International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, 2018, pp.-6336-6338.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

INFLUENCE OF INTEGRATED PHOSPHORUS MANAGEMENT AND GROWTH REGULATORS ON GROWTH AND YIELD OF FENUGREEK (*Trigonella foenum graecum* L)

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Received: June 03, 2018; Revised: June 11, 2018; Accepted: June 12, 2018; Published: June 15, 2018

Abstract: A field experiment was conducted during *rabi* season of 2016-17 on loamy sand soil at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand to study the "Influence of integrated phosphorus management and growth regulators on growth and yield of fenugreek (*Trigonella foenum-graecum* L.)". The experiment comprises twelve treatments and replicated four times. Treatment T11 (40 kg P_2O_5 ha^{-1} + NAA @ 20 ppm) was found significantly higher in seed yield (2274 kg ha^{-1}) than other treatments but was statistically at par with treatments T7 (2136 kg ha^{-1}) and T10 (2207 kg ha^{-1}). The minimum seed yield was recorded by treatment T1: PSB +VAM +Water spray (1761 kg ha^{-1}). The highest net return of₹67, 918 ha^{-1} was secured in T11 (40 kg P_2O_5 ha^{-1} + NAA @ 20 ppm) with the maximum BCR of 3.65. Treatments T7 (20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 20 ppm) and T10 (40 kg P_2O_5 ha^{-1}+ NAA @ 10 ppm) also recorded higher net return of ₹ 62, 093 ha^{-1} and ₹65, 363 ha^{-1} with BCR of 3.42 and 3.57, respectively. The lowest net return of ₹ 48, 220 ha^{-1} with BCR 2.99 was obtained under treatment T1 (PSB +VAM +Water spray). However, it was revealed that application of 40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm or 20 kg P_2O_5 ha^{-1}+ PSB + VAM+ NAA @ 20 ppm gave higher yield and net realization of fenugreek.

Keywords: *Growth regulators, Phosphorus Management, PSB, VAM, Fenugreek*

Citation: Purabiya V.S.,*et al*., (2018) Influence of Integrated Phosphorus Management and Growth Regulators on Growth and Yield of Fenugreek (*Trigonella foenum graecum* L). International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, pp.- 6336-6338.

Academic Editor / Reviewer: Dr M. S. Dudhare

Introduction

India is renowned world over for its spices and is popularly called as "The land of spices". From ancient times, India has been regarded as the home of cultivated spice crops. India is the largest producer, consumer and exporter of spices in the world. Gujarat and Rajasthan states have produced and contribute more than 80 percent of the total seed spices so these two states are considered as "Seed Spices Bowl". Other states where spices commonly grown are Haryana, Punjab, Madhya Pradesh, Maharashtra, Bihar, Uttar Pradesh, West Bengal, Orissa, Tamil Nadu and Karnataka. In India, this crop is grown in area of about 2.18 lac ha with the production of about 2.20 lac tones. In 2015-16, Gujarat produced 14, 470 tons of fenugreek from an area of 7, 040 ha [1]. Fenugreek commonly known as Methi, is one of the important seed spices of India. Fenugreek is an annual plant belonging to sub family *Papillionaceae* of the family *Leguminaceae*. Fenugreek being a legume crop is heavy feeder of phosphorus [2]. The fertilizer use efficiency of phosphatic fertilizer is very low (20-25%) due to chemical fixation in the soil. Application of all needed nutrients through chemical fertilizers had deleterious effect on soil fertility and leading to unsustainable yields, while integration with chemical fertilizers and bio fertilizers would be able to maintain the soil fertility and sustain productivity [3]. Phosphorus solubilizing bacteria (PSB) plays a significant role in making phosphorus availability to plant. Vesicular Arbuscular Mycorrhiza (VAM) has balanced mutualistic symbiosis, both provide and supply the phosphorus to the plant. The role of plant growth regulators in enhancing the production of crop has been recognized and now the low cost technology has emerged as a boon for enhancing the agricultural production at an unprecedented rate. Plant growth regulators like auxin works as stimulator for cell division and cell enlargement in apical region. It enhances the nucleic acid activities, flowering, fruit set, fruit retention and fruit quality of various crops [4]. Ethrel react favorably with different seed spices when applied judiciously [5].

In light of above cited facts, the main objective to study the effect of integrated phosphorus management and growth regulators on growth and yield of fenugreek (*Trigonella foenum graecum* L.) in sandy loam soil.

Materials and Methods

A field experiment was carried out in loamy sand, alluvial in origin, light brown in colour, well drained, low in organic carbon (0.39%) and available nitrogen (230.50 kg ha^{-1}), medium in available phosphorus (42.83 kg ha^{-1}) and fairly high in available potassium (311 kg ha^{-1}) at 0-15 cm soil depth during the *rabi* season of 2016-17 at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The climate of this this region is semi-arid and sub-tropical. With fairly dry and hot summer. Winter is severe and sets in the month of November and continues till the end of January. The experiment comprise twelve treatments viz., T1: PSB+ VAM+ Water spray, T2: PSB+ VAM+ NAA @ 10 ppm, T3: PSB+ VAM+ NAA @ 20 ppm, T4: PSB+ VAM+ Ethrel @ 100 ppm, T5: 20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Water spray, T6: 20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 10 ppm, T7: 20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 20 ppm, T8: 20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Ethrel 100 ppm, T9: 40 kg P_2O_5 ha^{-1}+ water spray, T10: 40 kg P_2O_5 ha^{-1}+ NAA @ 10 ppm, T11: 40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm, T12: 40 kg P_2O_5 ha^{-1}+ Ethrel 100 ppm. The experiment was conducted in a randomized block design having four replications and variety Gujarat Fenugreek 2 (GF 2) was selected for the study. Common application of nitrogen @ 20 kg ha^{-1} was given as basal dose and phosphorus was applied as per the treatments. Plant growth regulators were sprayed three time *i.e.* at 25, 45 (Full bloom-stage) and 65 (Pod filling stage) days after sowing as per treatments. Bio-fertilizers *i.e.* PSB @ 1.0 litre ha^{-1} and VAM @ 10.0 $kgha^{-1}$were given assoil application. Need based plant protection measures were given whenever required.

Table-1 Growth and yield attributes as influenced by integrated phosphorus management and growth regulators on fenugreek (*Trigonella foenum graecum* L.).

Treatment No.	Treatments	Plant height (cm)			Number of branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Harvest Index (%)
		30 DAS	60 DAS	At Harvest					
T_1	PSB+ VAM+ Water spray	15.85	44.18	62.49	4.80	36.63	13.39	13.29	26.09
T_2	PSB+ VAM+ NAA @ 10 ppm	17.05	46.01	63.33	5.15	39.65	14.21	13.75	25.93
T_3	PSB+ VAM+ NAA @ 20 ppm	17.35	46.80	64.72	5.18	40.36	14.37	14.12	25.99
T_4	PSB+ VAM+ Ethrel @ 100 ppm	16.65	46.54	63.16	5.05	38.38	14.00	13.60	25.87
T_5	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Water spray	17.45	47.03	65.37	5.20	40.67	14.56	14.86	25.42
T_6	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 10 ppm	17.85	47.48	66.02	5.60	43.70	15.17	15.47	25.75
T_7	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 20 ppm	17.90	48.67	67.93	5.65	46.28	15.83	16.23	26.35
T_8	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Ethrel 100 ppm	18.15	47.65	65.92	5.44	43.33	14.86	15.15	26.75
T_9	40 kg P_2O_5 ha^{-1}+ Water spray	17.80	47.46	65.77	5.45	43.07	14.62	15.10	26.46
T_{10}	40 kg P_2O_5 ha^{-1}+ NAA @ 10 ppm	18.25	51.29	71.85	5.75	50.29	16.65	17.50	25.48
T_{11}	40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm	19.20	52.10	72.66	6.15	50.91	17.75	17.75	25.75
T_{12}	40 kg P_2O_5 ha^{-1}+ Ethrel 100 ppm	17.90	47.75	67.65	5.45	43.60	14.90	15.25	26.45
S. Em. ±		0.60	1.33	2.20	0.17	2.36	0.67	0.67	1.10
CD (0.05)		NS	3.83	6.34	0.51	6.79	1.94	1.94	NS
CV%		6.74	5.57	6.64	6.63	10.96	9.00	8.91	8.49

Table-2 Yield and economics as influenced by integrated phosphorus management and growth regulators on fenugreek (*Trigonella foenum graecum* L.).

Treatment No.	Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross Income (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Net realization (₹ ha^{-1})	B:C Ratio
T_1	PSB+ VAM+ Water spray	1761	3985	72433	24213	48220	2.99
T_2	PSB+ VAM+ NAA @ 10 ppm	1915	4174	78687	24349	54338	3.23
T_3	PSB+ VAM+ NAA @ 20 ppm	1926	4366	79223	24483	54740	3.24
T_4	PSB+ VAM+ Ethrel @ 100 ppm	1880	4233	77316	25662	52957	3.02
T_5	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Water spray	1934	4387	79553	25404	54149	3.13
T_6	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 10 ppm	1997	4495	82127	25532	56595	3.22
T_7	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 20 ppm	2136	4639	87759	25666	62093	3.42
T_8	20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ Ethrel 100 ppm	1954	4414	80367	26847	54823	3.00
T_9	40 kg P_2O_5 ha^{-1}+ Water spray	1938	4445	79742	25381	54225	3.15
T_{10}	40 kg P_2O_5 ha^{-1}+ NAA @ 10 ppm	2207	5201	90880	25517	65363	3.57
T_{11}	40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm	2274	5221	93570	25652	67918	3.65
T_{12}	40 kg P_2O_5 ha^{-1}+ Ethrel 100 ppm	1963	4473	80756	26837	55228	3.01
S. Em. ±		93.69	241	-	-	-	-
CD (0.05)		270	691	-	-	-	-
CV%		9.41	10.66	-	-	-	-

Economics was calculated based on the input and output prices. The statistical analysis of various characters studied in the investigation was carried out through the procedure appropriate to the design of the experiment as described by Panse and Sukhatme, (1967) [6].

Result and Discussion

The periodical plant height at 30, 60 DAS and at harvest was measured. At 30 DAS no any treatment effect found significant, but plant height during 60 DAS and at harvest was recorded 52.10 and 72.66 cm respectively, in treatment T11.These could be attributed to the fact that phosphorus application encourages the formation of new cells, promote plant vigour and hasten leaf development, which helps in harvesting more solar energy, better utilization of nitrogen, which contribute towards the plant height. These results are in close conformity with those reported by Sammauria and Yadav, (2008)[7]. It is also evident that NAA have specific role in cell enlargement thereby increase the plant growth by hastening the root and shoot activities in plant, which increased the plant height. Similar results were reported by Meena and Malhotra, (2006) [8]. Application of 40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm (T11) recorded significantly higher number of branches (6.15) and pods (50.91), but was at par with treatments T7(20 kg P_2O_5 ha^{-1}+ PSB+ VAM+ NAA @ 20 ppm)and T10(40 kg P_2O_5 ha^{-1}+ NAA @ 10 ppm).The increase in number of branches and pods with application of phosphorus might be due to better development of root and canopy, which ultimately resulted in better growth and development of fenugreek crop in terms of producing more number of branches and pods. These results are in close proximity of those reported by Khiriya, *et al*. (2001) [9]. It was also evident that application of NAA which improves the dry matter accumulation due to reduction in photo respiration. It is also probable that photosynthetic efficiency might have sustained for longer duration, which cause greater translocation of photosynthates from source to sink. Thus, higher production of assimilates due to greater photosynthetic efficiency led to increased growth and development resulting into more number of branches per plant and pods per plant. These results are in accordance with those reported by Nehara, *et al*. (2006) [10]. Treatment T11 produced significantly higher number of seeds per pod (17.75), which was remained statistically at par with treatments T10 (16.65) and T7 (15.83). Seeds and straw yield were significantly influenced by different treatments (Table-2). Treatment T11 was found significantly higher in seed yield (2274 kg ha^{-1}) and straw yield (5221 kg ha^{-1}) than other treatments but were statistically at par with treatments T7 and T10.

The minimum seed yield (1761 kg ha^{-1}) and straw yield (3985kg ha^{-1}) were recorded by treatment T1. Application of 40 kg P_2O_5 ha^{-1}+ NAA @ 20 ppm (T11) recorded higher seeds and straw yield might be attributed to the favourable stimulatory effect of phosphorus, which play a key role in root development, energy translocation and metabolic process of plant through which increased translocation of photosynthates towards sink development might have occurred. Plant height, number of branches brought about substantial improvement in yield attributes viz., pods per plant, seeds per pod and seed weight, which ultimately resulted into higher seed yield and straw yield of fenugreek. These results are in close agreement with those reported by Chaudhary and Chaudhary, (2017) [11]. The application of growth regulators significant increase in seeds and straw yield seems to be attributed to cumulative effect of increased yield components due to enhanced photosynthetic efficiency and greater diversion of assimilates towards reproductive organs. NAA also stimulated carbohydrate and nitrogen status in the leaves, which might be responsive to produce more seed and straw yields. Similar results were reported by Singh, *et al*. (2010) [12]. Treatment T11 was found significantly higher in test weight (17.75 g), which was statistically at par with treatments T7 (16.23 g) and T10 (17.50 g). These could be attributed to the fact that phosphorus has many of essential role in root development, energy translocation and metabolic process of plant, through which increased translocation of photosynthates towards sink development might have increased the test weight of fenugreek seeds. These results are in close conformity with those reported by Gour, *et al*. (2009) [13]. The application of NAA increased in test weight and it was may be attributed to higher translocation of carbohydrates to reproductive parts during maturity. It has also important role in translocation of photosynthates towards the sink development and to higher translocation of carbohydrates to reproductive parts during maturity, which ultimate increased test weight of the seeds. The results are in close proximity of those reported by Dutta, *et al*. (2008) [14]. The data presented in Table-1 which was revealed that different treatments includes phosphorus, bio fertilizers and growth regulators failed to exert their significant effect on harvest index (%). There was an appreciable influence in net realization and BCR due to phosphorus and growth regulators as showed in Table-2. The highest net return of₹67, 918 ha^{-1} was secured in T11 with the maximum BCR of 3.65. Treatments T7 and T10 also recorded higher net return of ₹ 62, 093 ha^{-1} and ₹65, 363 ha^{-1} with BCR of 3.42 and 3.57, respectively. The lowest net return of ₹ 48, 220 ha^{-1} with BCR 2.99 was obtained under treatment T1.

Conclusion

On the basis of concluded experiments, it could be concluded that growth, yield attributes, yield and net realization of fenugreek can be increased with application of 40 kg P_2O_5 ha^{-1} + NAA 20 ppm or 20 kg P_2O_5 ha^{-1} + PSB + VAM+ NAA @ 20 ppm.

Application of research: To know the response of phosphorus with growth regulators and organic biofertilizers on fenugreek.

Research Category: Agronomy

Abbreviations: NAA: 1-Naphthaleneacetic acid, PSB Phosphate solubilizing bacteria, VAM: Vesicular Arbuscular Mycorrhizae, ppm Part per million

Acknowledgement / Funding: Author thankful to Anand Agricultural University, Anand, 388110, Gujarat, India

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University: Anand Agricultural University, Anand, 388110, Gujarat, India
Research project name or number: M.Sc. (Agri.) Thesis

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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