International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1401-1405

Received: 03-05-2020
Accepted: 08-06-2020

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Response of fenugreek (*Trigonella-foenum-graecum*) to different levels of nitrogen and phosphorus

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4m.9794

Abstract
An experiment was conducted during the *rabi* season of 2014-15, to study the "Effect of nitrogen and phosphorus on growth and seed yield of fenugreek" at the Main garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Factorial Randomized Block Design with three replications. Twelve treatment combinations were formed with a view to integrate four nitrogen doses and three phosphorus doses. The allocation of treatments was made by random method. On the basis of results obtained in the present investigation, that growth parameters *viz.*, plant height and number of branches were significantly better with application of 100 kg N + 60 kg P per hectare. Whereas, the seed yield per hectare was observed significantly maximum with application of the treatment of 80 kg N + 60 kg P per hectare.

Keywords: Fenugreek, vegetative growth, maturity parameters, nitrogen, phosphorus and yield

Introduction
Fenugreek (*Trigonella foenum-graecum* Linn.) is an important seed spice specially known as methi. It is an annual herb of leguminosae family. Fenugreek is the third largest seed spice in India after coriander and cumin (NBH2011-12). Fenugreek is an important condiment crop grown in Southern India during the kharif and rabi seasons. In India, fenugreek seed production is being under taken on 115.6 thousand hectares area with an annual production of 136.6 thousand tonnes and having productivity of 1.2 tonnes ha^{-1}. The Maharashtra occupies 1122 hectares of area under fenugreek cultivation with an annual production of 4519 tonnes and having productivity of 4.02 tonnes ha^{-1}. In Vidarbha region it is being cultivated on an area of 278 ha with annual production of 1134 tonnes and average productivity of 5.77 tonnes ha^{-1} (Anon., 2014) [1]. Fenugreek is a rich source of wide variety of components. Fenugreek seeds substantially contain 'Diosgenin' which is used as a starting material in the synthesis of sex hormones. The content of diosgenin in fenugreek seeds varies from 0.40-1.26%. Minerals like Ca (360.0 mg), P (51.0 mg), Thiamine (0.05 mg), Riboflavin (0.15 mg), Na (76.0 mg), K (31.0 mg), Cu (0.26 mg) and Mg (67.0 mg per 100 g fresh weight) are occurred abundantly in fenugreek. It is also a rich source of Vitamin A and C (Das, 1992) [2]. Medicinal value of fenugreek is well recognized in India since antiquity. Methi seeds and leaves are important particularly against the digestive disorders (Sheoran *et al*. 1999) [11] and useful for diabetic patients. Fenugreek seeds are mainly used as a spice for the preparation of different tasty dishes. It also have a high medicinal and industrial importance. It prevents constipation, removes indigestion, stimulates spleen and liver, and is appetizing and diuretic. Seeds are of industrial importance as used for dye and for extraction of alkaloids or steroids. It is also used as a fodder. Indian women use to consume the seeds of fenugreek for its power to promote lactation.
Generally, seed production of methi is taken after 2-3 cuttings, but seed yield obtained without cuttings are better than the seed yield obtained from 2-3 cuttings. It is, therefore, recommended to take seed production of methi without any cuttings (Gill and Singh, 1988) [33]. In Maharashtra, though methi is cultivated as an important leafy vegetable and is also grown as a spice, but less attention is being paid on its commercial seed production. Scientific seed production resembles the importance of quality seed to be used for raising of crop in order

to get the higher production of good quality. The less availability of quality seeds has been one of the drawback in getting an increased agricultural production in vegetable crops. The availability of pure and good quality seeds has a significance in vegetables seed production; where, more uniformity of The colour, size and purity is required. Although, the seed production in vegetables are highly profitable, yet the growers are afraid to take up this venture because of lack of technical knowledge in production technology. Fenugreek seed production is a highly specialized job and it requires intimate knowledge of crop production particularly, the floral biology, mode of pollination, isolation, climatic requirement and nutritional requirements.

Materials and Methods

The field experiment was conducted during the *rabi* season of 2014-15, to study the “Effect of nitrogen and phosphorus on growth and seed yield of fenugreek” at the Main garden, University Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Akola is situated in the sub-tropical zone at the latitude of 22°42N and longitude of 77°02E. The altitude of the place is 307.4 m from mean sea level. The experiment was laid out in Factorial Randomized Block Design with 12 treatments replicated for three times. The layout consisted of 36 plots. The treatments consisted of two factors, nitrogen doses and phosphorus doses. In first factor there are four different nitrogen doses *viz*. N_1 (40kg ha^{-1}), N_2 (60kg ha^{-1}), N_3 (80kg ha^{-1}) and N_4 (100kg ha^{-1}). In second factor there different phosphorus doses *viz*. P_1 (20kg ha^{-1}), P_2 (40kg ha^{-1}) and P_3 (60kg ha^{-1}). Thus in all twelve treatment combinations were studied to find out the suitable combination of nitrogen and phosphorus doses for maximum production of fenugreek. The sowing was done by flat bed system on 24th of December 2014 with spacing of 30cm between rows and 10 cm between plants. The gross and net plot size were 1.8 m X 1.8 m (3.24 m^2) and 1.2 m x 1.7 m (2.04 m^2).

The soil type of experimental plot was medium black, clay loam and well drained. It was low in available nitrogen (146 kg ha^{-1}), medium in phosphorus (16 kg ha^{-1}) and high in potassium (290 kg ha^{-1}). It was alkaline in reaction (pH 8.1) having EC (0.45 dSm^{-1}). The fenugreek cv. Pusa Early Bunching recommended for all states of northern India, released from CCSHAU, Hisar. It is a mid –late variety with medium to small, oval shaped seeds. Seeds having a light red colour at the time of maturity, dual purpose variety grown for both spices as well as leaves, spreading in nature and resistant to water lodging. it is a high yielding cv. average yield is 20-25q/ha. The doses of nitrogen fertilizer given through use of urea (46% N) and phosphorus through single super phosphate (16% P_2O_5). The experimental field was irrigated immediately after sowing and subsequent irrigations were given to the plots at an interval of 3-4 days during the period of experimentation. Observations were recorded on different parameters, *viz.*, Plant height(cm), No. of branches, Days required for harvesting, Days required for first flowering, Days required for 50% flowering, No. of pods per plant, No. of seeds per pod, Seed yield per plant(g), Seed yield per plot(kg) and Seed yield per hectare(q). The data were statistically analyzed as per the method prescribed and suggested by Panse and Sukhatme (1985) [10].

Results and Discussion

Plan height and number of branches

Effect of nitrogen levels: A perusal of data on (Table 1) revealed that plant height was significantly influenced by different levels of nitrogen at different growth stages. At 60 DAS, the nitrogen level 100 Kg ha^{-1} recorded significantly maximum plant height (46.93 cm) which was found to be superior over all other treatments. However minimum plant height (42.74 cm) was recorded in treatment 40 Kg Nha^{-1}.Similarly, at 90 DAS also the nitrogen level 100 kg nitrogen recorded significantly maximum plant height (80.85 cm) which was statistically found to be at par with treatment 60 Kgha^{-1}.Whereas, minimum plant height (75.38 cm) was recorded with treatment 40 Kg Nha^{-1}. This was probably happened due to favourable function of nitrogen, being a major structural constituent of cell, help in stimulating the cell division and cell elongation. The nitrogen rate of 100 Kg Nha^{-1} gave the significantly maximum height of plant. This finding collaborate the results of Nath *et al.* (2008), Moosavi *et al*. (2013) [9], Lokhande *et al*. (2015) [7] and Meena *et al*. (2015) [8] in various seed spices.

In case of number of branches, at 60 DAS, the nitrogen levels 80 Kg Nha^{-1} recorded significantly maximum number of branches (4.13) which was significantly superior over all other treatments. Whereas, minimum number of branches (3.42) were recorded with treatment 40 Kg Nha^{-1}. At 90 DAS, the nitrogen level 80 Kg Nha^{-1} recorded maximum number of branches (4.88) and the minimum number of branches (3.77) was recorded with 40 Kg Nha^{-1}. Number of branches per plant had contributing effect on seed yield, thus this parameter could be used as indicator of improving yield potential in coriander. Similar results were obtained during experiment of Khan *et al.* (2005) [6] and Jat *et al.* (2012) [5].

Effect of Phosphorus levels

In case of plant height was also significantly influenced by different levels of phosphorus at different growth stages. At 60 DAS, the phosphorus level 60 kg phosphorus recorded maximum plant height (45.09cm) which was significantly superior to other levels. However, minimum plant height (44.56cm \) was recorded with 20Kg Pha^{-1}. Similarly, At 90 DAS, the phosphorus level 60 kg recorded maximum plant height (78.48cm) which was significantly superior over all other treatments. Whereas, minimum plant height (77.38cm) was recorded with 20 Kg Pha^{-1}. Application of phosphorus increased vegetative growth of the plant. Similar results were found by Shirmohammadi *et al.* (2014) [12] during his experiment on fenugreek.

In case number of branches, at 60 DAS, the phosphorus level 60 kg recorded maximum number of branches that is (3.99) which was significantly superior to all other treatments. Whereas, minimum number of branches (3.37) were recorded with 40Kg Pha^{-1}. At 90 DAS, the phosphorus level 60 Kg Nha^{-1} recorded maximum number of branches (4.18) which were found to be significantly superior over all other treatments. Whereas, minimum number of branches (4.03) were recorded with treatment 20 Kg Pha^{-1}**.** Results obtained in this study are in agreement to the study of Jat *et al.* in fenugreek.

Table 1: Plant height and number of branches as influenced by different nitrogen and phosphorus levels at different growth stages

Treatments	Plant height (cm)		Number of branches	
	60 DAS	90 DAS	60 DAS	90 DAS
Nitrogen levels				
N_1(40kg ha^{-1})	42.74	75.38	3.42	3.77
N_2(60kg ha^{-1})	43.92	76.59	3.59	3.88
N_3(80kg ha^{-1})	45.41	78.38	4.13	4.88
N_4(100 kg ha^{-1})	46.93	80.85	3.85	4.21
'F test'	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	0.14	0.15	0.05	0.05
CD at 5%	0.40	0.45	0.16	0.15
Phosphorus levels				
P_1(20 kg ha^{-1})	44.56	77.38	3.99	4.03
P_2(40 kg ha^{-1})	44.60	77.54	3.37	4.04
P_3(60 kg ha^{-1})	45.09	78.48	3.89	4.18
'F' test	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	0.12	0.01	0.05	0.04
CD at 5%	0.35	0.39	0.14	0.13

Interaction effect

The data in respect to interaction effect of nitrogen and phosphorus levels on plant height and number of branches at 60 and 90 DAS is presented in Table 2. Interaction effect due to different nitrogen and phosphorus levels on plant height and no. of branches was found to be significant. At 60 DAS, significantly maximum plant height was recorded with treatment N_4P_3. However, the minimum plant height was observed at N_1P_1. At 90 DAS, significantly maximum plant height was recorded with combination of N_4P_3 and minimum height was observed at N_1P_1. Interaction effect due to different nitrogen and phosphorus levels on number of branches was found to be significant. The maximum number of branches per plant were observed with treatment combination N_4P_3 at 60 and 90 DAS. Whereas, the minimum number of branches per plant was recorded with application of N_1P_1 combination.

Table 2: Plant height and number of branches as influenced by interaction of different nitrogen and phosphorus levels at different growth stages

Treatments combination	Interaction Effect (N×P)			
	Plant height (cm)		Number of branches	
	60 DAS	90 DAS	60 DAS	90 DAS
N_1P_1 (40kg N+20kg P)	40.93	70.81	2.80	3.54
N_1P_2(40kg N+40kg P)	42.16	75.87	3.49	3.67
N_2P_3 (40kg N+60kg P)	45.11	79.38	3.92	4.13
N_2P_1 (60kg N+20kg P)	47.98	81.50	3.87	3.96
N_2P_2 (60kg N+40kg P)	41.16	71.61	3.54	3.64
N_2P_3 (60 kg N+60kg P)	42.61	76.66	3.34	4.02
N_3P_1 (80 kg N+20kg P)	45.68	80.05	4.28	4.47
N_3P_2 (80 kg N+40kg P)	48.17	82.44	4.08	4.24
N_3P_3 (80kg N+60kg P)	42.37	72.63	4.02	3.91
N_4P_1 (100kg N+20 kg P)	43.65	77.13	4.27	4.18
N_4P_2(100kg N+40 kg P)	46.88	80.24	3.03	4.61
N_4P_3(100 kg N+60 kg P)	50.25	85.17	4.28	4.65
'F' test	Sig.	Sig.	Sig.	Sig.
S.E.(m)±	0.23	0.26	0.09	0.08
CD at 5%	0.69	0.77	0.27	0.25

Days to 50% flowering, days required for harvesting and seed yield

Days to 50% flowering

Similar to days for first flowering, minimum period to complete 50% flowering is desirable.

Effect of nitrogen

Data presented in Table.3 revealed that days to 50% flowering was significantly influenced by different nitrogen levels. 100 Kg Nha^{-1} recorded maximum days to 50% flowering (58.42) and minimum days (53.68) were recorded with 40 Kg Nha^{-1}. This was might be due to the fact that more nitrogen doses positively affect the vegetative flush because plant utilizes more applied nitrogen, due to increase nitrogen doses period for 50% flowering also delayed. Whereas, minimum days for 50% flowering are desirable. These results are in accordance with the research findings of Jagdale *et al*. (2015) [4] in fenugreek crop.

Effect of phosphorus

Days to 50% flowering was significantly influenced by phosphorus levels. Application of 60 Kg Pha^{-1} was recorded maximum days to 50% flowering (56.79), Whereas minimum days to 50% flowering (55.68) were recorded with 20 Kg Pha^{-1}. Similarly, the days required for 50% flowering also delayed significantly with increase in phosphorus levels. Phosphorus is responsible for root growth so with increase in phosphorus levels root length increases and flowering periods delays as plant have to go through prolong herbaceous growth. The minimum days to 50% flowering (55.67) were obtained with application of 20 Kg Pha^{-1} and maximum days 50% flowering (56.79) were obtained with 60 Kg Pha^{-1}.

Days required for harvesting

Minimum period for harvesting the crop is desirable.

Effect of nitrogen

Data presented in Table 3 revealed that days required for harvesting was significantly influenced by nitrogen levels. Nitrogen level 100 Kg Nha^{-1} recorded significantly maximum days for harvesting (93.13) which was statistically found to be at par with treatment 60 Kg Nha^{-1}. Whereas, minimum days for harvesting (83.00)was recorded with treatment 40kg Nha^{-1}.

Effect of phosphorus

Data presented in table 3 revealed that days required for harvesting was significantly influenced by phosphorus levels. phosphorus level 60 Kg Pha^{-1}recorded significantly maximum days for harvesting (88.63). Whereas, minimum days for harvesting (86.37) was recorded with 20 Kg Pha^{-1}.

Seed yield per hectare

The data in respect of seeds yield per hectare as influenced by different nitrogen and phosphorus levels are presented in Table 3

Effect of nitrogen

Seed yield per hectare was significantly influenced by different nitrogen levels. Significantly maximum seed yield per hectare (13.27q) was recorded with 80 Kg Nha^{-1}, which was found to be significantly superior over other treatments. Whereas, minimum seed yield per hectare (8.24q) was recorded with 40 Kg Nha^{-1}.

Effect of phosphorus

Seed yield per hectare was significantly influenced by different phosphorus levels. Significantly maximum seed yield per hectare (11.96q) was recorded with 60 Kg Pha^{-1}. However, minimum seed yield per hectare (10.15q) was recorded with 20 Kg Pha^{-1}.

Table 3: Days to 50% flowering, days required for harvesting and seed yield as influenced by different nitrogen and phosphorus levels at different growth stages

Treatments	Days to 50% flowering	Days required for harvesting	Seed yield (q ha^{-1})
Nitrogen levels			
N_1(40Kgha^{-1})	53.68	83.00	8.24
N_2(60Kgha^{-1})	55.46	85.28	10.72
N_3(80Kgha^{-1})	57.40	88.01	13.27
N_4(100 Kgha^{-1})	58.42	93.13	12.35
'F' test	Sig.	Sig.	Sig.
S.E.(m)±	0.04	0.09	0.13
CD at 5%	0.11	0.27	0.37
Phosphorus levels			
P_1(20 kg ha^{-1})	55.68	86.37	10.15
P_2(40 kg ha^{-1})	56.25	87.06	11.32
P_3(60 kg ha^{-1})	56.79	88.63	11.96
'F' test	Sig.	Sig.	Sig.
S.E.(m)±	0.03	0.08	0.11
CD at 5%	0.09	0.23	0.32

Interaction effect

Interaction effect due to different nitrogen and phosphorus levels on days to 50% flowering was found to be significant. The maximum days to 50% flowering was recorded with treatment N_4P_3. And the minimum days to 50% flowering was observed with treatment N_1P_1. Interaction effect due to different nitrogen and phosphorus levels on days required for harvesting was found to be significant. The maximum days for harvesting were observed with treatment combination N_4P_3 at 30,60 and 90 DAS. Whereas, the minimum number of branches per plant was recorded with application of N_1P_1 combination. Interaction effect due to different nitrogen and phosphorus levels on seed yield per hectare was found to be significant. The significantly maximum seed yield per hectare was received from the treatment N_3P_3. Whereas, minimum yield per hectare was recorded from treatment of N_1P_1.

Days to 50% flowering delayed significantly due to application of different nitrogen levels. Minimum days for 50% flowering (53.67) were recorded with application of 40 Kg Nha-1 and maximum days for 50% flowering (58.41) were obtained from 100 Kg Nha-1 This was might be due to the fact that more nitrogen doses positively affect the vegetative flush because plant utilizes more applied nitrogen, due to increase nitrogen doses period for 50% flowering also delayed. Whereas, minimum days for 50% flowering are desirable. These results are in accordance with the research findings of Jagdale *et al*. (2015) [4] in fenugreek crop. Similarly, the days required for 50% flowering also delayed significantly with increase in phosphorus levels. Phosphorus is responsible for root growth so with increase in phosphorus levels root length increases and flowering periods delays as plant have to go through prolong herbaceous growth. The minimum days to 50% flowering (55.67) were obtained with application of 20 Kg Pha-1 and maximum days 50% flowering (56.79) were obtained with 60 Kg Pha-1.

The observation days required for harvesting was significantly increased with increase of nitrogen levels. This might be due to this fact that with increase of nitrogen levels vegetative growth prolongs and crop takes more time for harvesting. Hence, minimum days for harvesting are desirable. The minimum days for harvesting (83.00) were observed with application of 40 Kg Nha^{-1} and the maximum days for harvesting (93.13) were recorded with treatment 100 Kg Nha^{-1}. Similarly, there were significant effect of phosphorus levels on days required for harvesting. The minimum days required for harvesting (91.48) were recorded with application of 20 Kg Pha^{-1}. Whereas, maximum days required for harvesting were (94.61) with 60 Kg Pha^{-1} Seed yield per hectare in crop was significantly influenced by increased nitrogen level. This was probably due to application of higher nitrogen doses resulted in better growth and good seed yield per plant and per plot which subsequently increased seed yield per hectare. The increase phosphorus levels also significantly influenced the seed yield per hectare. Since the application of phosphorus significantly increased the number of pods per plant and seeds per pod etc. Hence, seed yield per hectare was also increased with increased phosphorus application of phosphorus. Maximum number of seed yield per ha (11.96 q) was recorded with 60 Kg Pha^{-1} and the minimum seed yield per ha (10.15 q) was recorded with application of 20 Kg Pha^{-1}.

Table 4: Days to 50% flowering, days required for harvesting and seed yield as influenced by interaction of different nitrogen and phosphorus levels at different growth stages

Treatments combination	Interaction Effect (N×P)		
	Days to 50% flowering	Days required for harvesting	Seed yield (q ha^{-1})
N_1P_1 (40 kg N + 20 kg P)	53.16	82.29	6.97
N_1P_2 (40 kg N + 40 kg P)	53.70	82.71	8.38
N_2P_3 (40 kg N + 60 kg P)	54.17	83.99	9.39
N_2P_1 (60 kg N + 20 kg P)	54.52	84.74	9.81
N_2P_2 (60 kg N + 40 kg P)	55.53	85.10	10.76
N_2P_3 (60 kg N + 60 kg P)	56.32	86.00	11.58
N_3P_1 (80 kg N + 20 kg P)	57.03	86.80	11.96
N_3P_2 (80 kg N + 40 kg P)	57.43	87.62	13.50
N_3P_3 (80 kg N + 60 kg P)	57.75	89.60	14.35
N_4P_1 (100 kg N +20 kg P)	58.00	91.64	11.88
N_4P_2(100 kg N +40 kg P)	58.33	92.83	12.66
N_4P_3(100 kg N +60 kg P)	58.92	94.92	12.52
'F' test	Sig.	Sig.	Sig.
S.E.(m)±	0.06	0.16	0.22
CD at 5%	0.19	0.46	0.64

Conclusions

The maximum vegetative growth of the plant i.e. plant height and number of branches were the maximum with an application of 100 kg nitrogen ha^{-1} and 60 kg phosphorus ha^{-1}. The maximum days were required for first flower initiation, 50 per cent flowering, and maturity of seed crop due to the higher level of fertilizer application i.e. 100 kg nitrogen ha^{-1} and 60 kg phosphorus ha^{-1}.The seed yield per hectare was the highest (12.52 q ha^{-1}) with an application of 100 kg nitrogen $ha^{-1}$and 60 kg phosphorus ha^{-1}.

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