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Yield and yield attributes of fenugreek *(Trigonella foenum-graecum)* influenced by nitrogen and spacing levels

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Abstract

Concerning the low yield potentiality of fenugreek in Bangladesh, an experiment was conducted at Sher-e-Bangla Agricultural University, Bangladesh to evaluate the optimum rate of nitrogen fertilizer and spacing on yield and seed yield attributes of fenugreek during the period of November 2017 to March 2018. The two factorial experiment were laid out in Randomized Complete Block Design (RCBD) with three replications. Different levels of nitrogen and spacing influenced significantly on most of the parameters. For nitrogen, N_3; 120 kg Nha^{-1} performed the plant spread (26.14 cm), pod per plant (42.0), seed per pod (14.0), seed per plant (12.5 g) and seed yield (789 kg ha^{-1}) .In case of spacing (s), plant spreading (22.65 cm), pod per plant (36.2), seed per pod (13.5), seed per plant (9.2 g) and seed yield (663.3 kg ha^{-1}) obtained from S_3; 30 cm × 10 cm. For combined effect plant spreading (27.06 cm^2), pod $plant^{-1}$ (43.3), seed pod^{-1} (15.1), weight of seed $plant^{-1}$ (3.9 g), and seed yield (801.7 kg ha^{-1}) were obtained from N_3S_3. So, it can be concluded that 120 kg Nha^{-1} with 30 cm × 10 cm was the best for growth and yield attributes of fenugreek. Its needs to conduct more experiments with Nitrogen and spacing whether can regulate the morphological characters, yield and seed yield attributes of fenugreek.

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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. Shokhmgar (2009) showed that nitrogen fertilization significantly affected fenugreek seed yield. 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. Plant spacing controls the plant density of the crop. Wider or too low spacing beyond the optimum can affect the yield of crop. 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 on fenugreek and showed that the optimum sowing arrangement produced the highest seed yield. Seghatoleslami and Ahmadi Bonakdar (2010) indicated that plant density had no significant effect on 1000-seed weight and harvest index. Information is not available on the nitrogen level and spacing for production potentials of methi, nor its nutrient and plant density requirement worked out so far. Keeping the above facts in mind the present experiment was carried out with the two objectives: (a) to determine the optimum N fertilization rate and suitable plant spacing for higher seed yield of fenugreek (b) to examine the interaction effect of nitrogen and plant spacing on yield and yield attributes of fenugreek.

Materials and methods

Experimental site

The experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from November 2017 to March 2018 and it was located in 24.09° N latitude and 90.26° E longitudes. The area belongs to the Agro-ecological Zone (no. 28): (Madhupur Tract).

Climate and soil

The climate of the experimental site is sub-tropical, wet and humid. The soil of experimental area was silty clay in texture. Soil pH was 6.7 and has organic carbon 0.45%.

Experimental treatments

High yielding variety of Fenugreek, BARI Methi-1 developed by the Bangladesh Agricultural Research Institute (BARI) was used as experimental material. For factor A: four nitrogen levels such as N_0 = 0 ka ha^{-1}, N_1= 40 ka ha^{-1}, N_2 = 80 ka ha^{-1}, N_3 = 120 ka ha^{-1} and for factor B: Two Spacing such as S_1 = 20 × 10 cm , S_2 = 25 × 10 cm and S_3 = 30 × 10 cm, a total of 12 treatment combinations were used. The experiment was laid out in randomized complete block design (RCBD) having twelve treatments with 3 replications. The size of unit plot was 3 m × 1.2 m. The total number of treatments was (4 Levels of nitrogen × 3

population density) 12 and the number of plots were 36.

Crop husbandry

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.

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.

Data collection

Ten (10) plants from each plot were selected at 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 up rooted 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 plant spreading, number of pods plant^{-1}, seed pod^{-1}, Weight of seed plant^{-1} (g), Seed yield (t ha^{-1}). The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results.

Statistical analysis

Collected data were statistically analyzed using MSTAT-C computer package programme. Difference between treatments was assessed by Duncan's Multiple Range Test at 5% level of significance (Gomez and Gomez, 1984).

Results and discussion

Plant spread (cm²)

Nitrogen (N) levels showed significant effect on fenugreek plant spread at different days after sowing (DAS) (Figure.1). 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 Nha^{-1} in cabbage.

Table 1. Different dose of Manure and Fertilizer application.

Nutrient/Fertilizer	Dose
Cowdung	5 tha^{-1}
Nitrogen	According to treatment
Phosphorus	35 kgha^{-1}
Potassium	67 kgha^{-1}
Sulphur	20 kgha^{-1}

Manures and fertilizers were applied at the following doses as par Anon., 2001.

Plant spread was significantly affected by different plant spacing at DAS (Figure 2). 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 cm × 10 cm) that was statistically similar with medium spacing of S_2 (25 cm × 10 cm) at 50 DAS and S_2 & S_1 at 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 × 10 cm).

The plant spread was significantly influenced by the interaction between nitrogen levels and spacing (Table 2).The maximum plant spread (7.117, 10.51 , 18.01 and 27.06 cm² 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.

Number of pods plant^{-1}

Different levels of nitrogen showed significant variation on number of pod per plant (Table 3). The highest number of pod per plant (42.0) was observed in N_3 (120 kg/ha) and the lowest number (23.5) was found from N_0 (Table 3). Sharma (2000) reported that the highest number of pods was obtained from the higher nitrogen doses (60 kg Nha^{-1}).

Table 2. 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.

The number of pod values obtained in the study was compatible with the other researcher's findings. On other hand, Halesh *et al.* (2000) reported that the highest number of pods was obtained from 60 kg N ha^{-1}.

The number of pod plant^{-1} differed significantly due to variation of spacing and as the spacing increased the number of pod plant^{-1} also increased significantly (Table 4). The maximum number of pod plant^{-1} (36.2) was found from the spacing of 25 cm x 10 cm and the lowest (27.9) was found from 20 cm x 10 cm spacing.

Wider spacing produced more number of pod 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 more dry matter production. Ghobadi and Ghobadi (2010) reported number of pod plant^{-1} increased with the increased plant spacing.

Table 3. Effect of nitrogen levels on number of pods plant^{-1}, number of seeds pod^{-1} and weight of seeds plant^{-1}.

(Levels of nitrogen)[X]	No. of pods plant^{-1}	No. of seed pod^{-1}	Weight of seed plant^{-1} (g)
N_0 (control)	23.5 c	11.3 b	8.8 c
N_1 (40 kg ha^{-1})	33.1 b	11.6 b	11.8 ab
N_2(80 kg ha^{-1})	32.9 b	13.4 a	11.4 b
N_3 (120 kg ha^{-1})	42.0 a	14.0 a	12.5 a
LSD (0.05)	0.8	0.8	0.9
CV (%)	2.8	7.1	8.9

[X] N_0 (control), N_1 (40 kg ha^{-1}), N_2 (80 kg ha^{-1}), N_3 (120 kg ha^{-1})

[Y] 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 4. Effect of spacing on number of pods plant^{-1}, number of seeds pod^{-1} and weight of seeds plant^{-1}.

Spacing[X]	No. of pods plant^{-1}	No. of seed pod^{-1}	Weight of seed plant^{-1} (g)
S_1(20cm x 10 cm)	27.9 c	11.6 c	8.4 b
S_2(25cm x 10 cm)	36.1 a	13.5 a	9.2 a
S_3(30cm x10 cm)	34.6 b	12.6 b	8.9 ab
LSD (0.05)	0.8	0.8	0.8
CV (%)	2.8	7.1	8.9

[X] S_1 (20 x 10 cm), S_2 (25 x 10 cm), S_3 (30 x 10 cm)

[Y] 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.

Number of pod plant $^{-1}$ was significantly influenced by the interaction effect of nitrogen levels and spacing (Table 5). The maximum number of pod plant^{-1} (43.3) produced by the interaction effects of N_3 (120 kg/ha) with 25 cm x10 cm spacing which was similar with N_3S_3 combination. The lowest number of pod plant^{-1} was produced by the interaction effects of nitrogen (0 kg/ha) with 20 cm x10 cm spacing. The 66.1% increase in pod number per plant as affected by the increase in Nitrogen rate from 0 to 150 kg ha^{-1} and spacing could be associated with the positive effect of the fertilization on vegetative growth of fenugreek was reported by Moosavi *et al.* (2012) Zandi *et al.* (2011) also observed that number of pod per plant increase with increasing combination of nitrogen and spacing.

Table 5. Interaction effect of nitrogen levels and spacing on number of pods plant^{-1}, number of seeds pod^{-1} and weight of seeds plant^{-1}

(Nitrogen levels X Spacing)[X]	No. of pods plant^{-1}	No. of seed pod^{-1}	Weight of seed plant^{-1} (g)
N_0S_1	17.5 i	10.7 f	8.4 d
N_0S_2	27.3 g	11.7 cdef	9.3 d
N_0S_3	25.6 h	11.6 def	8.9 d
N_1S_1	24.3 h	10.9 ef	11.1 c
N_1S_2	38.6 c	12.2 cde	12.6 abc
N_1S_3	36.3 d	11.8 cdef	11.7 bc
N_2S_1	29.4 f	12.0 cdef	8.5 d
N_2S_2	35.3 de	14.9 a	13.0 ab
N_2S_3	34.3 e	13.2 bc	12.8 abc
N_3S_1	40.4 b	13.0 bcd	11.2 c
N_3S_2	43.3 a	15.1 a	13.9 a
N_3S_3	42.3 a	14.0 ab	12.5 abc
LSD (0.05)	1.6	1.5	1.7
CV (%)	2.8	7.1	8.9

[X] N_0 (control), N_1 (40 kg ha^{-1}), N_2 (80 kg ha^{-1}), N_3 (120 kg ha^{-1}) ,S_1 (20 x 10 cm), S_2 (25 x 10 cm), S_3 (30 x 10 cm)

[Y] 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.

Number of seed pod^{-1}

Different levels of nitrogen showed significant variation on seed per pod (Table 3). The highest number of seed per pod (14.0) was observed in N_3 (120 kg/ha) which was statistically identical with N_2 .The lowest number (13.6) was found from N_0 (Table 3). Similar results were reported by Data *et al.* (2005) who reported that the number of seeds in pod of fenugreek increased with increasing nitrogen levels. On the other hand, Shalaby and Mohamed (1976) reported that the number of seeds in pod decreased with increasing nitrogen levels. Spacing significantly influenced the number of seed pod^{-1} (Table 4). Increase of spacing increased the number of seed pod^{1} significantly.

Table 5. Interaction effect of nitrogen levels and spacing Seed yield (Kg) ha^{-1}.

Combination	Seed yield (kg ha^{-1})
N_0S_1	335.3 f
N_0S_2	399.6 e
N_0S_3	493.6 d
N_1S_1	538.0 cd
N_1S_2	562.7 c
N_1S_3	589.4 c
N_2S_1	672.9 b
N_2S_2	695.9 b
N_2S_3	768.6 a
N_3S_1	777.6 a
N_3S_2	787.9 a
N_3S_3	801.7 a
LSD (0.05)	54.40
CV (%)	5.19

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

The spacing of (25 cm × 10 cm) produced the highest number of seed pod^{-1} (13.5) lowest number of secondary branches plant^{-1} (11.6). The result of the present investigation regarding seeds per umbellate in coriander is in agreement with Bhandari and Gupta (1993).

Seed per pod was significantly influenced by the interaction effect of nitrogen levels and spacing (Table 5). The maximum seed per pod (15.1) produced by the interaction effects of N_3 (120 kg/ha) with 25 cm × 10 cm spacing which was similar with N_3S_2 combination, which was similar with N_3S_2. The lowest seed (10.7) pod^{-1} was produced by the interaction effects of nitrogen (0 kg/ha) with 20 cm x10 cm spacing. Zandi *et al.* (2011) observed that number of seed per pod increase with increasing combination of nitrogen and spacing.

Weight of seed plant^{-1} (g)

Nitrogen levels showed significant variation on weight of seed plant^{-1} (Table 3). The maximum weight of seed plant^{-1} (12.5 g) was observed from N_3 (120 kg/ha) which was followed by N_1 (40 kg/ha) and the minimum (8.8 g) was found in N_0 (control) (Table 3).

The weight of seed plant^{-1} differed significantly due to variation of spacing and as the spacing increased the weight of seed plant^{-1} also increased significantly (Table 4).

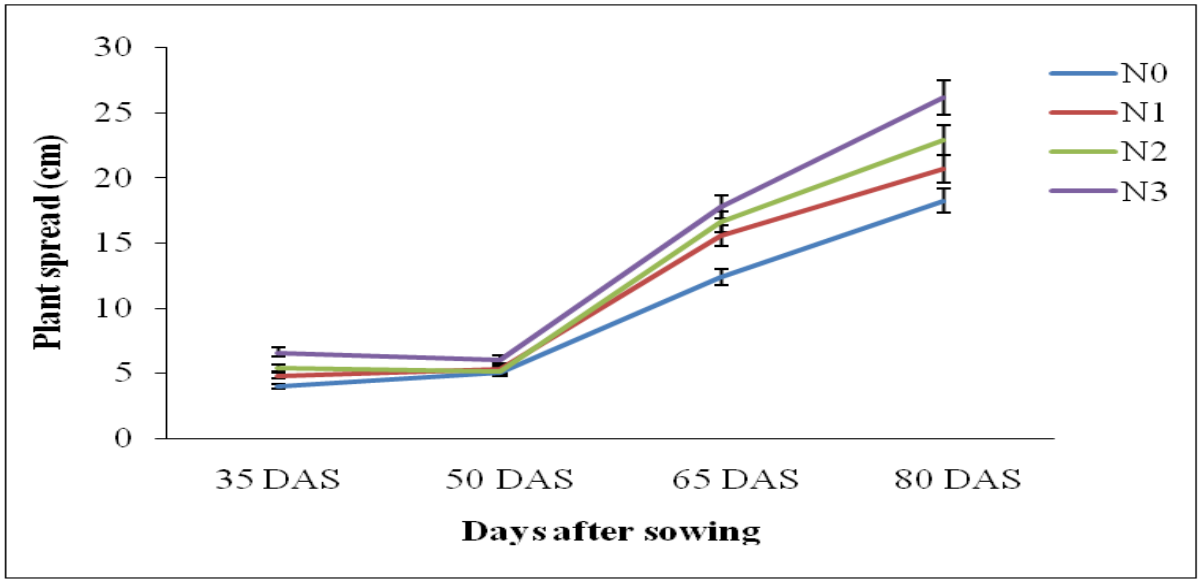

Fig. 1. Effect of different levels of nitrogen at different DAS on plant spread (cm) (DAS= Days after sowing, N_1 = 40 kg ha^{-1}, N_2= 80 kg ha^{-1}, N_3 =120 kg ha^{-1}, Error bar represents standard deviation).

The maximum weight of seed plant^{-1} (9.2 g) was found from the spacing of 25 cm × 10 cm which was similar with spacing 30 cm × 10 cm and the lowest (8.4) was found from 20 cm × 10 cm spacing. This implies that an inter-row spacing of 30 cm was best for a seed crop of fenugreek, and beyond that it was ineffective and not beneficial Similar kind of results have also been reported by Tuncturk (2011), Gowda *et al.* (2006), Singh *et al.* (2005), Basu *et al.* (2004) and Yadav *et al.* (2000).

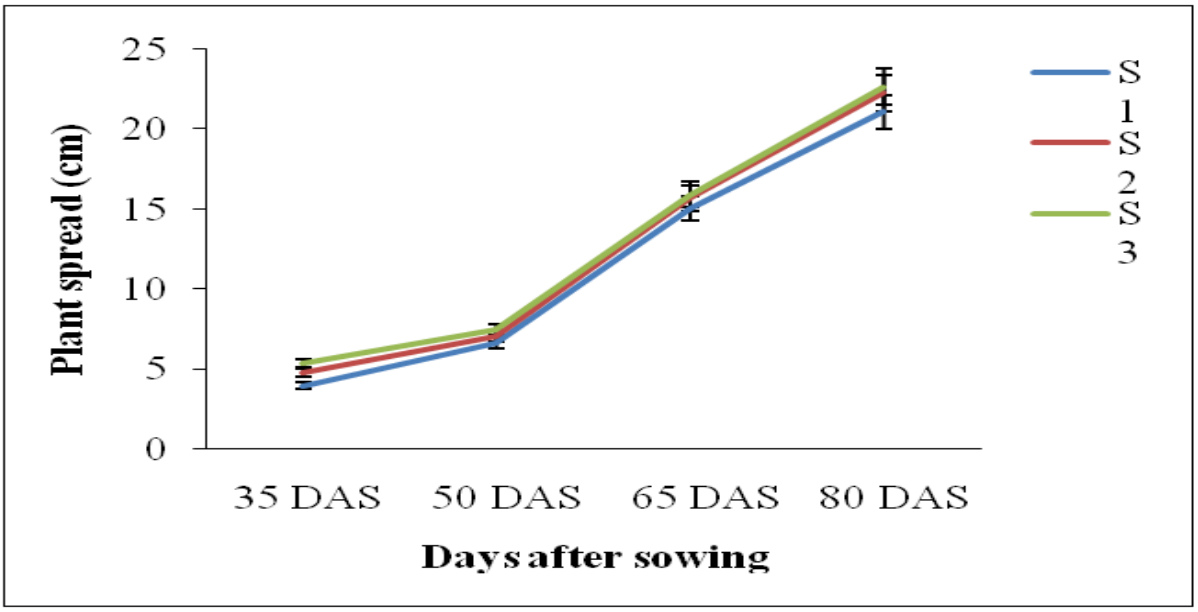

Fig. 2. Effect of different spacing at different DAS on plant spread (cm) (DAS = Days after sowing, S_1 = 20 cm × 10 cm, S_2 =25 cm × 10 cm, S_3 = 30 cm × 10 cm; Error bar represents standard deviation).

Seed weight (g) plant^{-1} was significantly influenced by the interaction effect of nitrogen levels and spacing (Table 5). The maximum Seed weight (g) plant^{-1} (13.9 g) produced by the interaction effects of N_3 (120 kg/ha) with 25 cm × 10 cm spacing which was similar with N_3S_2 combination, which was similar with N_3S_3 and N_2S_3. The lowest weight of seed (8.4 g) plant^{-1} was produced by the interaction effects of nitrogen (0

kg/ha) with 20 cm × 10 cm spacing which was similar with nitrogen (0 kg/ha) with 25 cm × 10 cm. Nitrogen level might be attributed to the increased photosynthetic activities, translocation and accumulation of photosynthates from source to the developing sinks (seeds) resulting into higher yield of bolder and heavier seeds.

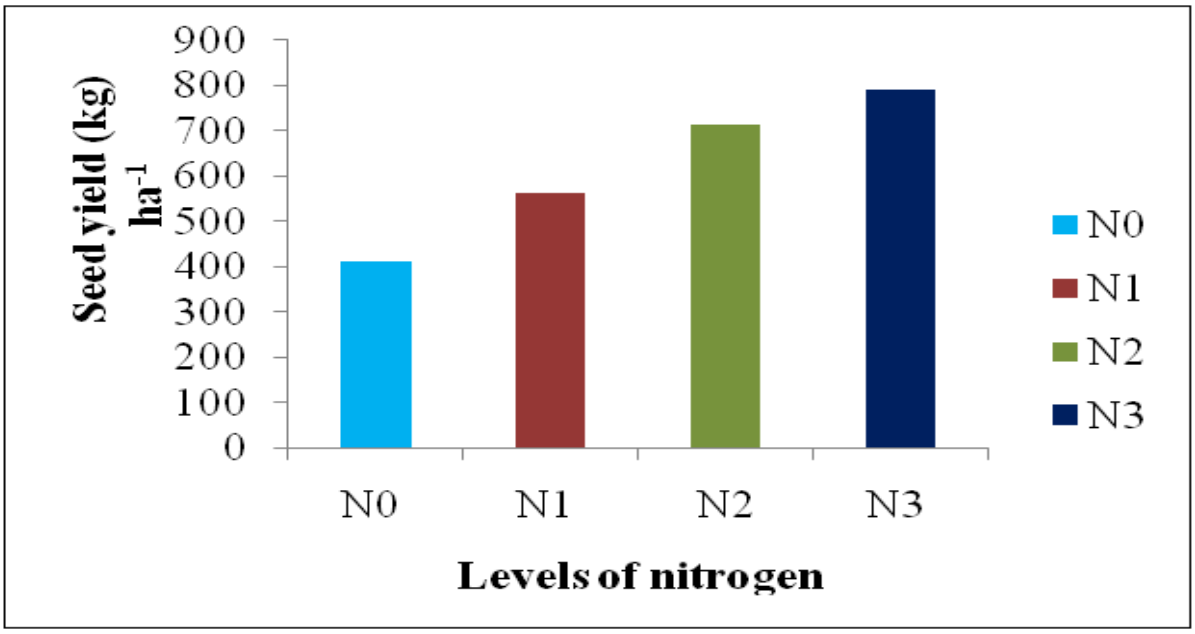

Fig. 3. Effect of different levels of nitrogen on seed yield (kg) ha^{-1} N_1 (40 kg ha^{-1}), N_2 (80 kg ha^{-1}), N_3 (120 kg ha^{-1}).

These results are in agreement with those of Dwivedi *et al.* (2002) in dolichos bean and Data *et al.* (2005) in fenugreek.

Seed yield (kg ha-1)

Seed yield showed significant inequality among the varieties shown in Figure 3.

The highest seed yield (789.0 kg ha^{-1}) was recorded by nitrogen fertilizer application (N_1:120 kg ha^{-1}).

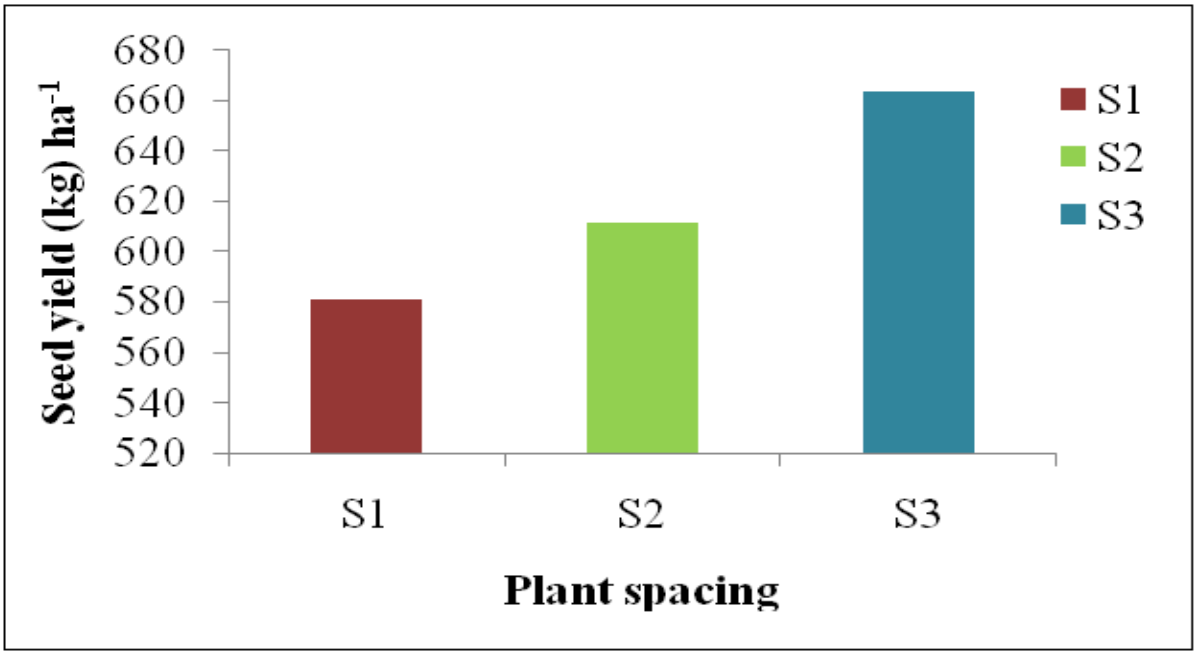

Fig. 4. Effect of different spacing on seed yield (kg) $ha^{-1}S_1$ (20 x 10 cm), S_2 (25 x 10 cm), S_3 (30 x 10 cm).

The lowest seed yield (409.5 kg ha^{-1}) was obtained from without nitrogen fertilizer (N_0). Jagdale and Dalve (2010) observed that 120 kg nitrogen in a hectare of land increasing seed yield of fenugreek plant. Similarity was found by Tuncturk *et al.*(2011) application of nitrogen fertilizer increase seed yield of fenugreek.

Seed yield exerted significant inequality among the different spacing (Figure 04). Result revealed that the highest seed yield (663.3 kg ha^{-1}) was recorded from spacing S_3 (30 cm x 10 cm) and the lowest yield (580.9 kg ha^{-1}) was obtained from spacing S_1 (20 cm x 10 cm). Bairagi (2014) find out row spacing increase seed yield in fenugreek plant because less competition for food materials as a result plant produces more seed.

Interaction between different levels of nitrogen and plant population density played an important role for promoting the seed yield. Seed yield exposed significant inequality due to different levels of nitrogen and spacing combinations (Table 5).

The highest seed yield (801.7 kg ha^{-1}) was recorded from N_3 (120 kg ha^{-1}) with 30 cm x 10 cm spacing 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 combination.

The lowest seed yield (N_0S_1: 335.3 kg ha^{-1}) was recorded from without nitrogen with 20 cm x 10 cm spacing. Zandi *et al.* (2011) observed that seed yield increase with increasing levels of nitrogen with population density combination. Moosavi *et al.* (2012) also found same result by application of 150 ka nitrogen ha^{-1}.

Conclusion

Lastly, it can be concluded that combined use of 120 kg N ha^{-1} and 30 cm x 10 cm spacing was the best combination among the other used on the experiment which was followed by combination of 120 kg N ha^{-1} and 25 cm x 10 cm spacing might be used as the used in the farmer's levels after repeated trial. It would be beneficial to increase the seed yield of fenugreek.

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