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EFFECT OF SULPHUR AND BORON ON THE GROWTH AND SEED YIELD OF FENUGREEK (*Trigonella corniculata* L.)

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Abstract

A field experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the Rabi season of November, 2021 to April, 2022 to study the effects of different level of sulphur and boron on the yield and yield components of fenugreek (*Trigonella corniculata*) seed. The experiment consisted of two factors: Factor A: 4 Levels of sulphur (S); $T_0 = S_0$ kg ha^{-1}, $T_1 = S_{10}$kg ha^{-1}, $T_2 = S_{15}$kg ha^{-1}, $T_3 = S_{20}$kg ha^{-1} and Factor B: 4 levels of boron (F); $F_0 = B_0$kg ha^{-1}, $F_1 = B_{1.0}$kg ha^{-1}, F2 = $B_{1.5}$kg ha^{-1}, $F_3 = B_{2.0}$kg ha^{-1}. The experiment was laid out in randomized complete block design (RCBD) with three (3) replications. Data on different growth, yield contributing and yield parameter of fenugreek were recorded and significant variation was observed from different treatments. T_3F_3 treatment showed better performance over other treatment combination. Maximum plant height (50.08 cm), number of primary branches per plant (10.41), secondary branches per plant (5.09), number of seeds per pod (8.91), number of pod per plant (1192.30), weight of seeds per plant (2.50 g), weight of seed per plot (75.00 g), maximum seed yield per hectare (625.00 kg) was obtained from T_3F_3 treatment combination.

Keywords: Chlorophyll, Combination, Fenugreek, Flowering, Micronutrient.

Introduction

Fenugreek (*Trigonella corniculata* L.) is a semi-arid crop belonging to the family Fabaceae. It is commonly known as 'Champamethi' and 'Marwari methi', is a diffused sub erect and strongly scented annual herb. In Bangladesh, it is also known as Firingi. The green leaves contain several alkaloids like trigonelline, choline, gentianine and carpain. The leaves and seeds of fenugreek are used as spice and condiments and as flavoring agents due to their characteristic pleasant odor. Improper nutrient management is one of the major reason which causes lower yield and poor quality seed in fenugreek. So, the integrated nutrient management approach could be a rational way to increase herbage yield and seed quality. Sulphur is a plant nutrient with a crop requirement similar

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to that of phosphorus. 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. It has been observed when Sulphur is present in critical amount of soil (less than 10 ppm), the plant growth, quality and total production of crop is adversely affected (Jones *et al*., 1972). Sulphur also helps in improving the nutrient content and uptake of nutrients in legume crops (Singh and Singh, 1992). Protein, tryptophan, lysine, methionine, globulin, and egg white content all fundamentally increased with rising sulfur levels up to 30 kg ha^{-1}. Boron (B) is the only non-metal among the plant essential micro-nutrients, quite rare and occurs chiefly as borates of calcium and sodium. Boron deficiency has been proved to be of the major constraints for crop production. Boron is involved directly and indirectly in the cell growth of new shoots and root as it is also highly important for boll formation, flowering, pollination, and seed development (Dordas *et al*., 2007). It also increases the utilization of macro-nutrients by plants and promotes the translocation of photosynthetic products from the source towards the sink during the crop life cycle (Ali *et al*., 2009). Studies revealed that deficiency of boron cause prominent reduction of growth, nodulation, yield percentage, vigour and viability in legume and cereal crops (Ahmad *et al.*, 2012). Boron supply increases the uptake and reutilization of N, P, K, Na, Ca and other (Yaseen *et al*., 2004). Under the above mention context and situation, the present experiment was conducted to find out the optimum level of sulphur and boron for maximum growth and seed yield of fenugreek.

Materials and Methods

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2021 – April, 2022 to find out the optimum level of sulphur and boron for maximum growth and seed yield of fenugreek. The seeds of Fenugreek (var. BARI firingi-1) were collected from Horticultural Division of Bangladesh Agricultural Research Institute (BARI), Gazipur. The experiment consists of two factors i.e., Factor A: 4 Levels of Sulphur; T_0 = S_0kg ha^{-1}(Control), T_1 = S_{10}kg ha^{-1}, T_2 = S_{15}kg ha^{-1} and T_3 = S_{20}kg ha^{-1}; Factor B: 4 levels of Boron; F_0 = B_0kg ha^{-1}(Control), F_1 = $B_{1.0}$kg ha^{-1}, F_2 = $B_{1.5}$kg ha^{-1} and F_3 = $B_{2.0}$kg ha^{-1}.

Table 1. Chemical characteristics of the initial soil of the experimental field

pH	6.48
Organic Matter (%)	0.86
Total N (%)	0.079
Total P (ppm)	15
Exchangeable K (meq/100 g dry soil)	0.12
Available S (meq/100 g dry soil)	0.119

The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The size of unit plot was 1.2 m × 1 m. Manures and fertilizers were applied such as Cowdung, @ 2 t ha^{-1}, Urea 125, TSP 100, MoP 100 kg ha^{-1}. The desired

population density was maintained by thinning plants. Irrigation, mulching, weeding and plant protection measures etc., were performed for proper plant growth. Data were recorded on plant characters, yield and yield attributes. Land preparation, fertilizer, irrigation and labor costs for all treatments, from seeding to harvesting, were recorded per experimental plot and converted to cost per hectare The cost was calculated using market rates. Data were analyzed using analysis of variance (ANOVA) technique with the help of R software package (version: 4.2.2) and the mean differences were adjudged by least significant difference test (LSD) at 5% level of probability Gomez and Gomez (1984).

Results and Discussion

Combined effect of sulfur and boron showed statistically significant variation on plant height (Table2). The longest plant height (50.08 cm) was recorded at T_3F_3 (S_{20} kg ha^{-1} + $B_{2.0}$kg ha^{-1}) while the lowest (43.00 cm) at T_0F_0 treatment (Table 2). These results obtained are closely similar by Mehta *et al.* (2013). Number of maximum primary branches $plant^{-1}$ was observed from T_3F_3 (10.41) while T_0F_0 (control) showed minimum number of primary branches $plant^{-1}$. Number of maximum secondary branches $plant^{-1}$ (5.09) was observed from T_3F_3 followed by T_3F_2 treatment but T_0F_0 (control) treatment combination showed minimum number of secondary branches $plant^{-1}$.The T_3F_3 treatment took minimum days to flower initiation (43 days) which was almost similar to T_3F_2 treatment (44 days) while the control treatment took maximum days (53 (Table 2).This might be due to fact that adequate supply of sulphur and boron can promote the growth and development of reproductive organs and improved metabolic activities resulting in earlier flowering. Lal (2015) stated earlier that increased level of sulphur and boron influence in early flowering of legume plants. Both the control application dose combination of sulphur with boron took maximum days to 50% flowering where control treatment took maximum (69 days) to 50% flower initiation. The highest level of sulphur with boron application dose took minimum days for 50% flowering but T_3F_3 treatment took minimum (61 days) to 50% flowering (Table 2). The t study was observed that increased level of Sulphur and boron reduced the time to 50% flowering .Similar results was recorded by Kalaiyarasan *et al.*(2020) that effect between sulphur with boron was significant on growth attributes at all stages of crop growth.

Table 2. Effects of sulphur and boron on plant characters, days to first and 50% flowering of fenugreek

Treatment	Plant height (cm)	Primary branches $plant^{-1}$ (no.)	Secondary branches $plant^{-1}$ (no.)	Days to first flowering	Days to 50% flowering
T_0F_0	43.00 o	7.14 l	2.94 bc	53.17 a	68.58 a
T_0F_1	43.48 no	7.49 kl	3.02 bc	50.2 de	66.18 de
T_0F_2	44.88 kl	8.07 ij	3.22a-c	47.27 gh	64.30 hi
T_0F_3	45.83 ij	8.27 h-j	3.58a-c	45.43 jk	62.89 kl
T_1F_0	43.94mn	7.75 jk	2.88 c	52.27 b	67.59 b
T_1F_1	46.32 hi	8.63 f-h	3.76a-c	49.67 ef	65.71 ef

Treatment	Plant height (cm)	Primary branches plant^{-1} (no.)	Secondary branches plant^{-1} (no.)	Days to first flowering	Days to 50% flowering
T_1F_2	47.26 fg	9.05 d-f	4.12a-c	46.63 hi	63.83 ij
T_1F_3	48.18 de	9.38 c-e	4.49a-c	44.80kl	62.42 lm
T_2F_0	44.32 lm	7.87 jk	3.04 bc	51.43 bc	67.12 bc
T_2F_1	46.76 gh	8.84 e-g	3.94a-c	49.07 f	65.24 fg
T_2F_2	48.63 cd	9.58 b-d	4.66a-c	46.00ij	63.36 jk
T_2F_3	49.12 bc	9.79 bc	4.85 ab	44.27 lm	61.95 mn
T_3F_0	45.32 jk	8.45g-i	3.40a-c	50.83 cd	66.65 cd
T_3F_1	47.71 ef	9.21 de	4.31a-c	47.83 g	64.77 gh
T_3F_2	49.57 ab	9.97 ab	5.05 a	43.63 mn	61.47 no
T_3F_3	50.08 a	10.41 a	5.09 a	43.00 n	61.07 o
LSD (0.05)	0.61	0.28	0.98	0.43	0.37
CV%	4.02	5.36	4.56	8.25	7.25

Here, T_0=control (no sulphur), T_1=S_{10}kg ha^{-1}, T_2=S_{15}kg ha^{-1}, T_3=S_{20}kg ha^{-1}and F_0 = control (no boron), F_1= $B_{1.0}$kg ha^{-1}, F_2= $B_{1.5}$kg ha^{-1}, F_3 = $B_{2.0}$kg ha^{-1}

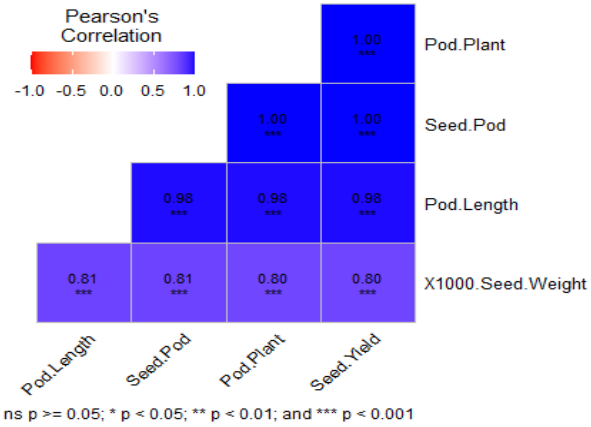
The difference in pod number per plant was significantly influence by application of sulphur and boron t (Table 3). The maximum pod number plant^{-1} (1192.30) was recorded from T_3F_3 which was statistically similar to T_3F_2 (1160.30). On the other hand, the lowest pod number plant^{-1} (722.0) was found from T_0F_0 (control) (Table 3). Maximum length of the pod was noticed with T_3F_3 (2.51 cm), while the minimum length of pod was 1.71 from treatment T_0F_0.The number of seeds per pod ranged from 5.10 to 8.91. The maximum number of seeds per pod (8.91) was obtained from the T_3F_3which was statistically similar (8.66) to T_3F_2.The lowest number of seeds per pod (5.10) was obtained from the T_0F_0 treatment. This might be due to optimum sulphur and boron attributed to lesser flower drop and enhanced pollen germination and pollen tube growth probably restricted fertilization. Treatment T_3F_3 recorded higher 1000- green seeds weight (1.76 g) and lowest weight in T_0F_0 (control) treatment (1.45 g) which was statistically similar to T_0F_1 (1.47).Wide variation was found with the application of different levels of sulphur and boron in seed yield per hectare (Table 3). It ranged from 463.70 to 625.00 kg per hectare. The highest average seed yield of 625.00 kg ha^{-1} was obtained in the T_3F_3while the lowest yield of 463.70 kg ha^{-1} from the T_0F_0 treatment. Shivran (2000) reported that combined application of 20 kg sulphur and 2 kg boron ha^{-1} significantly increased plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of seeds/pod, 1000-seed weight and seed yield of Fenugreek.

Table 3. Effect of sulphur and boron on yield and yield attributes of Fenugreek

Treatment	Pods plant^{-1} (no.)	Pod length(cm)	Seed pod^{-1} (no.)	1000- Seed weight (g)	Seed yield (kg ha^{-1})
T_0F_0	722.00 o	1.71	5.10 o	1.45	463.70 o
T_0F_1	753.40 no	1.76	5.27 no	1.47	473.53 no
T_0F_2	847.40 kl	1.90	6.05 kl	1.53	506.23 kl
T_0F_3	910.00 ij	2.07	6.57 ij	1.58	527.93 ij
T_1F_0	783.20 mn	1.81	5.60mn	1.50	485.20 mn
T_1F_1	941.80 hi	2.06	6.82 hi	1.60	538.60 hi
T_1F_2	1003.80 fg	2.16	7.35 fg	1.63	560.33 fg
T_1F_3	1066.90 de	2.26	7.87 de	1.68	581.73 de
T_2F_0	815.70 lm	1.86	5.79 lm	1.51	494.50 lm
T_2F_1	973.20 gh	2.12	7.08 gh	1.62	549.40 gh
T_2F_2	1098.00 cd	2.33	8.13 cd	1.70	592.97 cd
T_2F_3	1129.80 bc	2.39	8.39 bc	1.72	603.80 bc
T_3F_0	878.90 jk	1.96	6.30 jk	1.56	517.00 jk
T_3F_1	1035.40 ef	2.21	7.61 ef	1.66	571.17 ef
T_3F_2	1160.30 ab	2.45	8.66 ab	1.74	614.97 ab
T_3F_3	1192.30 a	2.51	8.91 a	1.76	625.00 a
LSD (0.05)	6.27	1.02 ^{NS}	2.64	0.36 ^{NS}	9.78
CV%	4.95	5.36	6.45	7.25	8.75

Here, T_0=control (no sulphur), T_1=S_{10}kg ha^{-1}, T_2=S_{15}kg ha^{-1}, T_3=S_{20}kg ha^{-1}and F_0 = control (no boron), F_1= $B_{1.0}$kg ha^{-1}, F_2= $B_{1.5}$kg ha^{-1}, F_3 = $B_{2.0}$kg ha^{-1}

From the correlation study, it was observed that yield showed significant and positive correlation with podsplant^{-1} (no.), Seedspod^{-1} (no.), pod length (cm) and seed yield (kg ha^{-1}) (Fig. 1). Latye *et. al*. (2 016) was also found the similar results.



Here, Pod.Plant- Pod plant^{-1} (no.), Seed.Pod- Seed pod^{-1} (no.), Pod.Length- Pod length (cm), X1000.Seed.Weight- Seed yield (kg ha^{-1})

Fig. 1. Correlation among the yield contributing attributes of fenugreek.

In the combination of different levels of sulphur and boron, maximum gross return (Tk. 61803) was obtained from the T_3F_3 treatment while lowest gross return (Tk. 36819) was obtained in T_0F_0 treatment**.** The highest gross margin (Tk 109375) was obtained from the T_3F_3 treatment and second highest gross margin (Tk. 107620) was obtained in T_3F_2. The lowest gross margin (Tk. 81148) was obtained from the treatment combination of T_0F_0. Variation was observed in BCR of different level of nutrient combination. The highest benefit cost ratio (2.30) was attained from the T_3F_3 treatment and the lowest benefit cost ratio (1.83) was obtained from of T_0F_0 (Table 4).

Table 4. Cost and return analysis of different levels of sulphur and boron application of Fenugreek

Treatment	Gross return (Tk.)	Cost of production(Tk)	Gross margin (Tk.)	BCR
T_0F_0	36819	44329	81148	1.83
T_0F_1	38369	44499	82868	1.86
T_0F_2	43922	44668	88590	1.98
T_0F_3	47550	44838	92388	2.06
T_1F_0	39214	45696	84910	1.86
T_1F_1	48389	45866	94255	2.06
T_1F_2	52023	46035	98058	2.13
T_1F_3	55598	46205	101803	2.20
T_2F_0	40158	46380	86538	1.87
T_2F_1	49596	46549	96145	2.07
T_2F_2	57051	46719	103770	2.22
T_2F_3	58777	46888	105665	2.25
T_3F_0	43411	47064	90475	1.92
T_3F_1	52722	47233	99955	2.12
T_3F_2	60217	47403	107620	2.27
T_3F_3	61803	47572	109375	2.30

Here, T_0=control (no sulphur), T_1=S_{10}kg ha^{-1}, T_2=S_{15}kg ha^{-1}, T_3=S_{20}kg $ha^{-1}$and F_0 = control (no boron), F_1= $B_{1.0}$kg ha^{-1}, F_2= $B_{1.5}$kg ha^{-1}, F_3 = $B_{2.0}$kg ha^{-1}. Total cost of production was done in details according to the procedure of Alam *et al.* (1989).

Where, Sale of marketable yield at175 Tk/kg. Gross income = Marketable yield × Tk/kg, Gross margin = Gross income -Total cost of production. Benefit Cost Ratio (BCR) = Gross return ÷ Cost of production

Conclusion

The highest growth, yield and yield contributing parameter was recorded from S_{20} with $B_{2.0}$ kg ha^{-1}along with Cowdung,@ 2 t ha^{-1}, Urea 125,TSP100, MoP100kg ha^{-1}.

Further study may be needed at different level of sulphur and boron combination in relation to growth and seed yield and quality performance of fenugreek in different agro-ecological zones (AEZ) of Bangladesh.

Author's contribution

M. Khatun, K. Khatun, and T. Mostarin designed and developed the study; M. Khatun collected the data; M. Khatun, K. Khatun, T. Mostarin, and S. E. Akter analyzed and interpreted the results; and M. J. Hasan, M. K. A. Nadim, S. M. A. Chowdhury, and S. E. Akter prepared the draft paper. The results were evaluated by all authors, who then approved the final version of the paper.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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