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Performance of fenugreek (*Trigonella foenum graecum* L.) as influenced by sulphur and zinc

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Abstract

A field investigation was carried out during the Rabi season of 2011-12 and 2012-13 at NRCSS, Ajmer, Rajasthan, to study growth and yield of fenugreek as influenced by different levels of sulphur and zinc nutrients. Treatments comprising of three sulphur levels (soil application of 20, 30 and 40 kg sulphur ha^{-1}) and three zinc levels (foliar application of 0.4, 0.5 and 0.6 % zinc) were studied in factorial randomized block design with three replications. Non significant influence with respect to reduction in days to seed germination and days of flowering were observed due to higher dosage of sulphur. Similarly plant height at different growth stages after sowing was not significantly influenced with varying levels of sulphur. Number of primary and secondary branches, number of pods and seed yield was affected significantly with different levels of sulphur. The highest number of primary branching $plant^{-1}$ (6.87) and number of pods $plant^{-1}$ (50.72) with maximum seed yield (1571.53 kg ha^{-1}) was obtained with soil application of 30 kg ha^{-1} sulphur. Different levels of zinc as foliar application did not influence significantly the seed germination, plant height at different growth stages and number of primary and secondary branches. However, it influenced significantly the number of pods and seed yield of fenugreek. The highest number of primary branches $plant^{-1}$ (6.57), number of pods $plant^{-1}$ (51.80) and maximum seed yield (1544.43 kg ha^{-1}) were obtained with foliar application of 0.5% zinc. Application of sulphur in the soil as basal dose @ 30 kg ha^{-1} along with 0.5 percent zinc as foliar spray is better for realizing better plant growth, flowering, nodulation and maximum seed yield of fenugreek.

Key words: Fenugreek, nutrient, plant growth, sulphur, yield, zinc.

Introduction

Fenugreek (*Trigonella foenum graecum* L.) called "Methi" in Hindi, is grown in India as Rabi season crop, considered to be one of the major seed spices. Major fenugreek growing states are Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Maharashtra, Himachal Pradesh and Punjab. It grows in about 93000 ha area with annual production of about 113000 tonnes having average productivity 1215 kg ha^{-1} (Tiwari *et al*., 14), which seems to be very low and required to be increased. Important factors contributing to reduced yields is poor soil fertility, a reflection of low carbon sequestration coupled with alarmingly higher nutrient mining from these soils, besides pests and diseases affecting fenugreek crop. Poor nutrient management by the growers has resulted in depletion of carbon reserves, reduced nutrient levels, and decreased nutrient cycling processes due to decreased biological activity (Dixit and Shukla, 3). Abnormal pH and lower levels of organic carbon, S, Ca, Mg, Mn, Fe, Cu, Zn etc., are the limiting factors in spice growing fields for the lower productivity and quality. Micronutrient deficiencies are widespread, 50 percent of world soils are deficient in zinc (Korayem, 5) which is essential for the transformation of carbohydrates and synthesis of tryptophan, which act as precursor of Vit.'A', regulating consumption of sugars. It is also the part of the enzyme systems which regulate plant growth. Its deficiency causes interveinal necrosis where the main veins remain green. In the early stages of zinc deficiency the younger leaves become yellow and pitting develops in the interveinal upper surfaces of the mature leaves and may exhibit delayed maturity.

Sulphur is essential for production of protein, fats and oils, promotes enzyme activity and helps in chlorophyll formation, improves root growth and grain filling resulting in vigorous plant growth and resistance to cold. Its deficiency causes interveinal chlorosis with a very distinct reddish color of the veins and petioles (Shanyn and Lucy, 12).

Generally, farmers apply nutrients when crops show deficiency symptoms, while nutrient deficiencies decrease yields before symptoms appear. Applications of micro nutrients along with judicious use of macronutrients (Recommended Dose of Fertilizers-RDF) will not only enhance productivity but will also increase the total production and the efficiency of

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fertilizer use in fenugreek crop. While doing so, there is an urgent need to augment supplies of customized fertilizers supplying secondary and micronutrients to support sufficiently, the integrated use of nutrient management in fenugreek production. Considering the above fact in mind some studies on the influence of sulphur and zinc on the vegetative growth, flowering, fruiting, yield and yield attributes of fenugreek were carried out.

Materials and methods

The present investigation was carried out at the National Research Center on Seed Spices, Tabiji, Ajmer (Rajasthan) during Rabi 2011-12 and 2012-13, to find out the influence of sulphur and zinc on growth and yield of coriander. The soil of the experimental field was sandy loam having 77.69 kg ha^{-1} available nitrogen, 8.88 kg ha^{-1} available phosphorous and 214.17 kg ha^{-1} available potassium, 9.88 kg ha^{-1} available sulphur and 0.39 mg kg^{-1} DTPA extractable zinc. The study was carried out with soil application of sulphur (20, 30, 40 kg ha^{-1}) through sulphur dust (85% S) at the time of field preparation just before sowing and two foliar spray of zinc (0.4 percent, 0.5 percent, 0.6 percent) through $ZnSO_4$ (34% Zn) were done at 30 and 60 days after sowing $_{(DAS)}$ on RMt-305 variety. The recommended dose of major nutrients (NPK) for the crop was applied (25:20:20 kg ha^{-1}). Experiment was performed in Factorial RBD and the plot size was 4m x 2m (8 m^2) with three replications. Fenugreek was sown at 30 cm row to row and 10 cm plant to plant spacing using 22 kg seed per hectare. Healthy crop of fenugreek was raised following standard agronomic practices. The observations on vegetative growth, nodulation, flowering, yield parameters and yield of fenugreek were recorded periodically with respect to influence of sulphur, zinc and their interaction effects. The data were statistically analyzed as per the method suggested by Panse and Sukhatme (8).

Results and discussion

Growth parameters

It is inferred from the data (Table 1) that days to germination of fenugreek were not influenced with the application of sulphur and zinc. However data showed early germination with higher levels of sulphur and zinc as compared to (S_1 and Zn_1) lower level as the germination is not influenced much by the nutritional level of the soil in most of the crops and is mainly affected by the temperature and moisture level of soil. Similarly, plant height of the fenugreek crop (at 30 DAS, 60 DAS, 90 DAS and at harvest) was also not influenced significantly with the application of sulphur and zinc (Table1), however, maximum plant height at all the stages was recorded with the application of 40 kg ha^{-1} sulphur (S_3 treatment) and 0.6% zinc (Zn_3 treatment) as compared to minimum with the application of 20 kg ha^{-1} sulphur (S_1 treatment) and 0.4% zinc (Zn_1 treatment). Further, this investigation revealed that interactive effects of sulphur and zinc did not influenced significantly the days to seed germination and plant height at all the growth stages (Table 1). Fenugreek variety RMt-305 used in the investigation is of determinate and spreading type having less height as compared to other varieties of the crop, not influenced significantly with application of sulphur and zinc.

With respect to the primary and secondary branching of fenugreek crop, our study exhibited that application of sulphur influenced significantly the number of primary as well as secondary branches (Table 2). The maximum numbers of primary branches (6.87 plant^{-1}) were recorded with the application of 30 kg ha^{-1} sulphur (S_2 treatment) and secondary branches (18.13 plant^{-1}) with 40 kg ha^{-1} sulphur (S_3 treatment) as compared to minimum number of primary branches (6.35 plant^{-1}) and secondary branches (16.02 plant^{-1}) with the application of 20 kg ha^{-1} sulphur (S_1 treatment). Contrary to the above, results revealed that application of zinc as foliar spray did not affect significantly the numbers of primary as well as secondary branches.

Nodulation, flowering, yield and yield parameters

Findings of the investigation (Table 2) revealed that formation of nodules in roots of fenugreek was influenced significantly with the application of sulphur. Nodulation increased with the increasing levels of sulphur and maximum number of nodules at 45 DAS (17.94 plant^{-1}) and at 75 DAS (13.17 plant^{-1}) were recorded with the application of 40 kg ha^{-1} sulphur (S_3 treatment), however, it was at par especially at 45 DAS with that of 30 kg ha^{-1} (S_2 treatment) in comparison to minimum number of nodules at 45 DAS (15.72 plant^{-1}) and at 75 DAS (10.72 plant^{-1}) with the application of 20 kg ha^{-1} sulphur (S_1 treatment). Application of zinc as foliar spray did not affect significantly the nodule formation in the fenugreek roots, however it was increased with the increasing levels of zinc and maximum number of nodules was recorded with the application of 0.6% zinc (Zn_3 treatment) at both the stages i.e. 45 and 75 DAS and minimum nodules were recorded at Zn_1 treatment (0.4%). Interactive effect of sulphur and zinc also not influenced the nodulation significantly.

Results presented in Table 2 further exhibited that days to flower initiation and 50% flowering were not influenced significantly with the application of sulphur, zinc and their interactions. The flower initiation was recorded from 50 to 51 DAS and 50% flowering was recorded from 64 to 66 DAS in different treatments. However, early flowering was recorded with higher levels of sulphur as compared to relatively late flowering with lowest dose. The data recorded for flowering with the foliar application of zinc were not showing any particular trend.

Application of sulphur as basal dose in soil significantly influenced the number of pods per plant and seed yield per hectare (Table 2) in fenugreek. Soil application of 30 kg ha^{-1} sulphur (S_2 treatment) produced highest number of pods $plant^{-1}$ (50.72) and exhibited maximum seed yield (1571.53 kg ha^{-1}) as compared to lowest number of pods $plant^{-1}$ (46.73) and minimum seed yield (1448.83 kg ha^{-1}) with the application of 20 kg ha^{-1} sulphur. Number of pods per plant and seed yield of fenugreek was significantly influenced with different levels of foliar application of zinc (Table -2). Foliar application of 0.5 percent zinc (Zn_2 treatment) resulted in the highest number of pods per plant (51.80) and seed yield (1544.52 kg ha^{-1}) as compared to lowest number of pods per plant (48.18) and minimum seed yield (1460.28 kg ha^{-1}) with the application of 0.4% zinc (Zn_1 treatment).

The flower initiation was little bit early with the application of nutrients such as sulphur and zinc, the other yield attributing traits were better in the later stages, this could easily be explained as the availability of balanced nutrition (RDF plus other essential nutrients) helped to flourish the plants to its complete efficiency in both the stages (Vegetative and reproductive) and elongates the life span of the plants. Lal *et al.* (6) in coriander and Bochalia (2) in fenugreek also reported higher yield with higher level of sulphur.

As a secondary plant nutrient, sulphur is essential for synthesis of several vitamins and amino acids viz., cystine, cysteine and methionine and it helps in photosynthesis and nitrogen fixation. Nitrogen, phosphorous and sulphur uptake by plants were also increased with the application of sulphur (Sivkumaran *et al.*, 13) in coriander. Increased content of sulphur in plant helped in better development and thickening of xylem, collenchymas tissue and such favourable effects might have resulted in stronger stem and increasing photosynthetic as well as meristematic activities which might have promoted vegetative growth and consequently yield attributes and yield. Application of sulphur might be attributed to increased availability of nutrients owing to favourable environment created by sulphur and also it plays a significant role in overall biosynthesis process. These findings of the study are in line of work reported by Sivkumaran *et al.* (13) and Rampratap *et al.* (10).The positive effect of zinc with respect to plant vegetative growth and yield with its attributes is due to the fact that zinc favors the enzyme system, auxin and protein synthesis and seed production directly or indirectly (Sharma *et al.*, 11). Khattab and Umer (4) in fennel and Pariari *et al.* (9) in fenugreek also recorded and increased plant growth and yield with zinc application.

Interaction effects

Combined effect of varying levels of sulphur and zinc was significant with respect to seed yield (Table 3). The highest seed yield (1620.80 kg ha^{-1}) of fenugreek was obtained with soil application of 30 kg ha^{-1} sulphur along with 0.6 % foliar application of zinc (S_2Zn_3 treatment combination), however these results were at par with that of S_2Zn_2 (1541.70 kg ha^{-1}) and S_3Zn_2 (1556.30 kg ha^{-1}) treatment combinations. The improvement in the fenugreek yield with interactive effects might be due to additive influence of improvement in growth, yield attributes and yield due the application of sulphur and zinc. The application of sulphur as secondary nutrient and zinc as micro nutrient in an integrated manner might have exhibited the positive effects in plant growth, development and yield. Similar findings have also been reported by Lal *et al.* (6) in coriander. Manure *et al.* (7) also reported that yield attributes, seed and oil yield and oil content were all enhanced by the application of N, S and Zn fertilizers. Aishwath *et al.* (1) also advocated that micro nutrients play a significant role towards improving growth, yield and quality of seed spices. Thus on the basis of the above findings it is concluded that basal application of sulphur at the rate of 30 kg ha^{-1} along with foliar application of 0.5% zinc is better for realizing appropriate plant growth and yield of fenugreek.

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Table 1. Effect of sulphur and zinc fertilization on growth parameters in fenugreek.

Treatment	Days to germination	Primary branches plant^{-1}	Secondary branches plant^{-1}	Plant height			
				30 DAS	60 DAS	90 DAS	at harvest
Soil application of Sulphur (S)							
S_1 : 20 kg ha^{-1}	4.26	6.35	16.02	7.19	21.92	40.41	40.45
S_2 : 30 kg ha^{-1}	3.42	6.87	18.09	7.93	22.75	41.24	41.24
S_3 : 40 kg ha^{-1}	3.43	6.59	18.13	8.20	22.80	41.84	41.83
S Em±	0.12	0.14	0.16	0.67	0.74	0.72	0.61
CD(P =0.05)	NS	0.40	0.45	NS	NS	NS	NS
Foliar application of Zinc (Zn)							
Zn_1 : 0.4%							
Zn $_2$: 0.5%	3.32	6.57	17.46	7.99	22.48	40.94	40.93
Zn $_3$: 0.6%	3.20	6.31	17.63	7.87	22.66	42.50	42.49
S Em±	0.42	0.36	0.16	0.42	0.87	0.72	0.61
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of sulphur and zinc fertilization on flowering, nodulation and seed yield in fenugreek.

Treatment	Days to flower initiation	Days to 50% flowering	No. of nodules plant^{-1} at 45 DAS	No. of nodules plant^{-1} at 75 DAS	No of pods plant^{-1}	Seed yield (kg ha^{-1})
Soil application of Sulphur (S)						
S_1 : 20 kg ha^{-1}	51.50	65.57	15.72	10.72	46.73	1448.83
S_2 : 30 kg ha^{-1}	51.06	65.38	17.39	12.17	50.72	1571.53
S_3 : 40 kg ha^{-1}	50.28	63.89	17.94	13.17	50.00	1543.80
S Em±	0.76	0.29	0.28	0.26	1.43	19.19
CD(P =0.05)	NS	NS	0.81	0.76	4.09	54.89
Foliar application of Zinc (Zn)						
Zn_1 : 0.4%	51.61	65.87	16.61	11.39	48.18	1460.28
Zn $_2$: 0.5%	50.28	64.06	16.83	11.94	51.80	1544.52
Zn $_3$: 0.6%	50.95	66.31	17.61	12.72	51.31	1543.43
S Em±	0.17	0.97	0.28	0.26	1.09	20.25
CD(P=0.05)	NS	NS	NS	NS	3.13	57.91

Table 3. Combined effect of sulphur and zinc fertilization on seed yield of fenugreek.

Soil application of Sulphur/foliar application of Zinc	Seed yield (kg ha^{-1})		
	Zn_1: 0.4% W/V	Zn_2 : 0.5% W/V	Zn_3 : 0.6% W/V
S_1 : 20 kg ha^{-1}	1331.3	1302.1	1423.8
S_2 : 30 kg ha^{-1}	1346.7	1541.7	1620.8
S_3 :40 kg ha^{-1}	1409.2	1556.3	1400.4
S Em±		50.11	
CD(P =0.05)		150.2	

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