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Influence of nitrogen and phosphorus levels on yield, soil status and economics of fenugreek (*Trigonella-foenum-graecum*)

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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, the yield parameters in respect to number of pods per plant, seeds per pod seed yield per hectare were observed significantly maximum in the treatment T_9 (N_3P_3) i.e. 80kg N+60kg P. Considering the cost economics, nitrogen level N_3 (80 kg ha $^{-1}$) and phosphorus level P_3 (60 kg ha^{-1}) was found to be most remunerative as per the B:C ratio (2.51).

Keywords: Fenugreek, yield parameters, Gross return, Net return, cost of cultivation, benefit cost ratio, 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) [3]. 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) [5]. 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) [9].

Results and Discussion

Number of pods per plant, Seeds per pod and seed yield

Effect of nitrogen levels

A perusal of data on (Table 1) revealed that number of pods per plant, seeds per pod and seed yield were significantly influenced by different levels of nitrogen at different growth stages. In case of number of pods per plant the data revealed that maximum number of pods (27.33) per plant were recorded with treatment 80 kg Nha^{-1} which was found to be superior over all other treatments. However, the minimum number of pod per plant (13.14) were recorded with 40 kg Nha^{-1}. And in case of number of seeds per pod, the maximum seeds per pod (13.64) were recorded with 80 Kg Nha^{-1}.Whereas, the minimum number of seeds per pod (9.01) were observed with application of 40 kg Nha^{-1}. The nitrogen levels show significant increase in seeds per pod. Up to 80 kg N ha^{-1}. In case Seed yield 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}. This was probably due to application of higher nitrogen doses resulted in better growth and good seed yield which increased seed yield per hectare. Increased nitrogen level found to have more number of pods per plant and seeds per pod as yield contributing characters. It might be due to fact that, profused nodulation leading to increased nitrogen fixation, which might in turn had profused effect on photosynthetic activity of plant. It accumulates food materials in seed. The results of this investigation supports the results of Patel *et al*. (2010) [10], Chaudhary *et al.* (2011) [4], and Mehta *et al*. (2012) [7] in fenugreek.

Effect of phosphorus

A perusal of data on (Table 1) also revealed that number of pods per plant, seeds per pod and seed yield were significantly influenced by different levels of phosphorus at different growth stages. The significantly maximum pods per plant (18.47) were recorded with 60 kg Pha^{-1} which was superior among all other treatments. Whereas, minimum number of pods (17.24) were recorded with treatment 20 kg Pha^{-1}. Significantly maximum seeds per pod (11.65) were recorded with 60kgPha^{-1}.Whereas, least number of seeds per pod (10.61) were recorded with treatment 20 Kg Pha^{-1}. 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}. The seed yield per plant increased with increase of phosphorus application may be due to improved nutritional condition. The higher uptake of nitrogen and phosphorus during seed formation might have increased number of seeds per plant. There was a significant increase in dry matter accumulation at different growth stage which finally reflected in significant improvement in productivity of crop. Significantly maximum seed yield per plant was recorded with 60 kg P ha^{-1} and the minimum was recorded with 20 kg P ha^{-1}. Similar results were observed by Sheron *et al.* (1999), Jat *et al.* (2001) [6] and Patel *et al.* (2010) [10].

Interaction effect

Interaction effect due to different nitrogen and phosphorus levels on number of pods per plant, seeds per pod and seed yield were found to be significant. The maximum pods per plant (22.77) was recorded from treatment N_3P_3 i. e. 80 kg N and 60 kg P per hectare. Minimum pods per plant (12.51) was recorded with treatment combination N_1P_1 i.e.40 kg N and 20 kg P per hectare. The maximum seed per pod (14.23) was recorded from treatment N_3P_3 i. e. 80 kg N and 60 kg P per hectare. 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 (14.35q) was received from the treatment N3P3 i. e. 80 kg N

and 60 kg P per hectare. Whereas, minimum yield per hectare (6.96q) was recorded from treatment of N1P1. The results of this investigation supports the results of Mavai *et al*. (2000) [8], Patel *et al.* (2010) [10] and Bairagi (2014) [2] in fenugreek.

Table 1: Number of pods, seed per pod and seed yield as influenced by different nitrogen and phosphorus levels

Treatments	Number of pods plant^{-1}	Seeds per pod	Seed yield (q ha^{-1})
Nitrogen levels			
N_1(40Kg ha^{-1})	13.14	9.01	8.24
N_2(60Kg ha^{-1})	15.37	10.19	10.72
N_3(80Kg ha^{-1})	27.33	13.64	13.27
N_4(100 Kg ha^{-1})	24.59	11.61	12.35
'F' test	Sig	Sig	Sig
S.E.(m)±	0.03	0.03	0.13
CD at 5%	0.10	0.10	0.37
Phosphorus levels			
P_1(20 Kgha^{-1})	17.24	10.61	10.15
P_2(40 Kgha^{-1})	17.87	11.08	11.32
P_3(60 Kgha^{-1})	18.47	11.65	11.96
'F test'	Sig.	Sig.	Sig.
S.E.(m)±	0.03	0.03	0.11
CD at 5%	0.08	0.09	0.32

Table 2: Number of pods, seed per pod and seed yield as influenced by interaction of different nitrogen and phosphorus levels

Treatments combination	Interaction Effect (N×P)		
	Number of pods plant^{-1}	Seeds per pod	Seed yield (q ha^{-1})
N_1P_1 (40 kg N + 20 kg P)	12.51	8.61	6.97
N_1P_2 (40 kg N + 40 kg P)	13.16	8.95	8.38
N_2P_3 (40 kg N + 60 kg P)	13.76	9.48	9.39
N_2P_1 (60 kg N + 20 kg P)	14.74	9.74	9.81
N_2P_2 (60 kg N + 40 kg P)	15.31	10.18	10.76
N_2P_3 (60 kg N + 60 kg P)	16.07	10.66	11.58
N_3P_1 (80 kg N + 20 kg P)	21.47	12.99	11.96
N_3P_2 (80 kg N + 40 kg P)	22.20	13.68	13.50
N_3P_3 (80 kg N + 60 kg P)	22.77	14.23	14.35
N_4P_1 (100 kg N +20 kg P)	20.24	11.12	11.88
N_4P_2(100 kg N +40 kg P)	20.79	11.49	12.66
N_4P_3(100 kg N +60 kg P)	21.28	12.23	12.52
'F test'	NS	Sig.	Sig.
S.E.(m)±	0.05	0.05	0.22
CD at 5%	-	0.17	0.64

Nutrient status of soil after harvesting of crop

Effect of nitrogen levels

Data presented in table number 3 indicated that, the available nutrient content in soil after harvest, significantly influenced by different nitrogen levels. The treatment 100 kg recorded significantly maximum nitrogen and phosphorus (235.70 and 30.20 kg ha $^{-1}$),which was significantly superior over other treatment. Whereas minimum levels of nitrogen and phosphorus in soil after harvest was recorded with treatment 40 kg N ha^{-1}.

Available nitrogen and phosphorus content of the soil after harvesting was influenced significantly due to the nitrogen levels. Significantly maximum soil nitrogen and phosphorus after harvesting was noted from the plot which received 100 kg N ha $^{-1}$. whereas it was significantly minimum under plot which received 40 kg ha^{-1}. It was probably due to the fact that plants from the plot where maximum nitrogen were applied, utilized nitrogen up to a certain limit which resulted maximum nitrogen level in soil after harvesting the crop.

Effect of phosphorus levels

Available nutrient content in soil was significantly influenced by phosphorus levels. The maximum nitrogen and phosphorus levels (233.25 and 28.44 kg ha $^{-1}$) was recorded from 60 kg P ha^{-1} and the minimum phosphorus in soil after harvest was recorded with treatment 20 kg P ha^{-1}. An available nitrogen and phosphorus content of soil was influenced significantly due to the phosphorus levels. Significantly maximum soil phosphorus was noted from the plot which received 60 kg P ha^{-1}. Whereas, levels of nitrogen and phosphorus after harvest was minimum from the plot which received 20 kg P ha^{-1}.

Interaction effect

Interaction effect due to different nitrogen and phosphorus levels on available nutrient in soil after harvesting was found to be non- significant.

Table 3: Nutrient status of soil after harvesting as influenced by different nitrogen and phosphorus levels

Treatments	Nutrient uptake(kg ha $^{-1}$)	
	Nitrogen	Phosphorus
Nitrogen Levels		
N_1(40Kgha^{-1})	229.15	26.76
N_2(60Kgha^{-1})	230.84	27.80
N_3(80Kgha^{-1})	233.76	28.97
N_4(100Kgha^{-1})	235.70	30.20
'F' Test	Sig	Sig
SE(m) ±	0.10	0.04
CD at 5%	0.30	0.11
Phosphorus levels		
P1(30Kgha$^{-1)}$	231.64	28.01
P2 (40Kgha$^{-1)}$	232.20	24.84
P3(50Kgha^{-1})	233.25	28.44
F' Test	Sig	Sig
SE(m) ±	0.09	0.03
CD at 5%	0.20	0.09
Interaction effect(N×P)		
F' Test	Sig	NS
SE(m) ±	0.18	0.06
CD at 5%	0.52	-----

Economics of treatments

Data presented in table 4 indicated that, highest net return (86401 Rs per ha), highest gross return (143500 Rs per ha) and highest benefit cost ratio (2.51) was recorded from treatment N_3P_3 i.e. 80 kg N and 69 kg P ha^{-1}. The maximum net return of Rs. 86401 Rs per ha and B:C was recorded in the treatment of 80 kg N and 60 kg P ha $^{-1}$. Owing to higher yield of fenugreek 40 kg nitrogen and 20 kg phosphorus. The results obtained in this study were in range of those given by Chaudhary *et al*. (2011) [4], Mehta *et al*. (2012) [7] and Patel *et al*. (2010) [10].

Table 4: Cost of cultivation, Gross return, Net return and cost benefit ratio as influenced by different nitrogen and phosphorus levels

Treatments	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C ratio
N1P1 (40 kg N + 20 kg P)	69600	43782.08	25817.92	1.58
N1P2 (40 kg N + 40 kg P)	83700	46152.4	37547.6	1.81
N2P3 (40 kg N + 60 kg P)	93800	47855.94	45944.05	1.96
N2P1 (60 kg N + 20 kg P)	98000	48576.22	49423.77	2.01
N2P2 (60 kg N + 40 kg P)	107500	50608.41	56891.59	2.12
N2P3 (60 kg N + 60 kg P)	115800	52012.06	63787.94	2.22
N3P1 (80 kg N + 20 kg P)	119500	52648.94	66851.06	2.26
N3P2 (80 kg N + 40 kg P)	135000	55252.55	79747.45	2.44
N3P3 (80 kg N + 60 kg P)	143500	57098.07	86401	2.51
N4P1 (100 kg N +20 kg P)	118800	53001.72	65798.28	2.24
N4P2(100 kg N +40 kg P)	126500	54305.26	72194.73	2.32
N4P3(100 kg N +60 kg P)	125200	54108.88	71091.12	2.31

Conclusions

For yield the treatment combination $(N_3P_3)T_8$ i. e. 80 kg N + 20 kg P per hectare were found to be significantly superior. The significantly maximum pods per plant (22.77), seed yield per pod (14.23) and seed yield per hectare (14.35q), Available nitrogen and phosphorus levels in soil after harvesting of fenugreek was significantly affected with different nitrogen and phosphorus combinations. The cost economics, nitrogen level N_3 (80 kg ha $^{-1}$) and phosphorus level P_3 (60 kg ha^{-1}) was found to be most remunerative as per the B:C ratio (2.51)

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