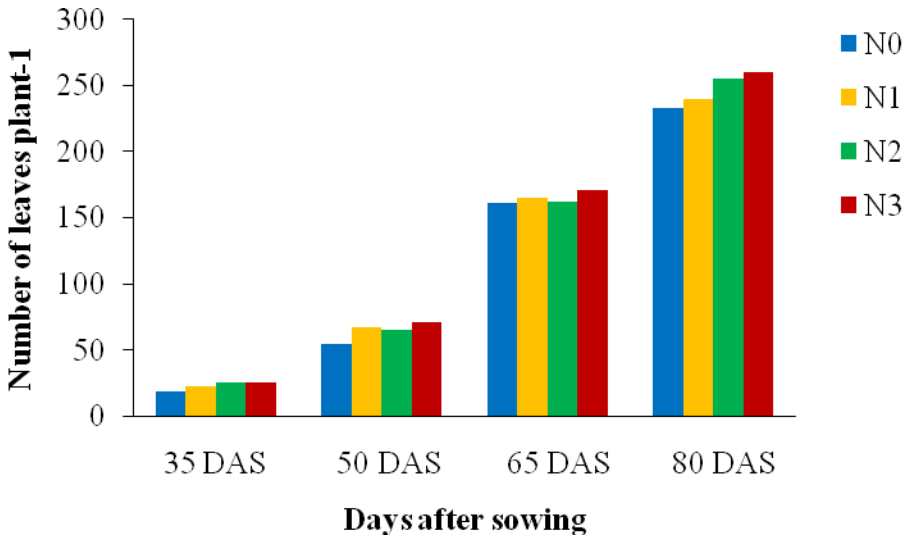


Fig. 4. Effect of different levels of nitrogen at different DAS on number of leaves plant^{-1} (DAS= Days after sowing, N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}).

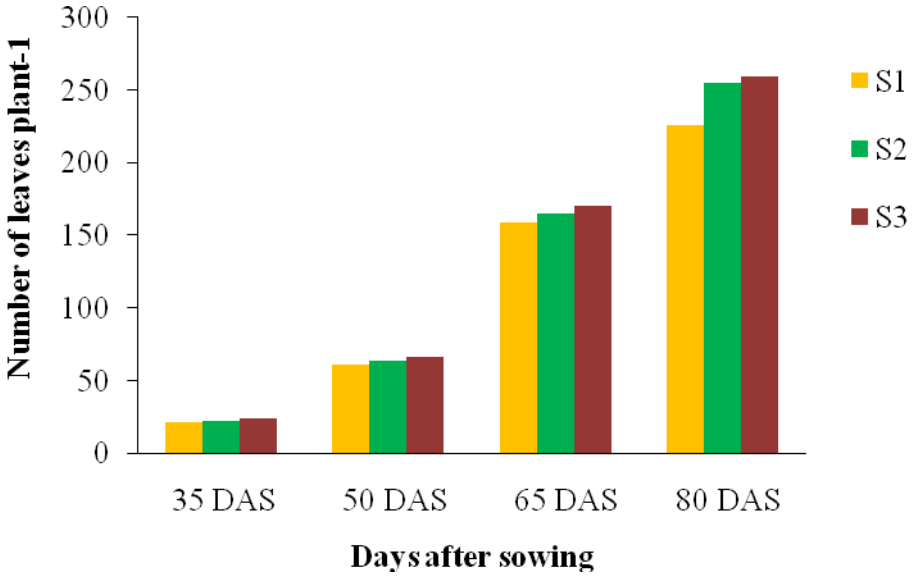


Figure 5. Effect of different spacing at different DAS on number of leaves plant^{-1} (DAS = Days after sowing, S_1 = 20 cm x 10 cm, S_2 =25 cm x 10 cm, S_3 = 30 cm x 10 cm).

Table 2. Interaction effect of nitrogen levels and spacing on number of leaves plant^{-1} at different growth stages of fenugreek

Nitrogen levels X Spacing	Number of leaves plant^{-1} at			
	35 DAS	50 DAS	65 DAS	80 DAS
N_0S_1	21.82 cde	47.20 e	154.1 g	208.8 e
N_0S_2	22.67 bcd	55.50 d	160.4 efg	255.2 abc
N_0S_3	24.30 abc	60.53 cd	167.1 bcd	259.9 ab
N_1S_1	18.56 e	65.57 bc	161.3 def	238.6 d
N_1S_2	18.67 e	67.07 abc	162.2 de	242.5 bcd
N_1S_3	20.07 de	68.07 ab	170.7 abc	253.1 abc
N_2S_1	21.13 cde	65.13 bc	154.4 g	226.5 de
N_2S_2	22.60 bcd	65.40 bc	165.5 cde	253.7 abc
N_2S_3	23.80 bc	65.53 bc	167.5 bcd	256.6 abc
N_3S_1	24.27 abc	68.23 ab	164.3 cde	235.5 cd
N_3S_2	25.33 ab	70.67 ab	172.4 ab	263.7 ab
N_3S_3	27.47 a	73.80 a	177.0 a	265.5 a
LSD (0.05)	3.292	7.235	6.552	21.23
CV (%)	8.48	6.64	2.35	5.07

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; DAS = Days after sowing

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

4.3 Plant spread (cm^2)

Nitrogen (N) levels showed significant effect on fenugreek plant spread at different days after sowing (DAS) (Fig. 6 and Appendix IV). The plant spread increased with increasing the age of the plants. The maximum plant spread (6.62, 6.05, 17.75 and 26.14 cm at 35, 50, 65 and 80 DAS, respectively) was recorded at N_3 (120 kg N ha^{-1}). In contrast, the minimum plant spread was recorded from control (N_0) at 35, 50, 65 and 80 DAS and plant spreads were 3.96, 4.98 , 12.35 and 18.23 cm, respectively. Pramanik (2007) reported that the maximum plant spread was obtained from the highest dose of 260 kg N/ha in cabbage.

Plant spread was significantly affected by different plant spacing at DAS (Fig. 7 and Appendix IV). Plant spread increased with increasing levels of spacing. The highest plant spread (5.386, 7.470, 15.94 and 22.65 cm at 35, 50, 65 and 80 DAS, respectively) was produced from the wider spacing of S_3 (30 x 10 cm) that was statistically similar with medium spacing of S_2 (25 cm x 10 cm) at 50 DAS and S_2& S_1at 65 DAS. The lowest plant spread (3.96, 6.6, 15.03 and 21.07 cm at 35, 50, 65 and 80 DAS, respectively) was found in the closer spacing of S_1 (20 x 10 cm).

The plant spread was significantly influenced by the interaction between nitrogen levels and spacing (Table 3 and Appendix IV).The maximum plant spread (7.117, 10.51 , 18.01 and 27.06 cm^2 at 35, 50, 65 and 80 DAS, respectively) was recorded in N_3S_3 closely followed by N_3S_3 at 50, 65 and 85 DAS, N_3S_1 at 35 DAS. In contrast, the minimum plant spread was recorded in N_0S_1 at 35, 50, 65 and 80 DAS and 3.33, 4.98, 10.4 and 17.27 cm, respectively that was statistically similar with N_0S_2 at 35, 50, 80 DAS .

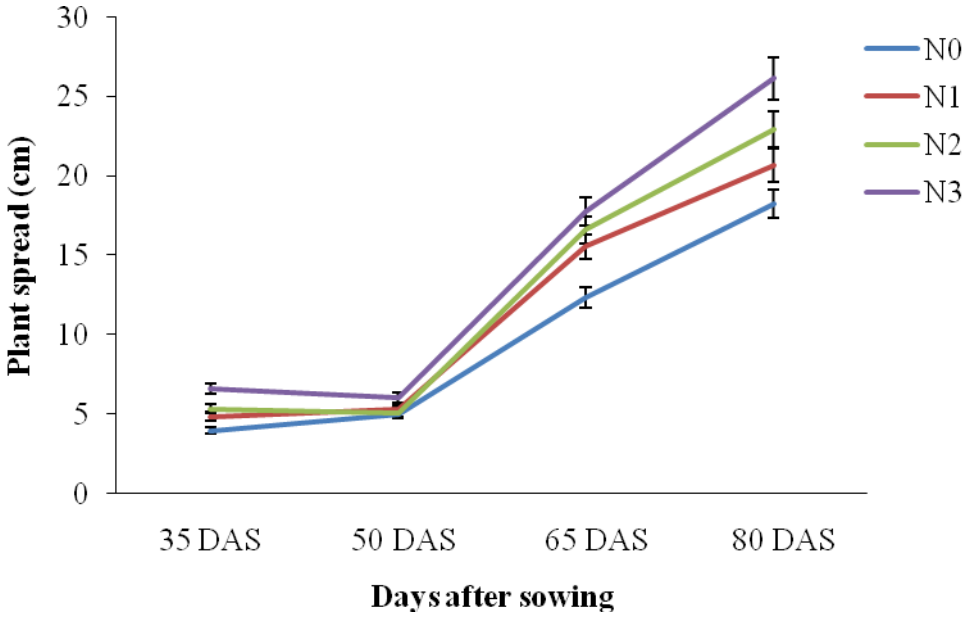


Figure 6. Effect of different levels of nitrogen at different DAS on plant spread (cm) (DAS= Days after sowing, N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, Error bar represents standard deviation).

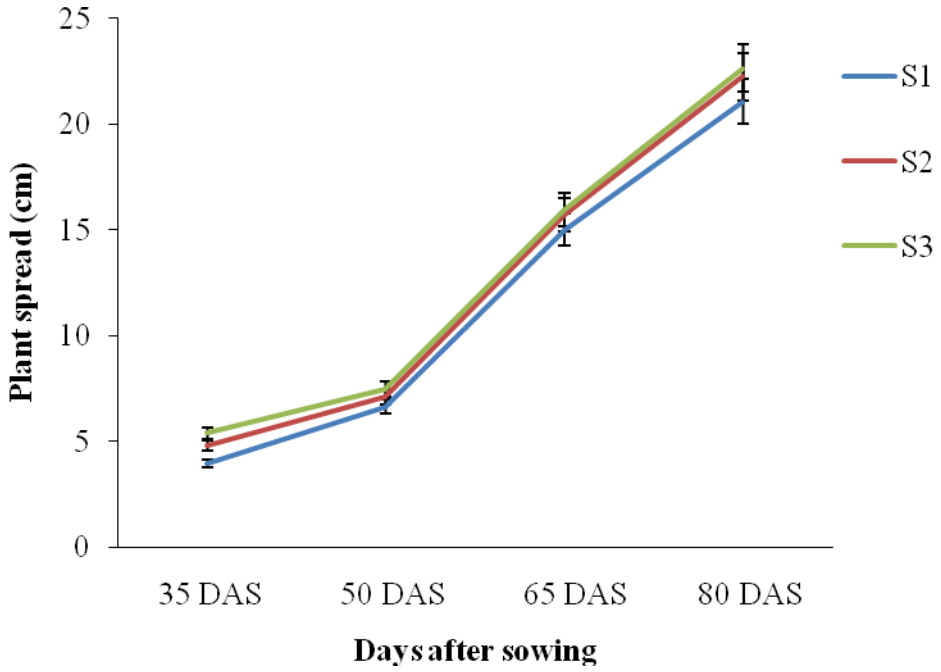


Figure 7. Effect of different spacing at different DAS on plant spread (cm) (DAS = Days after sowing, S_1 = 20 cm x 10 cm, S_2 =25 cm x 10 cm, S_3 = 30 cm x 10 cm; Error bar represents standard deviation).

Table 3. Interaction effect of nitrogen levels and spacing on plant spread at different growth stages of fenugreek

Nitrogen levels X Spacing	Plant Spread (cm)			
	35 DAS	50 DAS	65 DAS	80 DAS
N_0S_1	3.333 d	4.987 f	10.42 d	17.27 g
N_0S_2	3.920 d	5.297 ef	13.11 c	18.48 fg
N_0S_3	4.640 c	5.107 ef	13.52 c	18.93 fg
N_1S_1	4.753 c	6.047 def	15.64 b	19.36 ef
N_1S_2	4.833 c	6.220 de	15.48 b	21.25 de
N_1S_3	4.827 c	6.577 cd	15.49 b	21.40 d
N_2S_1	5.033 c	7.040 bcd	16.46 ab	22.70 d
N_2S_2	5.167 c	7.203 bcd	16.58 ab	22.82 d
N_2S_3	5.957 b	7.683 bc	16.74 ab	23.20 cd
N_3S_1	6.533 ab	8.147 b	17.60 a	24.94 bc
N_3S_2	6.207 b	9.973 a	17.63 a	26.42 ab
N_3S_3	7.117 a	10.51 a	18.01 a	27.06 a
LSD(0.05)	0.62	1.20	1.90	1.98
CV(%)	7.01	10.11	7.25	5.34

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; DAS = Days after sowing

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

Plate 1. Photograph shows the fenugreek grown with N_3S_3 treatment combination (120 kg N/ha and 30 cm x 10 cm).

Plate 2. Photograph shows the fenugreek grown with N_0S_1 treatment combination (without N and 20 cm x 10 cm).

4.4 Number of Primary branches plant^{-1}

Different levels of N had significant effect on number of primary branches plant^{-1} (Fig. 8 anAppendix V). The maximum number of primary branches plant^{-1} (4.7) was obtained from 120 kg N/ha (N_3). Control treatment produced the minimum number of branches plant^{-1} (3.89). Tomar *et al.* (1996), Tomar and Mishra (1991)), Ali and Ullah (1995) also obtained the highest number of branches plant^{-1} from the application of 120 kg N ha^{-1} in mustard.

Spacing influenced significantly on number of primary plant^{-1} (Fig. 9 and Appendix V). The highest number of primary branches plant^{-1} (4.1) was obtained from the wider spacing of S_3 (30 x 10 cm) and the lowest number of primary branches plant^{-1} (3.6) was obtained from the closer spacing of S_1 (20 cm x 10 cm). Kumar *et al.* (2007) stated that the highest number of primary branches plant^{-1} was found from the density of 10 plants m^{-2} treatment (wider spacing). Khorshidi *et al.* (2009) reported that the increase in inter-plant space increased significantly primary branches plant^{-1}.

Interaction between N rates and spacing put significant effect on the number of primary and secondary branches plant^{-1} (Table 4 and Appendix V). The maximum number of primary branches plant^{-1} (5.3) was obtained from N_3S_3 combination closely followed by N_3S_2. The lowest number of primary branches plant^{-1} (2.9) was found in N_0S_1 that was statistically similar with N_0S_2 and N_0S_3 treatment combinations.

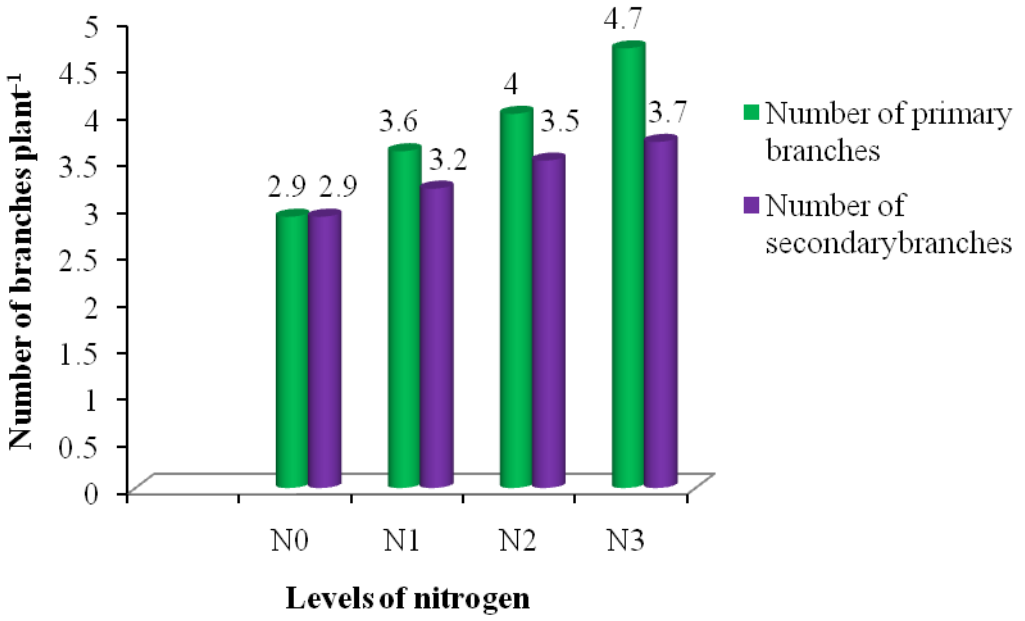


Fig. 8. Effect of different levels of nitrogen on number of primary and secondary branches plant^{-1}(DAS = Days after sowing, N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}). $LSD_{0.05}$ = 0.50 for secondary branches and 0.30 for primary branches.

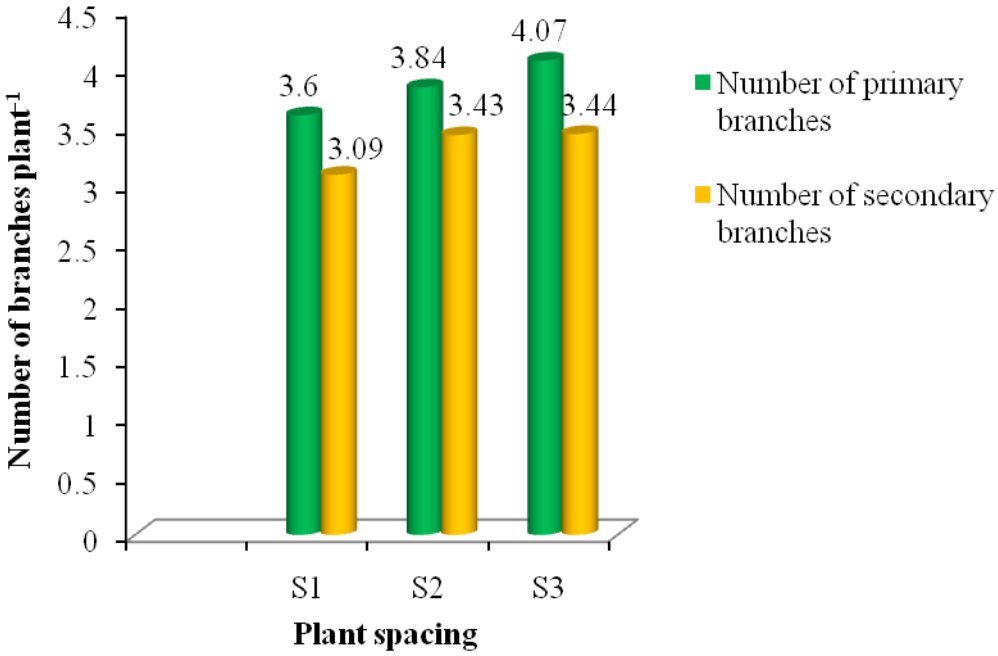


Fig. 9. Effect of different spacing on number of primary and secondary branches plant^{-1} (DAS = Days after sowing, S_1 = 20 cm x 10 cm, S_2 =25 cm x 10 cm, S_3 = 30 cm x 10 cm). $LSD_{0.05}$ = 0.39 for secondary branches and 0.32 for primary branches.

4.5 Number of secondary branches plant^{-1}

Number of secondary branches plant^{-1} among was significantly influenced by different nitrogen levels (Figure 8 and Appendix V). Secondary branches plant^{-1}(3.7) was found maximum from N_3 that was statistically similar with N_2, while the nitrogen level N_0 produced the lowest number of secondary branches plant^{-1} (2.9). Similar results have also been reported by Datta *et al.* (2005) and Thapa and Maity (2004).

Spacing significantly influenced the number of secondary branches plant^{-1} (Fig. 9 and Appendix V). Increase of spacing increased the number of secondary branches plant^{-1} significantly. The wider spacing of 30 cm x 10 cm produced the highest number of branches plant^{-1} (3.44) that was similar with medium spacing of 25 cm x 10 cm. The closer spacing (20 cm x10 cm) produced the lowest number of secondary branches plant^{-1} (3.09). The wider row spacing produced higher number of secondary branches plant^{-1} which might be due to less inter-plant competition for light, space nutrients and environmental resources. Rahman (2000) obtained secondary branches per plant ranged from 15.85 to 25.50 and the maximum was found from 30cm x10 cm spacing in Bilatidhonia (*Eryngium foetidum* L.). Khorshidi *et al*. (2009) reported that increase in inter-plant space increased number of secondary branches plant^{-1} significantly.

Number of secondary branches plant^{-1} was significantly influenced by the interaction of nitrogen levels and spacing (Table 4 and Appendix V). The maximum number of secondary branches plant^{-1} (3.8) was produced from N_3S_3 which was statistically similar with all combinations except $N_0S_1$and N_1S_3. The lowest number of branches plant^{-1} (2.1) was produced from N_0S_1combination.

Table 4. Interaction effect of nitrogen levels and spacing on number of primary and secondary branches plant^{-1} of fenugreek at harvest

Nitrogen levels X Spacing	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}
N_0S_1	2.9 d	2.1 c
N_0S_2	2.9 d	3.2 ab
N_0S_3	3.1 d	3.3 ab
N_1S_1	3.4 cd	3.3 ab
N_1S_2	3.5 cd	3.3 ab
N_1S_3	3.9 c	3.1 b
N_2S_1	4.0 bc	3.3 ab
N_2S_2	4.1 bc	3.5 ab
N_2S_3	4.0 bc	3.5 ab
N_3S_1	4.1 bc	3.7 ab
N_3S_2	4.8 ab	3.7 ab
N_3S_3	5.3 a	3.8 a
LSD (0.05)	0.80	0.60
CV (%)	12.3	11.6

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; DAS = Days after sowing

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

4.6 Days to 50 % flowering

Significant variation was observed among the different levels of nitrogen in respect of days to 50 % flowering at different days after sowing (DAS) (Table 5 and Appendix VI). The longest period was required for 50 % flowering in N_3 (120 kg N ha^{-1} (54.4 days) closely followed by N2 (53.56 days) while the shortest period in control (N_0) (50.22 days) (Table 5). The result showed that N_0 promoted early flowering, whereas N_3 caused late flowering. Early flowering reduced crop duration. Jagdale and Dalve (2010) obtained maximum days required to 50 % flowering from the application of 120 kg N ha-1 while shortest period from without nitrogen. Moosavi *et al*. (2012) also found that increased N rate caused late flowering.

Days to 50 % flowering were not significantly affected by spacing (Table 6 and Appendix VI). However, days to 50 % flowering was recorded maximum in wider spacing of 30 cm x 10 cm (S_3) (53.00 days) and minimum days in closer spacing of 20 cm x 10 cm (S_1).

Combination of nitrogen fertilizer dose and spacing affected days to 50% flowering (Table 7 and Appendix VI). The treatment combination N_3S_3 took maximum days to 50% flowering (55.0 days) that was identical with N_2S_1, N_2S_2, N_2S_3, N_3S_1 and N_3S_2 whereas N_0S_1 and N_0S_2 treatment combinations took minimum period (50.0 days) to reach 50 % flowering stage (Table 7). Moosavi *et al*. (2012) found that application of 150 kg N ha^{-1} coupled with 60 plant m^{-2} caused late flowering in fenugreek.

4.7 Number of pods $plant^{-1}$

Different levels of nitrogen showed significant variation on pods $plant^{-1}$ (Table 5 and Appendix VI). The highest number of pods $plant^{-1}$ (42.0) was observed in N_3 (120 kg/ha) followed by N_2 and N_1 (Table 5). There was no significant difference between N_2 and N_1 in respect of number of pods $plant^{-1}$. The lowest

number of pods plant^{-1} (23.5) was found from N_0. Moosavi *et al.* (2012) obtained the maximum number of pods plant^{-1} at 150 kg N ha^{-1}, but Sharma (2000) and Halesh *et al.* (2000) obtained the highest number of pods plant^{-1} from the application of 60 kg N ha^{-1} in fenugreek. Sharma and Jam (2002) reported that the highest number of pods plant^{-1} was obtained from the higher nitrogen doses (80 kg N ha^{-1}) in mustard.

Number of pods plant^{-1} differed significantly due to variation of spacing and as the spacing increased, number of pods plant^{-1} increased significantly (Table 6 and Appendix VI). The maximum number of pods plant^{-1} (36.1) was found from the wider spacing of 30 cm x 10 cm (S_3) followed by medium spacing of 25 cm x 10 cm (S_2) (34.6) and the lowest number (27.9) was found from 20 cm x 10 cm spacing (S_1). Wider spacing produced more number of pods plant^{-1} than closer spacing mainly because of the fact that wider spacing facilitated maximum utilization of solar energy as well as other environmental resources which helped in producing more dry matter plant^{-1}. Ghobadi and Ghobadi (2010) reported that number of umbels plant^{-1} increased with the decreased plant density i.e. increased plant spacing.

Number of pods plant^{-1} was significantly influenced by the interaction of nitrogen levels and spacing (Table 7 and Appendix VI). The maximum number of pods plant^{-1} (43.3) was obtained from N_3S_3 combination which was statistically similar with N_3S_2 combination. The lowest number of pods plant^{-1} was recorded from N_0S_1 combination. The increase in pod number plant^{-1} as affected by 150 kg N ha^{-1} and spacing could be associated with the positive effect of the fertilization on pod number was reported by Moosavi *et al.* (2012). Zandi *et al*. (2011) also observed maximum number of pods plant^{-1} was found from the combination of the highest dose of N @ 75 kg ha-1 and the lowest plant density i.e. wider spacing.

4.8 Weight of single pod (g)

Different levels of nitrogen showed significant variation in weight of single pod (Table 5 and Appendix VI). The maximum single pod weight (4.54 g) was obtained from N_3 (120 kg/ha) which was closely followed by N_2 (80 kg N ha^{-1}) N_1 (40 kg N ha^{-1}) and the minimum weight (3.5 g) was found in N_0 (control) (Table 5).

The weight of single pod $plant^{-1}$ differed significantly due to variation in spacing and as the spacing increased, the weight of single pod increased significantly (Table 6 and Appendix VI). The maximum weight of single pod (4.6 g) was found from the wider spacing of 30 cm x 10 cm (S_3) and the lowest weight (3.7) was found from the closer (20 cm x 10 cm) spacing (S_1).

Single pod weight (g) was significantly influenced by the interaction of nitrogen levels and spacing (Table 7 and Appendix VI). The maximum weight of single pod (5.1g) was obtained from N_3S_3 combination closely followed by N_3S_2, N_2S_3 and N_1S_3 combinations (Table 7). The lowest weight of single pod (2.5 g) was obtained from N_0S_1 combination. Moosavi *et al*. (2012) observed that interaction of N rate and plant density increased weight of single pod.

4.9 Number of seeds pod^{-1}

Different levels of nitrogen significantly influenced number of seeds pod^{-1} (Table 5 and Appendix VI). The highest number of seeds pod^{-1} (14.0) was observed in N_3 (120 kg/ha) which was identical with N_2(13.4).The lowest number (13.6) was found from N_0 (Table 5). Similar results were reported by Datta *et al*. (2005) who reported that the number of seeds in pod of fenugreek increased with increasing nitrogen levels. This is in agreement with the findings of Anon. (2015).

Spacing significantly influenced the number of seeds pod^{-1} (Table 6 and Appendix VI). Increase of spacing increased the number of seeds pod^{-1}. The wider spacing of S_3 (25 cm x 10 cm) produced the highest number of seeds pod^{-1} (13.5) and the lowest number of seeds pod^{-1} (11.6) was recorded in closer spacing of S_1(20 cm x 10 cm). Bhandari and Gupta (1993) obtained the maximum number of seeds per umbel from the wider spacing..

Number seeds pod^{-1} was significantly influenced by the interaction of nitrogen levels and spacing (Table 7 and Appendix VI). The maximum number of seeds pod^{-1} (15.1) was obtained from N_3S_3 combination closely followed by N_2S_2 and N_3S_2 combinations. The lowest number of seeds pod^{-1}(10.7) was produced by N_0S_1 combination. Zandi *et al*. (2011) observed that number of seeds per pod increased with combination of 75 kg N ha^{-1} and 100 plants m^{-2}.

4.10 Weight of seeds plant^{-1} (g)

Nitrogen levels significantly influenced weight of seeds plant^{-1} (Table 5 and Appendix VI). The maximum weight of seeds plant^{-1} (3.56 g) was observed in N_3 (120 kg ha^{-1}) which was closely followed by N_2 (80 kg ha^{-1}) and the minimum weight of seeds (2.50 g) was found in N_0 (control) (Table 5).

The weight of seeds plant^{-1} differed significantly due to variation of spacing and as the spacing increased, the weight of seeds plant^{-1} increased significantly (Table 5). The maximum weight of seeds plant^{-1} (3.18 g) was found from the wider spacing of S_3 (30 cm x 10 cm) and the lowest (2.68) was found from the closer spacing of S_1 (20 cm x 10 cm) which was similar with medium spacing of S_2 (25 cm x 10 cm). The fenugreek plants enjoyed more space, light and nutrient and other environmental factors that resulted higher weight of seeds plant for wider spacing compared to closer spacing. this implies that an intra-

row spacing of 30 cm x 10 cm was best for a seed crop of fenugreek and beyond that was ineffective and not beneficial. Similar kinds of result have also been reported by Tuncturk (2011), Gowada *et al*. (2006), Singh *et al*. (2005), Basu *et al*. (2004) and Yadav *et al.* (2000).

Seed weight plant^{-1} (g) was significantly influenced by the interaction of nitrogen levels and spacing (Table 7 and Appendix VI). The maximum seed weight plant^{-1} (3.9 g) was obtained from the interaction of N_3 (120 kg/ha) and 30 cm x10 cm spacing which was followed by N_3S_2 combination. The lowest weight of seeds plant^{-1} (2.43 g) was obtained from N_0S_1 combination. Zandi *et al.* (2011) reported that seed weight per plant increased with nitrogen 75 kg ha^{-1} with spacing combination. Nitrogen levels might be attributed to the increased photosynthetic activities, translocation and accumulation of photo-syntheses from source to the developing seeds (sinks)resulting into higher seed yield of bolder and heavier seeds. These results are in agreement with the findings of Datta *et al*. (2005) in fenugreek.

Table 5. Effect of nitrogen levels on days to 50 % flowering, number of pods plant^{-1}, weight of single pod, number of seeds pod^{-1} and weight of seeds plant^{-1}

Levels of nitrogen	Days to 50 % flowering	No. of pods plant^{-1}	Weight of single pod (g)	No. of seeds pod^{-1}	Weight of seeds plant^{-1} (g)
N_0	50.22 c	23.5 c	3.10 b	11.3 b	2.50 c
N_1	52.11 b	33.1 b	4.11 a	11.6 b	2.73 bc
N_2	53.56 a	32.9 b	4.25 a	13.4 a	3.01 ab
N_3	54.44 a	42.0 a	4.54 a	14.0 a	3.36 a
LSD (0.05)	1.08	0.80	0.43	0.80	0.35
CV (%)	2.11	2.80	11.20	7.10	12.60

N_0 = control, N_1 = 40 kg ha^{-1}, N_2 = 80 kg ha^{-1}, N_3 = 120 kg ha^{-1}

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

Table 6. Effect of nitrogen levels on number of pods plant^{-1}, weight of single pod, number of seeds pod^{-1} and weight of seeds plant^{-1}

Spacing	Days to 50% flowering	No. of pods plant^{-1}	Weight of single pod (g)	No. of seeds pod^{-1}	Weight of seeds plant^{-1} (g)
S_1	52.33 a	27.9 c	3.5 c	11.6 c	2.68 b
S_2	52.42 a	36.1 a	3.9 b	13.5 a	2.83 b
S_3	53.00 a	34.6 b	4.6 a	12.6 b	3.18 a
LSD (0.05)	0.94	0.80	0.37	0.80	0.30
CV (%)	2.11	2.8	11.2	7.1	12.60

S_1 = 20 x 10 cm), S_2 = 25 x 10 cm), S_3 = 30 x 10 cm

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

Table 7. Interaction effect of nitrogen levels and spacing on days to 50% flowering, number of pods plant^{-1}, weight of single pod, number of seeds pod^{-1} and weight of seeds plant^{-1}

Nitrogen levels X Spacing	Days to 50% flowering	No. of pods plant^{-1}	Weight of single pod (g)	No. of seeds pod^{-1}	Weight of seeds plant^{-1} (g)
N_0S_1	50.0 e	17.5 i	2.5 f	10.7 f	2.43 d
N_0S_2	50.0 e	27.3 g	3.4 e	11.7 cdef	2.47 cd
N_0S_3	50.7 de	25.6 h	3.4 e	11.6 def	2.60 bcd
N_1S_1	52.0 cd	24.3 h	3.7 de	10.9 ef	2.53 cd
N_1S_2	52.0 cd	38.6 c	3.8 cde	12.2 cde	2.63 bcd
N_1S_3	52.3 bcd	36.3 d	4.8 ab	11.8 cdef	3.03 bcd
N_2S_1	53.3 abc	29.4 f	3.6 de	12.0 cdef	2.77 bcd
N_2S_2	53.3 abc	35.3 de	4.2 bcd	14.9 a	3.07 bc
N_2S_3	54.0 ab	34.3 e	4.9 ab	13.2 bc	3.20 b
N_3S_1	54.0 ab	40.4 b	4.0 cde	13.0 bcd	3.00 bcd
N_3S_2	54.3 a	43.3 a	4.5 abc	15.1 a	3.17 b
N_3S_3	55.0 a	42.3 a	5.1 a	14.0 ab	3.90 a
LSD (0.05)	1.9 0	1.60	0.75	1.50	0.61
CV (%)	2.11	2.8	11.2	7.1	12.6

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; DAS = Days after sowing

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

4.11 1000 seed weight (g)

Different nitrogen levels had significant effect on 1000 seed (Table 8 and Appendix VII). The highest 1000 seed weight (7.7 g) was found in N_3 (120 kg ha^{-1}) which was closely followed by N_1 and N_2. The lowest 1000 seed weight (6.6 g) was obtained from N_0 (Table 8). Thousand-seed weight (14.4 g) was obtained from increasing nitrogen levels up to 50 kg N ha^{-1} (Thapa and Maity, 2004). Moosavi *et al*. (2012) stated that N levels of 75 and 150 kg N ha^{-1}had no significant effect on 1000 seed weight (9.41 and 9.74 g). Khan (1993) reported that application of 120 kg N ha^{-1} produced the highest 1000-seed weight in black cumin.

Spacing showed significant variation in 1000 seed weight (Table 9 and Appendix VII). The wider spacing of 30 cm x 10 cm (S_3) gave the highest 1000 seed weight (7.69 g) that was identical with that of medium spacing of (25 cm x 10 cm). The lowest 1000 seed weight (6.91 g) was found from 20 x 10 spacing. But Ghobadi and Ghobadi (2010) reported that no significant difference was observed in 1000-fruit weight due to variation in spacing.

The fenugreek responded differently to different levels of nitrogen fertilizer with spacing in respect of 1000 seed weight (Table 10 and Appendix VII). The highest 1000 seed weight (8.07 g) was found from N_3S_3 closely followed by N_1S_2, N_1S_3, N_2S_2,N_2S_3, N_3S_1 and N_3S_2 combinations. The lowest 1000 seed weight was obtained from N_0S_1 combination. Moosavi *et al.* (2012) reported that 1000 seed weight was increased by combination of nitrogen and spacing.

4.12 Weight of seeds pod^{-1} (g)

Nitrogen levels significant variation on weight of seed pod^{-1} (Table 8 and Appendix VII). The maximum weight of seed pod^{-1} (100.9 g) was obtained from N_3 (120 kg ha^{-1}) which was closely followed by N_2 (80 kg ha^{-1}) (100.7 mg) and the minimum (74.0 mg) was found in N_0 (control) (Table 8).

The weight of seed pod^{-1} differed significantly due to variation of spacing and as the spacing increased the weight of seed pod^{-1} also increased significantly (Table 9 and Appendix VII). The maximum weight of seeds pod^{-1} (99.0 mg) was found from the wider spacing of 30 cm x 10 cm followed by spacing 25 cm x 10 cm. and the lowest (80.1 mg) was found from the closer spacing 20 cm x 10 cm spacing

Seed weight pod $^{-1}$ was significantly influenced by the interaction of nitrogen levels and spacing (Table 10 and Appendix VII). The maximum seed weight pod^{-1} (116.8 mg) was produced by the interaction of N_3 (120 kg/ha) with 30 cm x10 cm spacing which was similar with N_3S_2 combination. The lowest weight of seed (62.7 mg) pod^{-1} was produced by the interaction of nitrogen (0 kg/ha) with 20 cm x10 cm spacing. Zandi *et al.* (2011) obtained that seed weight per pod increased with nitrogen 75 kg ha^{-1} with spacing combination.

4.13 Weight of straw plot^{-1}(kg)

Nitrogen levels showed significant variation on weight of straw plot^{-1} (Table 8 and Appendix VII). The maximum weight of straw plot^{-1} (0.37kg) was observed from N_3 (120 kg ha^{-1}) which was closely followed by N_2 (80 kg ha^{-1}) and the minimum (0.23 g) was found in N_0 (control) (Table 8). Moosavi *et al.* 2012) obtained maximum straw yield from 150 kg N ha^{-1}.

Spacing had a significant effect on weight of straw plot^{-1} (kg) (Table 9 and Appendix VII).The highest weight of straw plot^{-1} (0.34 kg) was found from the wider spacing of 30 cm x 10 cm followed by the medium spacing of 25 cm x 10 cm and the lowest weight of straw plot^{-1} (0.27 kg) was recorded from the closer spacing of 20 cm x 10 cm. Moosavi *et al.* 2012) got identical straw yield from 22, 33 and 66 plants m^{-2}.

There was a significant difference in straw weight (kg) plot^{-1} due to nitrogen levels and spacing interaction (Table 10 and Appendix VII). The highest straw weight (kg) plot^{-1} (0.39 kg) was found from the treatment combination of Nitrogen 120 kg ha^{-1} with 30 cm x10 cm spacing closely followed by N_3S_2, N_3S_1, N_2S_3 and the lowest straw weight (0.18 kg) plot^{-1} was found from the treatment combination of without nitrogen with 20 cm x 10 cm spacing closely followed by N_0S_2.

4.14 Number of plants plot^{-1} at harvest

Different levels of N had significant effect on number of plants plot^{-1} at harvest (Table 8, Appendix VII). The maximum number of plants (122.3 plot^{-1}) was recorded in 120 kg N/ha (N_3) which was statistically similar with N_2 (80 kg ha^{-1}) and N_1 (40 kg ha^{-1}). Control condition reduced number of plants plot^{-1} (120.3) at harvest.

Spacing significantly influenced the number of plants plot^{-1} (Table 9 and Appendix VII). Closer spacing of S_1 (20 cm x 10 cm) increased the number of plants plot^{-1} significantly. The highest number of plants plot^{-1} (147.7) was recorded from closer spacing of (20 cm x 10 cm) and the lowest number of plants plot^{-1} (98.42) from the wider spacing of (30 cm x 10 cm) at harvest.

Table 8. Effect of nitrogen levels on 1000 seed weight, weight of seeds pod^{-1}, weight of straw plot^{-1} and Number of plant plot^{-1} at harvest

Levels of nitrogen	1000 seed weight (g)	Weight of seeds pod^{-1} (mg)	Weight of straw (kg) plot^{-1}	Number of plants plot^{-1} at harvest
N_0	6.556 b	74.0 b	0.227 c	120.3 b
N_1	7.467 a	86.6 b	0.297 b	121.1 ab
N_2	7.517 a	100.7 a	0.344 a	121.9 a
N_3	7.711 a	100.9 a	0.368 a	122.3 a
LSD (0.05)	**0.43**	**13.9**	**0.031**	**1.30**
CV (%)	**5.4**	**8.6**	**10.9**	**1.10**

N_0 = control, N_1 = 40 kg ha^{-1}, N_2 = 80 kg ha^{-1}, N_3 = 120 kg ha^{-1}
In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 9. Effect of nitrogen levels on number of 1000 seed weight, weight of seeds pod^{-1}, weight of straw plot^{-1} and Number of plant plot^{-1} at harvest

Spacing	1000 seed weight (g)	Weight of seed pod^{-1} (mg)	Weight of straw plot^{-1}(kg)	Number of plant plot^{-1} at harvest
S_1	6.908 b	80.1 c	0.268 c	147.7 a
S_2	7.338 a	96.9 b	0.316 b	118.2 b
S_3	7.692 a	99.0 a	0.344 a	98.42 c
LSD (0.05)	0.37	1.88	0.026	1.13
CV (%)	5.4	8.6	10.9	1.10

S_1 = 20 x 10 cm, S_2 = 25 x 10 cm, S_3 = 30 x 10 cm
In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 10. Interaction effect of nitrogen levels on 1000 seed weight, weight of seeds pod^{-1}, weight of straw plot^{-1} and number of plants plot^{-1} at harvest

Nitrogen levels X Spacing	1000 seed weight (g)	Weight of seeds pod^{-1}	Weight of straws plot^{-1}	Number of plants plot^{-1} at harvest
N_0S_1	5.867 e	62.7 h	0.18 d	147.0 a
N_0S_2	6.667 d	75.6 g	0.23 cd	117.0 b
N_0S_3	7.133 bcd	78.0 fg	0.26 c	97.0 d
N_1S_1	6.933 cd	82.7 efg	0.21 d	147.3 a
N_1S_2	7.400 ad	96.3 cd	0.34 b	117.7 b
N_1S_3	8.067 a	95.20 cd	0.35 ab	98.3 cd
N_2S_1	7.233 bcd	85.4 ef	0.33 b	148.0 a
N_2S_2	7.550 abc	90.6 de	0.34 b	119.0 b
N_2S_3	7.767 ab	102.5 bc	0.37 ab	98.7 cd
N_3S_1	7.600 abc	98.8 c	0.35 ab	148.3 a
N_3S_2	7.733 ab	109.2 ab	0.36 ab	119.0 b
N_3S_3	7.800 ab	116.8 a	0.39 a	99.7 c
LSD (0.05)	0.75	0.61	0.053	2.26
CV (%)	5.4	8.6	10.9	1.10

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; Plot area = 3.6 m^2

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

The interaction of nitrogen levels and spacing put significant effect on number of plants plot^{-1} at harvest (Table 10 and Appendix VII). The highest plant population (148.3) was found from N_3S_1 closely followed by N_0S_1, N_1S_1, N_2S_1 (Table 10). The lowest plants plot^{-1} (97.0) was found from N_0S_3 combination closely followed by N_1S_3 and N_2S_3 combinations.

4.15 Seed yield plot^{-1} (g)

Different levels of nitrogen had significant effect on seed yield plot^{-1} (3.6 m^{-2}) (Fig. 10 and Appendix VIII). The highest seed yield per plot (284.1 g) was observed in N_3 (120 kg/ha) and the lowest (147.3 g) was found in N_0 (control) (Fig. 10).

Spacing had significant effect on seed yield plot^{-1} (Fig. 11 and Appendix VIII). The highest seed yield (238.7 g) was found from the wider spacing of 30 cm x 10 cm and the lowest seed yield (200.1 g) was recorded from the closer spacing spacing of 20 cm x 10 cm. In wider spacing all the fenugreek plants of each plot received more nutrients, space, light and other resources due to which plot yield increased.

There was a significant difference in seed yield (g plot^{-1}) due to levels of nitrogen and spacing interaction (Table 11 and Appendix VIII). The highest seed yield (288.6 g plant^{-1}) was obtained from the treatment combination of N_3S_3 closely followed by N_3S_2, N_3S_1 and N_2S_3 combinations and the minimum seed yield (120.7 g plant^{-1}) was found from the treatment combination of without nitrogen with 20 cm x 10 cm spacing.

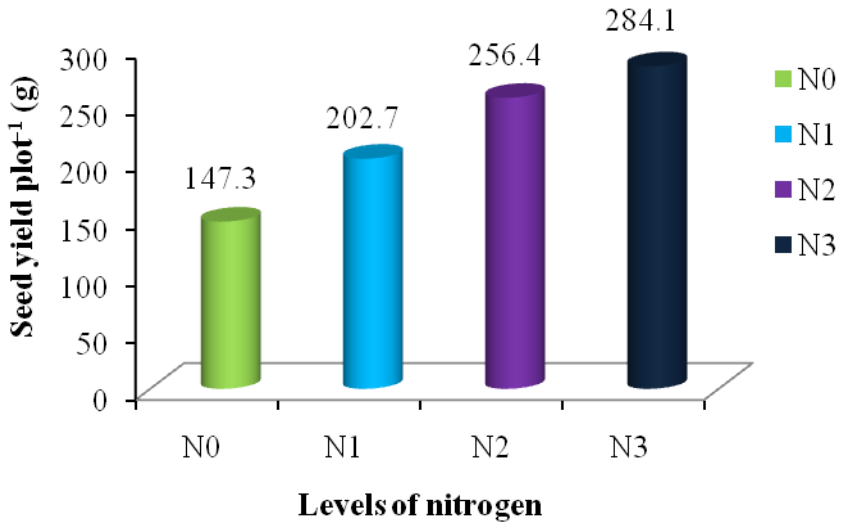


Fig. 10. Effect of different levels of nitrogen on seed yield plot^{-1} (N_1 = 40 kg ha^{-1}, N_2 = 80 kg ha^{-1} and N_3 = 120 kg ha^{-1}.Plot area: 3.6m2; $LSD_{0.05}$ = 8.77. Plot are: 3.6 m^2.

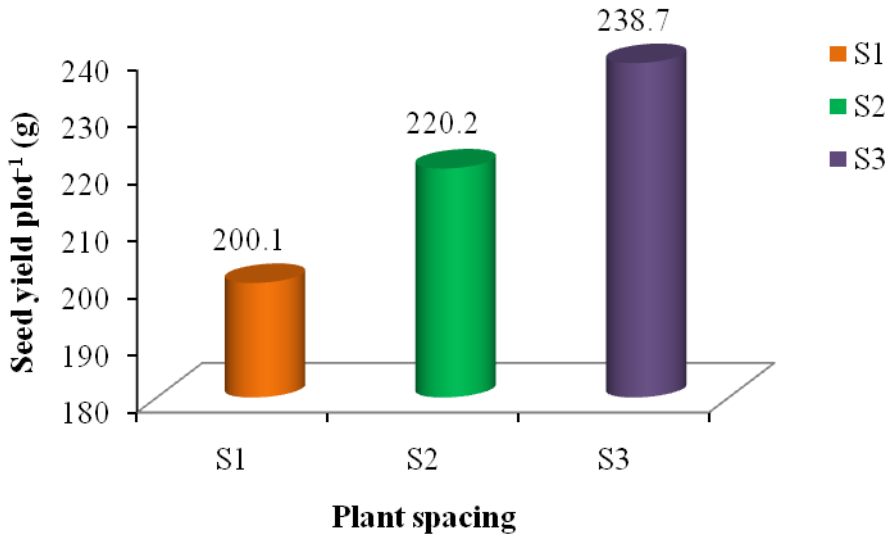


Fig. 11. Effect of different spacing on seed yield plot^{-1}; S_1 = 20 cm x 10 cm, S_2 = 25 cm x 10 cm and S_3 = 30 cm x 10 cm. LSD 0.05 = 7.60; Plot are: 3.6 m^2.

4.16 Seed yield (kg ha^{-1})

Different fertilization rates had significant influence on seed yield ha-1 (Fig. 12 and Appendix VIII). The highest seed yield (789.0 kg ha^{-1}) was recorded from 120 kg N ha^{-1} (N_3) nitrogen fertilizer application followed by N2 (80 kg N ha-1).The lowest seed yield (409.5 kg ha^{-1}) was obtained from control (N_0). This is in agreement with the findings of Jagdale and Dalve (2010). Tuncturk *et al.* (2011) obtained the highest seed yield of fenugreek from 90 kg N ha^{-1}, but Moosavi *et al.* (2012) got the maximum seed yield of fenugreek from the application of 150 kg N ha^{-1}. Khan (1993) reported that the application of 80 kg N ha^{-1} produced seed yield of black cumin.

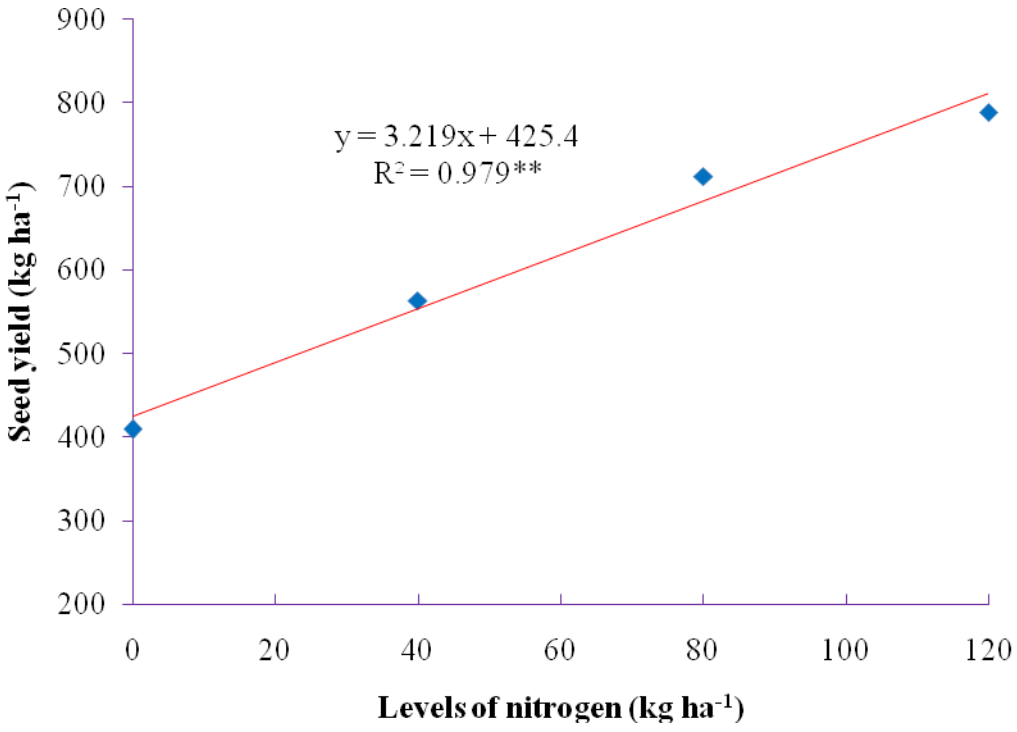


Fig. 12. Response of fenugreek seed yield to different nitrogen.

There was highly significant correlation between seed yield of fenugreek and nitrogen levels (Fig. 12). The relationship between seed yield and nitrogen showed a linear equation as $y = 3.219x + 425.4$; $R^2 = 0.979^{**}$ which stated that seed yield increased at the rate of 3.129 kg ha-1 for per unit change of nitrogen levels. The R^2 value indicated that 97.9% seed yield was attributed due to nitrogen levels.

Seed yield was significant influenced by different spacing (Fig. 13 and Appendix VIII). Result revealed that the highest seed yield (663.3 kg ha^{-1}) was recorded from the wider spacing of (30 cm x 10 cm) and the lowest yield (580.9 kg ha^{-1}) was obtained from the closer spacing of (20 cm x 10 cm). This corroborates the results of Bairagi (2014) and Anon. (2015) who got the highest seed yield of fenugreek seed from 30 cm x 10 spacing. Ahmed and Hauque (1986) obtained the highest seed yield in black cumin from the closer row spacing (15 cm).

Interaction of N and spacing had significant influence on seed yield ha^{-1} (Table 11 and Appendix VIII). The highest seed yield (801.7 kg ha^{-1}) was recorded from N_3S_3 combination closely followed by N_3S_2 (787.9 kg ha^{-1}), N_3S_1 (777.6 kg ha^{-1}) and N_2S_3 (768.6 kg ha^{-1}) treatment combinations. The lowest seed yield (335.3 kg ha^{-1}) was recorded from N_0S_1 combination. Zandi *et al*. (2011) got the maximum seed yield of fenugreek from the combination of 50 kg N ha^{-1} and 100 plants m^{-2}. Moosavi *et al.* (2012) reported that 150 kg N ha^{-1} coupled with 33 plant m^{-2} (30 cm x 10 cm) gave the highest yield of fenugreek.

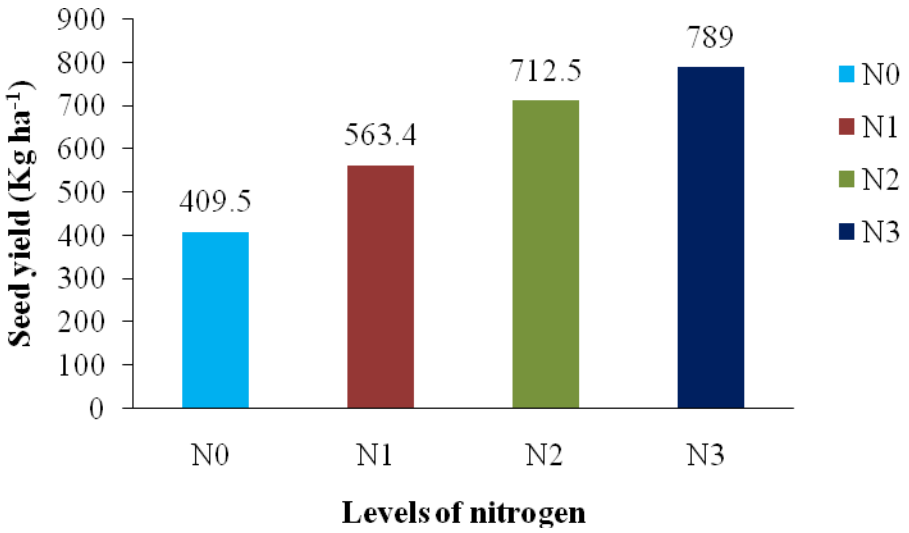


Fig. 13. Effect of different levels of nitrogen on seed yield ha^{-1} in fenugreek. N_1 = 40 kg ha^{-1}, N_2 = 80 kg ha^{-1} , N_3 = 120 kg ha^{-1}. $LSD_{0.05}$ = 31.41

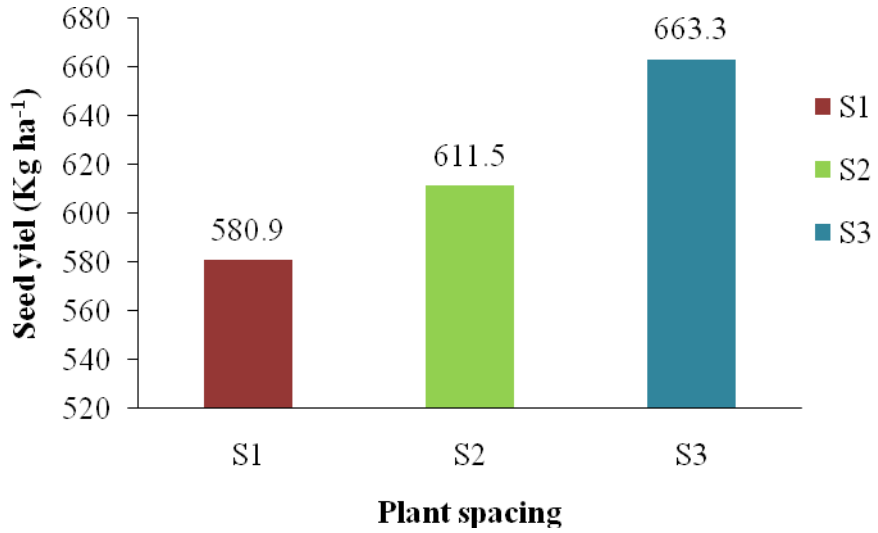


Table 14. Effect of different spacing on seed yield ha^{-1}. S_1 = 20 x 10 cm, S_2 = 25 x 10 cm. S_3 = 30 x 10 cm. $LSD_{0.05}$ = 27.20.

Table 11. Interaction effect of nitrogen levels on Seed yield (g) plot^{-1}weight of straw plot^{-1} and Seed yield ha^{-1}

Combination	Seed yield plot^{-1} (g)	Seed yield (kg ha^{-1})
N_0S_1	120.7 f	335.3 f
N_0S_2	143.8 e	399.6 e
N_0S_3	177.7 d	493.6 d
N_1S_1	193.7 c	538.0 cd
N_1S_2	202.5 c	562.7 c
N_1S_3	212.2 c	589.4 c
N_2s_1	242.2 b	672.9 b
N_2S_2	250.5 b	695.9 b
N_2S_3	276.7 a	768.6 a
N_3S_1	279.9 a	777.6 a
N_3S_2	283.6 a	787.9 a
N_3S_3	252.6 a	801.7 a
LSD (0.05)	15.20	54.40
CV (%)	4.74	5.19

N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm; Plot area = 3.6 m^2

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

Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The field experiment was conducted at Sher-e-Bangla Agricultural University (SAU) farm, Dhaka, Bangladesh during the *rabi* season from November 2014 to March 2015 to find out the optimum nitrogen fertilizer rate and suitable spacing for better vegetative growth yield attributes and yield of fenugreek (*Trigonella foenum-graecum* L). The treatment consisted of 4 levels of nitrogen (N_0= 0 kg, N_1 = 40 kg, N_2 =80 kg and N_3 = 120 kg N ha^{-1}) and three spacing (S_1=20 cm x 10 cm, S_2 = 25 cm x 10 cm, S_3 = 30 cm x 10 cm). The experiment was laid out in factorial randomized completely bock design (RCBD) having 12 treatments with three replications. The size of unit plot was 3 m x 1.2 m^{-2}. Data were collected on the following parameters- plant height (cm) at 35, 50, 65 and 80 days after sowing(DAS), number of leaves $plant^{-1}$ at 35, 50, 65 and 80 DAS, plant spread (cm) 35, 50, 65 and 80 DAS, number of primary and secondary branches $plant^{-1}$, days to 50% flowering, weight of single pod (g), number of seeds pod^{-1}, weight of seeds $plant^{-1}$(g), 1000-seed weight (g), weight of seeds pod^{-1} (mg), weight of straw $plot^{-1}$ (kg), number of plants $plot^{-1}$ at harvest, seed yield $plot^{-1}$ (g) and seed yield (kg ha^{-1}). Collected data were statistically analyzed by F-test to examine whether the treatment effects were significant. Mean separations were done by LSD (Least Significant difference Test) at 5% level of probability. Summary of the results and conclusion have been described in this chapter.

The plant height increased with increasing the age of the plants. The tallest plant (13.3, 18.1, 22.9 and 36.22 cm at 35, 50, 65 and 80 DAS, respectively) was recorded from N_3 and the smallest plants were recorded from control (N_0) at 35, 50, 65 and 80 DAS and the heights were 8.2, 16.1, 19.1, 27.1 cm, respectively. The maximum number of leaves per plant (24.9, 70.90, 171.2 and 260.6 at 35, 50, 65 and 80 DAS, respectively) was produced by N_3 and control treatment (N_0) produced the lowest number of leaves $plant^{-1}$ (18.56, 54.41,

160.9 and 233.4 at 35, 50, 65 and 80 DAS respectively). The maximum plant spread (6.62, 6.05, 17.75 and 26.14 cm at 35, 50, 65 and 80 DAS, respectively) was recorded at N_3 (120 kg N ha^{-1}). The lowest plant spread was recorded from control (N_0) at 35, 50, 65 and 80 DAS. The maximum number of primary branches $plant^{-1}$ (4.7) was obtained from 120 kg N/ha (N_3). Control treatment produced the minimum number of branches $plant^{-1}$ (3.89). Secondary branches $plant^{-1}$ (3.7) was found maximum from N_3 that was statistically similar with N_2, while the nitrogen level N_0 produced the lowest number of secondary branches $plant^{-1}$ (2.9).

The longest period was required for 50 % flowering in N_3 (120 kg N ha^{-1} (54.4 days) closely followed by N2 (53.56 days) while the shortest period in control (N_0) (50.22 days). The highest number of pods $plant^{-1}$ (42.0) was observed in N_3 (120 kg/ha) followed by N_2 and N_1. There was no significant difference between N_2 and N_1 in respect of number of pods $plant^{-1}$. The lowest number of pods $plant^{-1}$ (23.5) was found from N_0. The maximum single pod weight (4.54 g) was obtained from N_3 (120 kg/ha) which was closely followed by N_2 (80 kg N ha^{-1}) N_1 (40 kg N ha^{-1}) and the minimum weight (3.5 g) was found in N_0 (control). The highest number of seeds pod^{-1} (14.0) was observed in N_3 (120 kg/ha) which was identical with N_2(13.4).The lowest number (13.6) was found from N_0. The maximum weight of seeds $plant^{-1}$ (3.56 g) was observed in N_3 (120 kg ha^{-1}) and the minimum weight of seeds (2.50 g) was found in N_0 (control). The highest 1000 seed weight (7.7 g) was found in N_3 (120 kg ha^{-1}) which was closely followed by N_1 and N_2. The lowest 1000 seed weight (6.6 g) was obtained from N_0. The maximum weight of seed pod^{-1} (100.9 g) was obtained from N_3 (120 kg ha^{-1}) and the minimum (74.0 mg) was found in N_0 (control). The maximum weight of straw $plot^{-1}$ (0.37kg) was observed from N_3 (120 kg ha^{-1}) which was closely followed by N_2 (80 kg ha^{-1}) and the minimum (0.23 g) was found in N_0 (control). The maximum number of plants (122.3 $plot^{-1}$) was recorded in 120 kg N/ha (N_3) which was statistically similar with N_2 (80 kg ha^{-1}) and N_1 (40 kg ha^{-1}). Control condition reduced number of plants $plot^{-1}$

(120.3) at harvest. The highest seed yield per plot (284.1 g) was observed in N_3 (120 kg/ha) and the lowest (147.3 g) was found in N_0 (control). The highest seed yield (789.0 kg ha^{-1}) was also recorded from 120 kg N ha^{-1} (N_3) nitrogen fertilizer application followed by N2 (80 kg N ha-1).The lowest seed yield (409.5 kg ha^{-1}) was obtained from control (N_0). The relationship between seed yield and nitrogen showed a linear equation as y = 3.219x + 425.4; R^2 = 0.979** which stated that seed yield increased at the rate of 3.129 kg ha-1 for per unit change of nitrogen levels. The R^2 value indicated that 97.9% seed yield was attributed due to nitrogen levels.

Spacing had significant influence on most of parameters of fenugreek studied. The tallest plants (11.3, 17.2, 20.3 and 32.7 cm at 35, 50, 65 and 80 DAS, respectively) were recorded from the wider spacing of S_3 (30 x 10 cm) and the shortest plants (10.3, 16.1, 18.5 and 30 cm at 35, 50, 65 and 80 DAS, respectively were found in the closer spacing of S_1 (20 x 10 cm). The wider spacing of S_3 (30 x 10 cm) had the highest number of leaves (24.30, 66.98, 170.6 and 256.9 at 35, 50, 65 and 80 DAS, respectively) and the lowest number of leaves $plant^{-1}$ (21.82, 61.53, 158.8 and 228.5 at 35, 50, 65 and 80 DAS, respectively) was obtained from the closer spacing of S_1 (20 x 10 cm). The highest plant spread (5.386, 7.470, 15.94 and 22.65 cm at 35, 50, 65 and 80 DAS, respectively) was produced from the wider spacing of S_3 (30 x 10 cm) that was statistically similar with medium spacing of S_2 (25 cm x 10 cm) at 50 DAS and S_2& S_1at 65 DAS. The lowest plant spread (3.96, 6.6, 15.03 and 21.07 cm at 35, 50, 65 and 80 DAS, respectively) was found in the closer spacing of S_1 (20 x 10 cm). The highest number of primary and secondary branches $plant^{-1}$ was obtained from the wider spacing of S_3 (30 x 10 cm) and the lowest number of primary branches $plant^{-1}$ was obtained from the closer spacing of S_1 (20 cm x 10 cm). Days to 50 % flowering were not significantly affected by spacing. The maximum number of pods $plant^{-1}$ (36.1) was found from the wider spacing of 30 cm x 10 cm (S_3) followed by medium spacing of 25 cm x 10 cm (S_2) (34.6) and the lowest number (27.9) was found from 20 cm

x 10 cm spacing (S_1). The maximum weight of single pod (4.6 g) was found from the wider spacing of 30 cm x 10 cm (S_3) and the lowest weight (3.7) was found from the closer (20 cm x 10 cm) spacing (S_1). The wider spacing of S_3 (25 cm x 10 cm) produced the highest number of seeds pod^{-1} (13.5) and the lowest number of seeds pod^{-1} (11.6) was recorded in closer spacing of S_1 (20 cm x 10 cm). The maximum weight of seeds plant^{-1} (3.18 g) was found from the wider spacing of S_3 (30 cm x 10 cm) and the lowest (2.68) was found from the closer spacing of S_1 (20 cm x 10 cm). The wider spacing of 30 cm x 10 cm (S_3) gave the highest 1000 seed weight (7.69 g) that was identical with that of medium spacing of (25 cm x 10 cm). The lowest 1000 seed weight (6.91 g) was found from 20 x 10 spacing. The maximum weight of seeds pod^{-1} (99.0 mg) was found from the wider spacing of 30 cm x 10 cm followed by spacing 25 cm x 10 cm. and the lowest (80.1 mg) was found from the closer spacing 20 cm x 10 cm spacing. The highest weight of straw plot^{-1} (0.34 kg) was found from the wider spacing of 30 cm x 10 cm followed by the medium spacing of 25 cm x 10 cm and the lowest weight of straw plot^{-1} (0.27 kg) was recorded from the closer spacing of 20 cm x 10 cm. The highest number of plants plot^{-1} (147.7) was recorded from closer spacing of (20 cm x 10 cm) and the lowest number of plants plot^{-1} (98.42) from the wider spacing of (30 cm x 10 cm) at harvest. The highest seed yield (238.7 g) was found from the wider spacing of 30 cm x 10 cm and the lowest seed yield (200.1 g) was recorded from the closer spacing spacing of 20 cm x 10 cm. In wider spacing all the fenugreek plants of each plot received more nutrients, space, light and other resources due to which plot yield increased. Result revealed that the highest seed yield (663.3 kg ha^{-1}) was recorded from the wider spacing of (30 cm x 10 cm) and the lowest yield (580.9 kg ha^{-1}) was obtained from the closer spacing of (20 cm x 10 cm).

Nitrogen levels and spacing in combination had significant effect on most of the parameters studied. The tallest plants (13.8, 18.9, 23.7 and 37.4 cm at 35, 50, 65 and 80 DAS, respectively) were recorded in N_3S_3 combination. In contrast, the smallest plants were recorded from N_0S_1 combination at 35, 50, 65 and 80 DAS. Number of leaves per plant (27.47, 73.80, 177.0 and 255.5 at 35, 50, 65 and 80 DAS, respectively) was found in N3S3 combination closely followed by N^3S^2 combination and the lowest number of leaves plant^{-1} (21.8, 47.20, 154.1 and 208.8 at 35, 50, 65 and 80 DAS, respectively) was recorded inN_0S_1 combination. The maximum plant spread (7.12, 10.51, 18.01 and 27.06 cm^2 at 35, 50, 65 and 80 DAS, respectively) was recorded in N_3S_3 closely followed by N_3S_3 at 50, 65 and 85 DAS, N_3S_1 at 35 DAS. The minimum plant spread was recorded in N_0S_1 at 35, 50, 65 and 80 DAS and 3.33, 4.98, 10.4 and 17.27 cm, respectively that was statistically similar with N_0S_2 at 35, 50, 80 DAS. The maximum number of primary and secondary branches plant^{-1} was obtained from N_3S_3 combination closely followed by N_3S_2. The lowest number of primary and secondary branches plant^{-1} was found in N_0S_1 that was statistically similar with N_0S_2 and N_0S_3 treatment combinations. The treatment combination N_3S_3 took maximum days to 50% flowering (55.0 days) whereas N_0S_1 and N_0S_2 treatment combinations took minimum period (50.0 days) to reach 50 % flowering stage. The maximum number of pods plant^{-1} (43.3), weight of single pod (5.1g), number of seeds pod^{-1} (15.1), seed weight plant^{-1} (3.9 g), the highest 1000 seed weight (8.07 g), maximum seed weight pod^{-1} (116.8 mg), the highest straw weight (kg) plot^{-1} (0.39 kg) and the highest seed yield (288.6 g plant^{-1} and 801.7 kg ha^{-1}) were obtained from N_3S_3 combination which was statistically similar with N_3S_2 combination and their lowest values were recorded from N_0S_1 combination.

Based on the above results the following conclusions might be drawn-

i) Application of nitrogen @ 120 kg ha^{-1} gave the maximum growth and yield components, and therefore, the highest yield of fenugreek (cv. BARI Methi 1) was obtained.

ii) The spacing of 30 cm x 10 cm produced significantly maximum growth and yield attributes, and thus gave the highest seed yield of fenugreek.

iii) Application of 120 kg N ha^{-1} in combination with 30 cm x 10 cm gave the maximum seed yield of fenugreek, which was statistically similar with 25 cm x 10 cm spacing with the same dose of nitrogen.

The following recommendations might be drawn from the above results:

1. For fenugreek cultivation, application of 80-120 kg N ha^{-1} in combination with either 30 cm x 10 cm 25 cm x 10 cm spacing may be adopted.

2.Such type of study may be conducted in different agro-ecological zones (AEZs) of Bangladesh for exploitation of regional adaptability and with higher doeses of Nitrogen treatment (such as 160 kg N ha^{-1})

Chapter VI

References

CHAPTER VI
REFERENCES

Abbasdokht, K, Jaenaksorn, T. and Ikeda, H. (2003). Possibility of substituting soil less fertilizer for growing leafy vegetable in hydroponics. Acta Hort. **642**: 345-361.

Abdin, M. Z, Khan, N. Khan, I. Israr, M. and Jamal A.(2003). Nitrogen and sulphur interaction in relation to yield and quality attributes of rapeseed-mustard. Center for Biotechnology, Faculty of science, Flamdard University, New Delhi, India. **5**(3/4): 35-41.

Ahmed, N. U. and Haque, K. R. (1986). Effect of row spacing and time of sowing on the yield of black cumin (*Nigella sativa* L.). *Bangladesh. J. Agric*. **1**: 21-24.

Ali, M. H. and Ullah, M. J. (1995). Effect of different levels and methods of nitrogen application on growth and yield of rapeseed (*Brassica campestris* L.) *Ann. Bangladesh Agric.* **5**(2): 115-120.

Anonymous. 2010. Mashala Utpadan Projukti Mannual (In Bengali). Spices Research Centre, Bangladesh Agricultural Research Institute, Shibgonj, Bogra. pp. 58-60.

Anonymous. 2015. Anuual Research Report for 2014-2015. Spices Research Centre, Bangladesh Agricultural Research Institute, Shibgonj, Bogra. pp. 153-158.

Arabasi, O. and Bayram, E. (2004). The effect of nitrogen fertilization and different plant density on seed yield, essential oil and oil content of basil (*Ocimum basilicum* L.). *J. Agron.* **3**(4): 255-262.

Akbarinia, A., Daneshian ,J. and Mohammadbiegi, F. (2006). Effect of nitrogen fertilizer and plant density on seed yield, essential oil and oil content of coriander (*Coriandrum sativum* L.). *Iranian J. Med. Arom. Plants*. **22**: 410-419.

Babu, M. B. B. P. and Sarkar, M. C. (2000). Nitrogen use efficiency of 15N-labellcd urea applied to mustard. *J. Indian Soc. Soil Sci*. **50** (3):1248-253.

Bairagi, S. K. (2014). Effect of different doses of phosphorus and row spacing on the yield and quality of fenugreek (*Trigonella foenum-graecum* L.) seed. *The Asian J. Hort.* **9** (2): 338-341.

Basu, S., S. Achary, Bandara, M. and Thomas,J.(2004). Agronomic and genetic approaches for improving seed quality and yield of fenugreek (*Trigonella foenum-graecum* L.) in Western Canada. *Canadian J. Pl. Sci*. **85**(1): 167.

Budzynski, W., Jankowski, K.(2001). Effect of fertilization with sulphur, magnesimn and nitrogen on the growth and yield of white and Indian mustard seeds. Rosliny- Oleiste. Uniwersytet Warininsko-Mazurski, Olsztynie, Poland. **22**(1): 45-58.

Bhandari, M. M. and Gupta, A. (1993). Divergence analysis in coriander. *Indian J. Genet,* **53** (1): 71-75.

Birjees Bukhari S, Bhanger, M. L. and Memon, S. H. (2008). Antioxidative activity of extracts from fenugreek seeds (*Trigonella foenum-graecum* L). Pak. J. Ann. Environ. Chem. **9**: 78-83.

Danesh-Talab, S., Mehrafarin, A. Labbafi, M. Qavami, N. Qaderi, A. Naghdi Badi, H. (2014). Responses of fenugreek (*Trigonella foenum-graecum* L.) to exogenous application of plant growth regulators (PGRs). Trakia J. Sci, 2:142-148.

Datta, S., Alam, K. Chatterjee, R. (2005). Effect of different levels of nitrogen and leaf cutting on growth, leaf and seed yield of fenugreek (*Trigonella foenum-graecum* L.). *Indian J. Agril Sci.* **75**(9): 580-581.

Davey, K. (1965). Analysis of some food staffs of East Pakistan. *J. Biol. and Agril. Sci.* **9**: 25-29.

Dierchesen, A.(1996). Promoting the conservation and use of underutilized and neglected crop, coriander. International plant Genetic Resource Institute (IPGRI). Italy. 82p.

Dwivedi, Y. C., Kushwah, S. S. and Sengupta, S. K. (2002). Studies on nitrogen, phosphorus and potash requirement of dolichos bean. *Jnkvv Res. J.* **36**: 47-50.

FAO. (1998). Food and Agriculture Organization. Production Yearbook. Rome, Italy. **52**: 101-107.

Ghanbari, A. K., Taheri Mazandarani, M. (2003). Effects of sowing date and plant density on yield of pinto bean (In Persian). Seed plant J. **19**: 463-496.

Ghobadi, E. and Ghobadi, M. (2010). The effects of sowing dates and densities on yield and yield components of coriander (*Coriandrum sativum* L.). *Engineering and Technology*. **70**: 81-84.

Gowda. M. C., Halesh, D. P. and Farooqi, A. A. (2006). Effects of dates of sowing and spacing on growth and yield of fenugreek (*Trigonella foenum graceum* L.) Biomedicine. **1** (2): 141-146.

Gomez, K. A. and Gomez,A. A. (1984). Statistical procedures for agricultural research. 2nd edn. John Wiley and Sons. New York. 680p.

Gupta, V., Pratap, V. and Bhadauria, S. and Aarwal, R. L. (2011). Effect of nitrogen and split dosees of potassium on quality aspects of *Brassica spp. African J. Agri. Res.***6** (2).pp. 285-288.

Halesh, D. P., Gowda, M. C. Forooqi, A. A. Vasundhara, M. Srinivasappa, K. N. (2000). Influence of nitrogen and phosphorus on growth, yield and nutrient content of fenugreek (*Trigonella foenum-graecum* L.). Spices and aromatic plants: Challenges and opportunities in the new century. Contributory papers. *Centennial conference on spices and aromatic plant.* **20-23**: 191-194.

Hossain, A. and Gaifer, M. A. (1997). Influence of nitrogen on yield of mustard. *Bangladesh Tceh. Agric.* **15**(4): 72-80.

Islam, N. and Mondal, M. F. (1997). Effect of nitrogen nutrition on the growth and yield of mustard and rapeseed. *Bangladesh Sci. Res.* **15** (1):45-52.

Islam, M. R., Riasat, T. M. and Jahiruddin, M. (1997). Direct and residual of S, Zn and B on yield and nutrient uptake in a rice- mustard cropping system. *Indian Soc. Soil Sci*. **45**:126-129.

Jagdale ,Y. L. and Dalve, P. D. (2010). Effect of nitrogen and phosphorus levels on growth, flowering and pod formation of fenugreek. *The Asian J. Hort.* **5**(2): 301-304.

Kader, P., Singh, G. K. and Prasad, K. (2003). Studies on the effect of row spacings and nitrogen doses on the yield of and profit from Indian mustard. Progr. Agric. C. S. Azad University of Agriculture and Technology, Kanpur, India. **3**: 1-2: 146-147.

Kakati, P. K. and Kalita, M. M.(1996). Response of Indian mustard (*Brassica juncea)* varieties to nitrogen. *Indian J. Agron*. **41**(2): 338.

Khan, M. M. A. (1993). Nitrogen application ameliorates the productivity of *Nigella sativa* L. *In*: Glimpses in Plant Research Vol. XI. Medicinal Plant: New Vistas of Research.

Khan, N., Singh, A. Khan, S. and Samiullah, M. (2003). Interactive effect of nitrogen and plant growth regulators on biomass partitioning and seed yield in mustard. Department of Botany, Aligarh Muslim University, Aligarh, India. **5 :**(3 &4): 64-71.

Khorshidi, J. F., Tabatabaei, M. Omidbaigi, R. and Sefidkon, F. (2009). Effect of densities of planting on yield and essential oil components of fennel (*Foenicolum vulgare* Mill.) *J. Agril. Sci.* **1**(1): 131-140.

Kumar, S. D. and R. D. Singh. 2003. Indian mustard (*Brassica juncea* L.) seed yield as influenced by seeding date, spacing and N levels. *Applied Biol.* **13** (l/2): l39-146.

Kumar, K., Singh, G. P. Singh, N. Bhatla, A. K. and Nehra, B. K. (2007). Performance of seed crop of coriander under different levels of row spacing, nitrogen and cycocel. *Haryana J. Hort. Sci*. **36**(1&2): 127-128.

Koay, Y. and Chua, Z. (1979). Commercial lettuce production. University of Wisconsin Coop: Exl. Ser. 2340. pp. 1-83.

Masood, A., Sayed Asgha, H. Mohammad, Z. and Abdur, R. (2004). Effect of different sowing seasons and row spacing on seed production of fennel (*Foeniculum vulgar*e). *J. Biol. Sci.* **79**(7): 1144-1147.

Max B. (1992). This and That: The essential pharmacology of herbs and spices Trends. Pharma. Sci. **13**: 15 –20.

Meena, B. S. and Smneriya, H. K. (2003). Influence of nitrogen levels, irrigation and inter-culture on oil and protein content, soil moisture studies and interaction effects of mustard (*Brassica juncea* L.). *Crop Res. Hisar*. **26**(3): 409-413.

Meena. B. S., Sarma, G. L. and Shanna, R. P. (2002). Effect of nitrogen, irrigation and interculture on yield attributes and yield of mustard (*Brassica juncea* L. (Czem and Coss)). *Res. Crops*. **3**(l): 37-39.

Mehrafarin, A., Naghdi-Badi, H. Noormohammadi, G. Zand, E. Rezazadeh, S. H., and Qaderi, A. (2011). Effects of environmental factors and methanol on germination and emergence of Persian fenugreek (*Trigonella foenum-graecum* L.). *African J. Agril. Res.* **6**(19): 4631-4641.

Missinga, M. and Currie, J. K.(2002). Yield of gimakalmi grown with different organic compounds and pig manure. *Hort. Brasileira.* **12**(2): 42-72.

Mondal *et al.* 2001). Edited. Krishi Projukti Hatboi (Handbook on Agro-technology). 5th edition. Bangladesh Agricultural Research Institute, Gazipur 1701. pp. 207-208.

Moosavi, S. G., Seghatoleslami, M. J. Khosravi, M. and Joyban, Z. (2012). Effect of Irrigation interval, N fertilizer rate and plant density on yield and chemical composition of fenugreek (*Trigonella foenum-gracum* L.) *J. Med. Plants and By-products.* **2**: 91-99.

Mozaffari S.N., Babak, D. and Amirhossein, S. R. (2012). Effect of nitrogen and potassium levels on yield and some of the agronomical characteristics in mustard (*Brassica juncea*). *Indian J. Sci. and Tech*. **5** (2): 0974- 6846.

Mozumder, A. N. (2003). On farm investigation on Bilatidhonia cultivation and development of improved cultivation package. A survey report under NSICT, Ministry of Sci. & Information and Communication Technol., Dhaka-1000. 6p.

Nahdibadi, H., Yazdani, D. Nazari, F. and Mohammadali, S. (2002). Effect of different densities of planting on essential oil component of *Thymus vulgaris*. *Revive Researches of Medicinal and Aromatic plant of Iran*. **1**: 54-57.

Najafpoor, M. (1994). Subjects about medicinal plant of fenugreek (*Trigonella foenum graceum* L.). Research Forest and Range Institute, Iran. (In Persian).

Nandini V, Devaraj, S. N. and Devaraj, H. (2007). A fibre cocktail of fenugreek, guar gumand wheat bran reduces oxidative modification of LDL induced by an atherogenic diet in rats. Mole.Cell Bio. **294**: 145–153.

Norman, J. C. and Shongwe, V. D. (1993). Influence of some cultural practices on the yield and quality of amaranth. *Advances in Hort. Sci*. **7**: 4.

Okut, N. and Yidrim, B. (2005). Effect of different row spacing and nitrogen doses on certain agronomic characteristics of coriander (*Coriandrum sativum* L.). *Pakistan J. Bio. Sci.* **8**(6): 901-904.

Ozer, H. (2003). Sowing date and nitrogen rates effect on growth, yield and yield components of two summer rapeseed cultivars. *European Agron.* **19**(3): 453- 463.

Park, K. W., Han, K. S. and Won, J. H. (1993). Effect of propagation method, planting density and fertilizer level on the growth of water spinach (*Impomoea aquatia*). *J. Korean. Soc. Hort. Sci*., **34**(4): 241- 247.

Patel R. H., Sharma, V. and UsadadiaM, V. P. (2004). Influence of irrigation schedule, spacing and nitrogen on growth, yield and quality of mustard. Department of Agronomy, Gujarat Agriculttnal University, India. **5**(2/3): 290-293.

Patil, B. N., Lakkineni, K. C. and Bharsava, S. C. (1996). Seed yield and yield contributing characters as influenced by nitrogen supply in rapeseed and mustard. *J. Agronn. Crop Sci.* **l77**(3): 197-205..

Prasad, K., Chaudhary, H. P. and Uttam, S. (2003). Effect of nitrogen, phosphorus, sulphur and zinc on growth, yield attributes and yield of mustard under rainfed condition. Bhaitiya-Krishi-Anusandhan-Patrika. Chandra Shekhar Azad University of Agriculture & Technology, Kanpur - 2 (U .P.), India. **18**(3/4): 124- 129.

Pramanik , S.(2007). Effect of nitrogen and phosphorus on the growth and yield of cabbage. MS Thesis. Dept of Hort., SAU, Dhaka. pp.21-42.

Rahman, M. A.(2000). Morphological characters and yield potential of different coriander genotypes. Dept. of Hort. MS Thesis. Bangabondhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. 53 p.

Sainju, U. M., Syed, R. and Singh, B. P. (2001). Evaluating hairy vetch residue as nitrogen fertilizer for tomato in soilless medium. *Hort. Sci.* **36**(1): 90-93.

Santos, B. M., Dusky, J. A. Stall, W. M. . Brwick, T. A and Shilling, D. G. (2003). Mechanisms of interference of smooth pigweed and common purslane on lettuce as influenced by phosphorous fertility. *Weed science*. **52**(1): 78-82.

Selvarajan, M., Chezhiyan, N. (2001). Effect of *Azospirillum* in combination with different levels of nitrogen on growth and yield of fenugreek (*Trigonella foenum graecum* L.). South Indian Hort. **49**: 173-174.

Seghatoleslami, M. J. and Ahmadi Bonakdar, K.H. (2010). The effect of sowing date and plant density on yield and yield components of fenugreek (*Trigonella foenum graecum L.*). *Iranian J. Medicinal and Aromatic Plants.* **26**(2): 265-274.

Shareh, M. (1999). Effect of plant density and weed controlling frequency on yield and yield components of *Pimpinella anisum*. M. Sc. Thesis on

Agriculture, Department of Agriculture, Ferdowsi University of Mashad, Iran.

Sharawat, S., Singh, T. P. Singh, J. P. and Shawwals, S. (2002). Effect of nitrogen and sulphur on the yield and oil content of Varuna mustard (*Brassica juncea L.*). *Prog. Agric*. **2**(2): 177.

Shamsuddin, A. M., Islam, M. A. and Asaduzzaman, S. M. (1987). Effect of nitrogen on yield and yield contributing characters of mustard at different levels. Bangladesh *J. Agric. Sci*. **14**(2)5 165-l67.

Sharma, S. K. (2000). Response of nitrogen and spacing on fenugreek seed production. *Hort. J.* **13** (2): 39-42.

Sharma, P. P. and N. K. (2002). Nitrogen requirement on Indian mustard (*Brassica juncea*) under different crop sequences. *Indian J. Agril. Sci.* **72**(2): 101-103.

Shokhmgar, M. (2009). Effect of irrigation interval and N fertilization on qualitative and quantitative characterististic of fenugreek. M.Sc. Thesis, Islamic Azad University, Birjand Branch, Birjand, Iran. (In Persian).

Shukla, R. K., Kumar, A. Mahapatra, B. S. Basanth, K. Kumar, A. and Kandpal, B.(2002). Response of promising varieties of rapeseed (*Brassica napus*) to nitrogen and phosphorus fertilizer on the Tarai region of Uttaranchal. *Ann. Agril. Res*. **23**(4): 630-633.

Sidlauskas, G. (2000). The influence of nitrogen's role on spring oil seed rapeseed yield. *Agril. Sci. Articles*. **69**: 14-32.

Singh, S., Buttar, G.S. Singh, S.P. and Brar, D. S. (2005). Effect of different dates of sowing and row spacing on yield of fenugreek (*Trigonella foenum-graecum* L.). *J. Med. Arom. Plant Sci*. **27**(4): 629-630.

Singh, D., Jain, K. and Sharma, S. K. (2004). Quality and nutrient uptake in mustard as influenced by levels of nitrogen and sulphur. J. Maharashtra

Agril. Univ. Depart. of Agron., College of Agriculture, Bikaner, India. **29**(1): 87-88.

Singh, G. K. and Prasad, K. (2003). Studies on the effect of raw spacing and nitrogen doses on the yield and profit from Indian mustard. *Progress. Agric.* **3**(1/2): 146-147.

Singh, A. and Meena, N. L. (2003). Effect of nitrogen and phosphorus levels on the oil and protein yield of mustard (*Brassica juncea*). *Ann. Agric. Res.* **24**(2): 368-371.

Singh, P. C. (2002). Effect of different levels of nitrogen and phosphorus on yield, yield components and oil content of mustard. *J. Living World.* S.D.J. Post Graduate College, Chandeshwar, Azamgarh (U.P.), India. **9 (1)**:1-4.

Sinsinwar, B.S., Kumar, A. O. Premi, P. and Singh, F. (2000). Production potential and nitrogen requirement of Indian mustard. J. Oilseeds Res. **21**(l): 175-177.

Sinha, S., Nayak, R. L. and Mitra, B. (2003). Effect of different levels of nitrogen on the growth of rapeseed under irrigated and rainfed conditions. *Env. Ecol***. 21**(4): 741-743.

Thapa, U., Maity, T. K. (2004). Influence of nitrogen, phosphorus and number of cutting on seed yield of fenugreek (*Trigonella foenum-graecum* L.). *Seed Res.* **32** (1): 33-35.

Tomar, R. K. S., Chouraria, S. C. Raghu, J. S and Sing, V. B. (1996). Growth, yield and net returns of mustard under different levels of nitrogen and sulphur application on clay loam soils. *J. Oilseed Res*. **10**(1): 13-17.

Tomer, R. K. S. and Mishra, R. (1991). Influence of sowing dates and nitrogen on the yield of mustard (*Brassica juncea*). *J. Oilseed Res.* **8**:2.

Tuncturk, R. (2011). The effects of varying row spacing and phosphorus doses on the yield and quality of fenugreek (*Trigonella foenum-graecum* L.). *Turkish J. Field Crop.* **16**(2): 142-148.

Tuncturk, R., Celen, A. E. and Tuncturk, M. (2011). The effects of nitrogen and sulphur fertilizers on the yield and quality of fenugreek (*Trigonella foenum-graecum* L.). *Turkish J. Field Crops,* **16**(1): 69-75.

Yadav, J. S., Singh, J. Kumar, V. and Yadav, B. D. (2000). Effect of sowing time, spacing and seed rate on seed yield of fenugreek (*Trigonella foenum-graecum* L.) on light textured soil. *Haryana Agric. Univ. J. Res.* **30**(3/4): 107-111.

Verzalova, I., Kocurkova, B. and Stavkova, I. (1988). The response of two cultivars of fennel (*Foeniculum vulgare var. vulgare* Mill) to row spacing. *Acta Horticulture.* **15**(2): 101-106.

Vyas Amit S, Patel Nailesh, G. Panchal Aashish, H. Patel Rameshwar, K. and Patel Madhabhai, M. (2010). Anti- arthritic and vascular protective effects of fenugreek. *Boswellia serrata* and *Acacia catechu* alone and in combinations. *Pharma Sci Moni*. Vol. 1, Issue-2.

Xue W, Li, X. Zhang, J. Liu, Y. Wang, Z. H. and Zhang, R. J. (2007). Effect of *Trigonella foenum- graecum* (fenugreek) extract on blood glucose, blood lipid and hemorheological properties in streptozotocin-induced diabetic rats. *Asian Pak. J. Clin. Nutr*. **16** (1):422-426.

Zandi, P., Shirani Rad, A. H. and Bazrkar Khatibani, L. (2011). Agronomic study of fenugreek grown under different in row spacing and nitrogen levels in a paddy field of Iran. *Amer. Eurasian J. Agric. & Environ. Sci.* **10** (4): 544-550.

Chapter VII

Appendices

CHAPTER VI I

APPENDICES

Appendix I. Analytical data of soil sample of the experimental plot

A. Morphological Characteristics

Morphological features	characteristics
Location	SAU Farm, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percent
Sand	27
Silt	43
Clay	30

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix II. Analysis of variance of the data on plant height at different DAS of Fenugreek

	Mean Square for plant height				
Source of variation	**Degrees of Freedom (df)**	**35 DAS**	**50 DAS**	**65 DAS**	**80 DAS**
Factor A	3	122.274*	18.504*	70.370*	447.397*
Factor B	2	6.395*	2.405*	6.135*	44.176*
AB	6	7.235*	4.751*	3.985*	4.547*
Error	22	27.688	10.740	20.100	36.106
'*' indicates significant at 5% level of probability					

Appendix III. Analysis of variance of the data on leaf number at different DAS of Fenugreek

	Mean Square for leaf number				
Source of variation	**Degrees of Freedom (df)**	**35 DAS**	**50 DAS**	**65 DAS**	**80 DAS**
Factor A	3	93.077*	447.572*	185.976*	1457.068*
Factor B	2	19.114*	89.748*	419.681*	3921.410*
AB	6	1.341*	24.830*	14.551*	355.144*
Error	22	3.779	18.254	14.972	157.141
'*' indicates significant at 5% level of probability]					

Appendix IV. Analysis of variance of the data on plant spread (cm) at different DAS of Fenugreek

	Mean Square for plant spread (cm)				
Source of variation	**Degrees of Freedom (df)**	**35 DAS**	**50 DAS**	**65 DAS**	**80 DAS**
Factor A	3	48.975*	514.448*	3797.483*	9644.604*
Factor B	2	32.954*	77.131*	544.751*	895.416*
AB	6	14.510*	19.151*	222.365*	26.397*
Error	22	2.403	5.004	9.999	8.126
'*' indicates significant at 5% level of probability					

Appendix V. Analysis of variance of the data on branches number at different DAS of Fenugreek

Source of variation	**Degrees of Freedom (df)**	**Primary branch**	**Secondary branch**
Factor A	3	13.897*	3.565*
Factor B	2	1.354*	0.930*
AB	6	1.328*	2.117*
Error	22	4.904	3.236
'*' indicates significant at 5% level of probability			

Appendix VI. Analysis of variance of the data on No. of pods plant^{-1}, Weight of single pod, No. of seed pod^{-1}, Weight of seed plant^{-1} (g) of Fenugreek

		Mean Square for			
Source of variation	**Degrees of Freedom (df)**	**No. of pods plant^{-1}**	**Weight of single pod**	**No. of seed pod^{-1}**	**Weight of seed plant^{-1} (g)**
Factor A	3	1550.196 *	3.529 *	47.581*	69.994*
Factor B	2	461.502*	3.526*	21.302*	36.662*
AB	6	130.124*	0.136*	3.852*	17.745*
Error	22	18.451	0.199	17.587	22.095

'*' indicates significant at 5% level of probability

Appendix VII. Analysis of variance of the data on 1000 seed weight (g), weight of seed pod $^{-1}$ (g), weight of straw (g) plot^{-1} (kg) of Fenugreek

		Mean Square for		
Source of variation	**Degrees of Freedom (df)**	**1000 seed weight (g)**	**Weight of seed (g) pod^{-1}**	**Weight of straw (g) plot^{-1}**
Factor A	3	2.392*	1.223*	0.035*
Factor B	2	1.846*	0.790*	0.018*
AB	6	0.202*	0.093*	0.003*
Error	22	0.157	0.133	0.001

'*' indicates significant at 5% level of probability

Appendix VIII. Analysis of variance of the data on seed yield plot^{-1} (g) and seed yield ha^{-1} (Kg) of Fenugreek

Source of variation	**Degrees of Freedom (df)**	**Seed yield (g) plot^{-1}**	**Seed yield (Kg) ha^{-1}**
Factor A	3	29377.115*	253896.208*
Factor B	2	2139.081*	20822.424*
AB	6	309.014*	2704.893*
Error	22	80.611	1032.138

‘*’ indicates significant at 5% level of probability

Plate 3: Panoramic view of experimental plot