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Response of Soybean to Sulphur and Boron Nutrition in *Vertisols* of Kbirdham District of Chhattisgarh

Lomendra Kumar Kulhary and Tirath Das Sahu*

Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, Raipur, 492012, Chhattisgarh, India

*Corresponding Author: tdsahusoils@gmail.com

***Abstract*— *This study was carried out to study the response of soybean to sulphur and boron level in terms of yield and nutrient uptake. The experiment was conducted at KVK, Kawardha farm, Kabirdham (C.G.). Experiment comprised of four levels of sulphur viz. 0, 15, 30 and 45 kg ha^{-1} and four levels of boron viz. 0, 0.5, 1.0, 1.5 kg ha^{-1}. Yield attributes and yield of soybean were significantly influenced by different sulphur level and maximum yield (21.04 kg ha^{-1} seed yield and 22.55 kg ha^{-1} stover yield) was observed with application of 30 kg S ha^{-1} and it was closely followed by 45 kg S ha^{-1} (19.67 kg ha^{-1} seed yield and 22.20 kg ha^{-1} stover yield) but were statistically at par with each other. Among boron levels 1.0 kg B ha^{-1} was superior to others for getting maximum soybean yield (18.82 kg ha^{-1} seed yield and 21.05 kg ha^{-1} stover yield). Sulphur and boron application resulted in increased nutrient uptake by soybean. Maximum nitrogen, phosphorus, potassium, sulphur and boron uptake (147.03, 10.17, 39.61, 8.35 kg ha^{-1} and 98.71 g ha^{-1} respectively) was observed with 30 kg S ha^{-1}. Maximum uptake of nitrogen, phosphorus, potassium, sulphur and boron (131.51, 9.10, 36.85, 7.74 kg ha^{-1} and 89.38 g ha^{-1} respectively) was associated with application of 1.0 kg B ha^{-1}. Available nitrogen, phosphorus and potassium in post-harvest soil were found higher with application of 30 kgS ha^{-1} and 1.0 kg B ha^{-1}.*

***Keywords*— Sulphur, boron, soybean, seed yield, stover yield, nutrient uptake, nutrient status**

I. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is recognized as "Golden Bean" due to its high nutritional value such as high quality protein (40-45 %), oil (18-20 %), mineral nutrients like calcium, iron and glycine. Apart from these, it is a good source of isoflavone which helps in preventing heart disease, cancer and HIVs. In India, the area under soybean cultivation was 10.18 m ha and the production was 12.28 m t with productivity level of 1.21 t ha^{-1} (Anonymous. 2012). The major soybean producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh and Karnataka.

Sulphur is involved in synthesis of fatty acid and also increased protein quality through the synthesis of certain sulphur containing amino acid such as cystine, cystein and methionine.The role of sulphur in the seed production of soybean has been already (Shrivastava *et al.* 2000). The increase in seed yield of soybean by sulphur application can be related to increase in growth and yield characteristics as well as stimulatory effect of applied sulphur in photosynthetic activity by the crop, which in turn increases the yield. As soybean is rich in both oil and protein, the requirement of sulphur is quite high. Unless soybean is provided with required nutrient input to produce sufficient biomass it does not yield high (Singh *et al.*, 2003)

Boron plays an important role in nodulation, flowering, pollen germination, fruiting, seed setting and synthesis of protein and oil (Malewar *et al.*, 2001). Boron is having a marked effect on plant from the stand point of both nutrition as well as toxicity (Das, 2003). The critical limit of boron in plant refers to a level at or below which plant either develops deficiency symptoms or causes statistically significant or 5 to 10% reduction in crop yield as compared to optimum (Debnath and Ghosh, 2011).

. Non-judicious use of chemical fertilizers, intensive cultivation of crops, higher cropping intensity and limited use of organic matter are the most possible causes for sulphur deficiency limiting soybean yields. In addition to N, P and K deficiencies, deficiencies of some other nutrients such as S, Zn and B are being observed in many parts of the country (Jahiruddin *et al.*,1995). Taking these into account, the present investigation was carried out with an objective to find out the response of soybean to sulphur and boron in terms of yield and nutrient uptake in *Vertisols* of Kabirdham district

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II. MATERIALS AND METHODS

The experiment was conducted during the *Kharif* season of 2014 at Krishi Vigyan Kendra, Kawardha, Kabirdham (C.G.) which is located at 22°02' 68'' N latitude, 81°25'12" E longitude. A Physico-chemical characteristic of soil is presented in Table 1. The experiment was laid out in Randomized Complete Block Design with factorial arrangement. 16 treatments consisting of four levels of sulphur (0, 15, 30, 45 kg ha^{-1}) and four levels of boron (0, 0.5, 1.0, 1.5 kg ha^{-1}) were replicated thrice. Recommended dose of nitrogen, phosphorus and potassium @ 25:60:30 kg ha^{-1} through Urea, DAP and MOP were uniformly applied as basal to each plot. Sulphur was applied through bentonite sulphur powder (90% sulphur field grade) as basal. Boron was applied through boric acid (17 % boron) @ 0, 0.5, 1.0, and 1.5 kg ha^{-1} as basal. Soybean crop (variety JS-335) was sown on July 4th, 2014 by hand dibbling the seeds into line@ 75 kg ha^{-1}. The row x plant distance was kept 30 cm x 10 cm. The crop was harvested at maturity stage on 12th October, 2014. Pod and seed yield were recorded separately in each treatment plot wise. The harvest index was determined by using the formula given by Donald (1962).

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield}}{\text{Biological Yield}} X100$$

Where, Economic yield = Seed yield, Biological yield = Seed yield + Stover yield

Table 1: Physico-chemical properties of soil

S. No.	Soil Properties	Values
1	Mechanical composition	
	Sand (%)	21.4
	Silt (%)	28.2
	Clay (%)	50.4
2	CEC (cmol(p+) kg^{-1})	41.5
3	pH	7.40
4	Electrical conductivity (dSm^{-1})	0.49
5	Organic Carbon (%)	0.47
6	Available N (kg ha^{-1})	225.45
7	Available P (kg ha^{-1})	9.60
8	Available K (kg ha^{-1})	474.00
9	Available S (kg ha^{-1})	22.15
10	Available B (mg kg^{-1})	0.88

Initial soil samples were analysed in the laboratory for different parameters. Soil pH was measured by glass electrode pH meter in 1:2.5 soil water suspensions after stirring of 30 minutes as described by Jackson (1973). The soil samples used for pH determination were allowed to settle down the soil particles for 24 hours. The conductivity of supernatant liquid was determined by conductivity meter as described by Jackson (1973). Organic carbon was estimated by wet digestion method of Walkley and Black (1934). Cation exchange capacity was determined by leaching the soil with neutral normal ammonium acetate as described by Jackson (1973). Mechanical Composition (Particle size analysis) was determined by international pipette method (Day, 1965). Available nitrogen was determined by alkaline $KMnO_4$ method as described by Subbiah and Asija (1956). Available phosphorus in soil was extracted by 0.5M $NaHCO_3$ (pH 8.5) as described by Olsen *et al* (1954) and phosphorus in the extract was determined by phosphomolybdenum blue with ascorbic acid as reducing agent as described by Watanabe and Olsen (1965). Soil potassium was extracted by shaking with neutral normal ammonium acetate for five minutes at a constant temperature (25^{0}C) as described by (Hanway and Heidel (1952) and then K in the extract was estimated by flame photometer. Available sulphur in the soil was extracted by 0.15% $CaCl_2$ solution (Williams and Steinbergs, 1969) and content was determined by the turbidimetric method of Chesnin and Yien (1950). Available boron in soil was extracted by boiling with water and the extracted boron in the filtered extract was determined by the azomethine-H method of Gupta (1967). The data obtained on various characters under study were analysed statistically by using the method of analysis of variance for randomized complete block design and significance was tested by Gomez and Gomez (1984).

III. RESULTS AND DISCUSSION

Yield attributes and yields of soybean

Yield attributes and seed and stover yield of soybean was significantly affected by application of sulphur and boron. Seed and stover yield of soybean ranged from 13.72 to 21.83q ha^{-1} and 15.57 to 23.26 q ha^{-1} respectively (Table 2 and Figure1). Significant difference was observed in respect of seed and stover yield with different sulphur and boron level at 5 % level of probability. Maximum seed yield (21.04 q ha^{-1}) and stover yield (22.55 q ha^{-1}) was recorded with 30 kg S ha^{-1}. The second highest seed yield (19.67 q ha^{-1}) and stover yield (22.20 q ha^{-1}) was obtained from 45 kg S ha^{-1}. Seed and stover yield of soybean was significantly influenced by boron level. Significantly higher seed yield

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(18.82 q ha^{-1}) and stover yield (21.05 q ha^{-1}) was observed with 1.0 kg B ha^{-1} followed by 1.5 kg B ha^{-1} (18.71q $ha^{-1}$and 20.88 q ha^{-1} seed and stover yield respectively). Interaction effect of sulphur and boron level was found to be non-significant in relation to seed and stover yield.

Among the fertilizer elements sulphur requirement of oilseed crops is quite high as compared to other crops (Das and Das, 1994). The above results are in conformity with the results of Joshi and Billore (1998) who reported a gradual increase in the yield attributes of soybean with increasing levels of sulphur. Chaubey *et al*. (2000) observed significantly more numbers of primary branches, pods per plant, plant height and 100 kernel weight of groundnut by the application of sulphur. These finding were also supported by Singaravel *etal*. (2006) and Lakshman *etal*. (2015). With increased supply of sulphur, the process of tissue differentiation from somatic to reproductive, meristematic activity and development might have increased, resulting in increase in number and size of leaves. As in soybean, sink lies in leaves, when supply of sulphur is optimum, greater translocation of photosynthates occur from leaves to the site, i.e. seed. The sum total effect will be higher seed yield. The results confirm the findings of Kumar *et al.* (1992) and Sarkar *et al.* (2002). Results are in accordance with that of Singh *et al.* (2003), who documented that crop yields, in general, have been promoted by regular application of boron. Chowdhury *et al.* (2000) and Ram *et al.* (2014) also reported that seed yield of cowpea increased significantly with the increase in boron application.

Harvest Index (%)

Highest harvest index (48.25 %) was recorded with 30 kg S ha^{-1} followed by 15 kg S ha^{-1} (47.24 %) and 45 kg S ha^{-1} (46.97 %) and lowest harvest index (46.42 %) with 0 kg S ha^{-1} but the differences were non-significant (Table 2). Among boron level the highest value of harvest index (47.49 %) was recorded with 0.5 kg B ha^{-1} followed by 1.5 kg B ha^{-1} (47.25 %). Interaction of sulphur and boron level did not affect harvest index of soybean statistically and highest harvest index 48.94 % was observed with T_{10} ($S_{30}B_{0.5}$) and it was similar with harvest indices of T_9 (30 kg S ha^{-1} and 0 kg B ha^{-1}), T_{11} (30 kg S ha^{-1} and 1.0 kg B ha^{-1}) and T_8 (15 kg S ha^{-1} and 1.5 kg B ha^{-1}) and the corresponding values were 48.47. 48.32 and 48.08 respectively.

Table 2: Effect of sulphur and boron on yield attributes and yieldsof soybean

Treatment	Plant height (cm)	Pods $plant^{-1}$ (No.)	100 seed weight (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
T_1 - S_0 B_0	35.43	42.00	10.31	13.72	15.57	46.51
T_2 - S_0 $B_{0.5}$	38.57	44.67	10.34	13.77	15.98	46.30
T_3 - S_0 $B_{1.0}$	37.13	43.00	10.73	14.52	16.96	46.16
T_4 - S_0 $B_{1.5}$	36.03	45.00	10.80	14.60	16.64	46.73
T_5 - S_{15} B_0	36.47	44.33	10.45	13.90	16.56	46.03
T_6 - S_{15} $B_{0.5}$	38.90	44.00	10.57	16.66	18.49	47.39
T_7 - S_{15} $B_{1.0}$	41.97	45.67	12.46	18.12	20.02	47.47
T_8 - S_{15} $B_{1.5}$	40.43	44.67	12.39	18.96	20.48	48.08
T_9 - S_{30} B_0	39.43	45.33	10.34	19.78	21.04	48.47

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T_{10} - S_{30} $B_{0.5}$	43.13	48.33	13.66	21.75	22.66	48.94
T_{11} - S_{30} $B_{1.0}$	40.40	49.33	12.92	21.83	23.26	48.32
T_{12} - S_{30} $B_{1.5}$	43.57	49.00	12.36	20.81	23.25	47.25
T_{13} - S_{45} B_{0}	40.80	45.67	10.54	16.68	18.59	47.27
T_{14} - S_{45} $B_{0.5}$	43.37	50.00	11.56	20.73	23.10	47.33
T_{15} - S_{45} $B_{1.0}$	43.50	49.67	12.87	20.82	23.96	46.38
T_{16} - S_{45} $B_{1.5}$	43.90	50.04	12.20	20.47	23.15	46.89
S levels (kg ha^{-1})						
0	37.05	43.67	10.55	14.15	16.29	46.42
15	39.18	44.67	11.47	16.91	18.89	47.24
30	41.63	48.00	12.32	21.04	22.55	48.25
45	42.89	48.83	11.79	19.67	22.20	46.97
B levels (kg ha^{-1})						
0	38.03	44.33	10.41	16.02	17.94	47.07
0.5	40.99	46.75	11.53	18.23	20.06	47.49
1.0	40.75	46.92	12.25	18.82	21.05	47.08
1.5	40.98	47.17	11.94	18.71	20.88	47.24
SEm±						
S levels	0.90	0.93	0.43	0.74	0.78	0.58
B levels	0.90	0.93	0.43	0.74	0.78	0.58
(S x B) Interaction	1.80	1.86	0.86	1.47	1.55	1.17
CD (P=0.05)						
S levels	2.59	2.69	1.24	2.13	2.24	NS
B levels	NS	NS	1.24	2.13	2.24	NS
(S x B) Interaction	NS	NS	NS	NS	NS	NS

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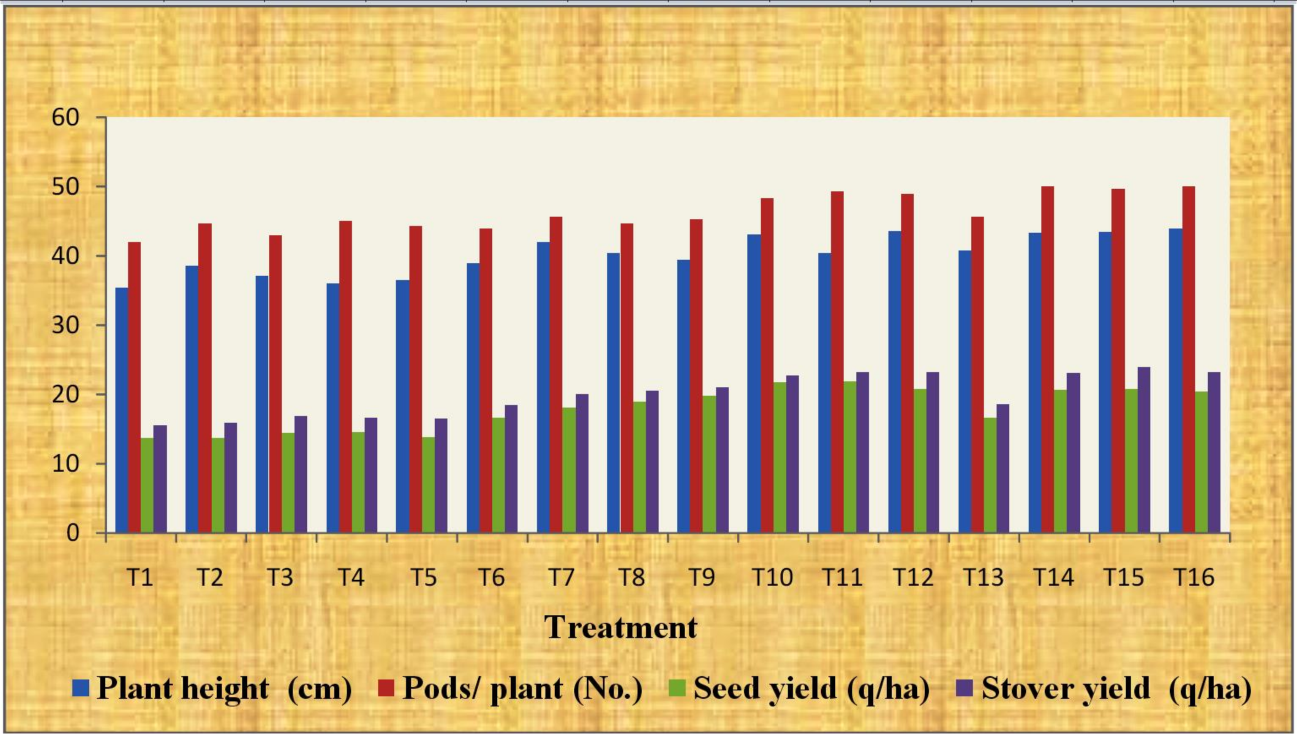

Fig.1: Effect of sulphur and boron on yield attributes and yields of soybean

Effect of sulphur and boron on nutrient uptake by soybean

Nitrogen Uptake

Application of different sulphur level significantly influenced the nitrogen uptake by seed, stover and total uptake (Table 3) and maximum uptake (122.17, 24.86 and 147.03 kg ha^{-1} in seed, stover and total respectively) was associated with 30 kg S ha^{-1} and minimum uptake (80.12, 16.86 and 96.97 kg ha^{-1} in seed, stover and total respectively) with the treatment where sulphur was not applied i.e. 0 kg S ha^{-1}. Increase in level of boron resulted in significantly increase in nitrogen uptake by soybean and maximum uptake (108.36, 23.15 and 131.51 kg ha^{-1} in seed, stover and total respectively) was observed with 1.0 kg B ha^{-1} while minimum in plot where boron was not applied (0 kg B ha^{-1}). Nitrogen uptake with 1.5 kg B ha^{-1} and 1.0 kg B ha^{-1} were statistically at par with each other but significantly higher over control i.e. 0 kg B ha^{-1}. Nitrogen uptake by soybean was not significantly affected by interaction of sulphur and boron level.

Phosphorus Uptake

Significant difference was observed in respect of phosphorus uptake due to different sulphur level (Table 3). Maximum total phosphorus uptake (10.17 kg ha^{-1}) was associated with 30 kg S ha^{-1} and it was closely followed by 45 kg S ha^{-1} (9.42 kg ha^{-1}). Phosphorus uptake in these sulphur levels were statistically at par with each other. Maximum total phosphorus uptake (9.10 kg ha^{-1}) was obtained with 1.0 kg B ha^{-1} followed by 1.5 kg B ha^{-1} (9.01 kg ha^{-1}) and 0.5 kg B ha^{-1} (8.56 kg ha^{-1}). Phosphorus uptake in these plots was significantly higher than those of 0 kg B ha^{-1}but statistically similar with each other. Interaction effect between sulphur and boron level was found to be non- significant and maximum total phosphorus uptake (10.61 kg ha^{-1}) being associated with T_{12} ($S_{30}B_{1.5}$).

Potassium Uptake

Potassium uptake was found more in stover than seed of soybean (Table 3). Increase in sulphur level resulted in significantly higher potassium uptake and maximum total uptake (39.61 kg ha^{-1}) was associated with 30 kg S ha^{-1} and minimum uptake (96.97 kg ha^{-1}) with the treatment where sulphur was not applied (0 kg S ha^{-1}). Maximum total potassium uptake (36.85 kg ha^{-1}) was observed with application of 1.0 kg B ha^{-1} followed by 1.5 kg B ha^{-1} and 0.5 kg B ha^{-1}. Different sulphur and boron level had no significant effect on potassium uptake.

Sulphur Uptake

Significant difference was observed in sulphur uptake by soybean due to different sulphur level (Table 4) and highest total sulphur uptake (8.35 kg ha^{-1}) was associated with 30 kg S ha^{-1} and it was statistically at par with 45 kg S ha^{-1} (7.83 kg ha^{-1}). Statistically higher total sulphur uptake over control was obtained with 1.0 kg B ha^{-1} (7.74 kg ha^{-1}) followed by1.5 kg B ha^{-1} (7.62 kg ha^{-1}) and 0.5 kg B ha^{-1} (7.05 kg ha^{-1}). However sulphur uptake in these treatments was statistically similar with each other. Interaction between sulphur and boron

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level was found to have no significant effect on sulphur uptake. Results are in agreement with those of Ganeshamurthy (1996) who reported that sulphur significantly increased the S uptake. Similar result was found by Chand *et al*. (1997) in mustard.

Table 3: Effect of sulphur and boron application on N, P and K uptake by soybean

Treatment	**Nitrogen Uptake ($Kg\ ha^{-1}$)**			**Phosphorus Uptake ($kg\ ha^{-1}$)**			**Potassium Uptake ($kg\ ha^{-1}$)**		
	Seed	**stover**	**Total**	**Seed**	**stover**	**Total**	**Seed**	**stover**	**Total**
T_1 - S_0 B_0	76.50	15.46	91.96	4.37	1.79	6.16	7.23	18.13	25.37
T_2 - S_0 $B_{0.5}$	79.13	16.87	96.00	4.42	2.00	6.42	7.60	19.42	27.02
T_3 - S_0 $B_{1.0}$	82.01	18.05	100.06	4.75	2.27	7.02	7.93	20.03	27.97
T_4 - S_0 $B_{1.5}$	82.82	17.04	99.86	4.72	2.11	6.83	7.83	20.02	27.85
T_5 - S_{15} B_0	77.26	16.48	93.74	4.37	2.05	6.42	6.73	19.59	26.32
T_6 - S_{15} $B_{0.5}$	94.28	18.81	113.09	5.30	2.34	7.64	8.55	21.75	30.30
T_7 - S_{15} $B_{1.0}$	105.64	22.01	127.65	6.07	2.73	8.80	11.34	25.03	36.37
T_8 - S_{15} $B_{1.5}$	108.60	21.89	130.49	6.19	2.52	8.71	10.39	23.91	34.30
T_9 - S_{30} B_0	116.48	22.46	138.94	6.65	2.81	9.46	11.56	24.94	36.49
T_{10} - S_{30} $B_{0.5}$	125.35	24.54	149.89	7.43	2.86	10.29	11.44	28.25	39.69
T_{11} - S_{30} $B_{1.0}$	125.39	26.76	152.15	7.36	2.96	10.32	13.00	29.23	42.23
T_{12} - S_{30} $B_{1.5}$	121.46	25.70	147.15	7.18	3.43	10.61	11.95	28.07	40.02
T_{13} - S_{45} B_0	95.83	18.74	114.57	5.13	2.51	7.63	8.95	22.70	31.66
T_{14} - S_{45} $B_{0.5}$	117.93	23.97	141.90	6.87	3.04	9.91	10.91	27.24	38.14
T_{15} - S_{45} $B_{1.0}$	120.39	25.78	146.17	7.11	3.14	10.25	11.46	29.37	40.82
T_{16} - S_{45} $B_{1.5}$	117.58	25.47	143.05	6.88	3.00	9.88	10.91	28.17	39.08
S levels ($kg\ ha^{-1}$)									
0	80.12	16.86	96.97	4.57	2.04	6.61	7.65	19.40	27.05

15	96.45	19.80	116.24	5.48	2.41	7.89	9.25	22.57	31.82
30	122.17	24.86	147.03	7.15	3.02	10.17	11.99	27.62	39.61
45	112.93	23.49	136.42	6.49	2.92	9.42	10.56	26.87	37.43
B levels (kg ha^{-1})									
0	91.52	18.28	109.80	5.13	2.290	7.42	8.62	21.34	29.96
0.5	104.17	21.05	125.22	6.00	2.560	8.56	9.63	24.16	33.79
1.0	108.36	23.15	131.51	6.32	2.776	9.10	10.93	25.91	36.85
1.5	107.61	22.52	130.14	6.24	2.766	9.01	10.27	25.04	35.31
SEm±									
S Level	4.39	0.86	5.07	0.270	0.141	0.380	0.506	1.088	1.471
B Level	4.39	0.86	5.07	0.270	0.141	0.380	0.506	1.088	1.471
(SXB) Interaction	8.78	1.73	10.13	0.540	0.283	0.759	1.011	2.177	2.941
CD (P=0.05)									
S Level	12.67	2.49	14.63	0.78	0.408	1.10	1.46	3.14	4.25
B Level	12.67	2.49	14.63	0.78	NS	1.10	1.46	3.14	4.25
(SXB) Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Boron Uptake

Boron uptake by seed was more than that of boron uptake by stover (Table 4). Different sulphur level significantly influenced boron uptake maximum total uptake (98.71 g ha^{-1}) was associated with 30 kg S ha^{-1} and minimum uptake (64.70 g ha^{-1}) with 0 kg S ha^{-1}. Maximum total uptake (90.08 g ha^{-1}) was observed with application of 1.0 kg B ha^{-1} followed by 1.5 kg B ha^{-1} (89.38 g ha^{-1}). Interaction of sulphur and boron level had no significant effect on boron uptake by soybean. The results are in concurrent with the findings observed by Kumar *et al*. (1996) and Islam *et al*. (1999) who reported that uptake of boron increased due to boron application.

Table 4: Effect of sulphur and boron application on S and B uptake by Soybean

Treatment	Sulphur Uptake (kg ha^{-1})			Boron Uptake (g ha^{-1})		
	Seed	Straw	**Total**	Seed	Straw	**Total**
T_1 - S_0 B_0	3.79	1.15	4.94	43.59	16.19	59.78
T_2 - S_0 $B_{0.5}$	3.95	1.35	5.30	48.62	15.34	63.95
T_3 - S_0 $B_{1.0}$	4.41	1.52	5.93	50.82	18.33	69.15
T_4 - S_0 $B_{1.5}$	4.61	1.47	6.08	47.78	18.12	65.90
T_5 - S_{15} B_0	4.00	1.38	5.38	47.98	17.50	65.48
T_6 - S_{15} $B_{0.5}$	5.16	1.42	6.58	56.88	22.15	79.03
T_7 - S_{15} $B_{1.0}$	5.68	1.87	7.55	61.33	22.00	83.33
T - S B	5.50	1.99	7.49	68.23	20.06	88.29

8 15 1.5						
T_9 - S_{30} B_0	5.65	1.77	7.42	67.84	22.26	90.10
T_{10} - S_{30} $B_{0.5}$	6.23	1.92	8.15	72.78	22.33	95.12
T_{11} - S_{30} $B_{1.0}$	7.02	1.93	8.94	77.85	26.02	103.88
T_{12} - S_{30} $B_{1.5}$	6.65	2.24	8.90	77.10	28.66	105.76
T_{13} - S_{45} B_0	5.15	1.47	6.62	54.60	17.36	71.96
T_{14} - S_{45} $B_{0.5}$	6.01	2.16	8.17	75.57	25.61	101.18
T_{15} - S_{45} $B_{1.0}$	6.39	2.14	8.53	75.09	26.06	101.14
T_{16} - S_{45} $B_{1.5}$	6.02	1.99	8.01	73.17	27.20	100.38
S levels (kg ha^{-1})						
0	4.19	1.37	5.56	47.70	17.00	64.70
15	5.08	1.67	6.75	58.60	20.43	79.03
30	6.39	1.96	8.35	73.89	24.82	98.71
45	5.89	1.94	7.83	69.61	24.06	93.66
B levels (kg ha^{-1})						
0	4.65	1.44	6.09	53.50	18.33	71.83
0.5	5.34	1.71	7.05	63.46	21.36	84.82
1.0	5.88	1.86	7.74	66.27	23.10	89.38
1.5	5.70	1.92	7.62	66.57	23.51	90.08
SEm±						
S Level	0.264	0.092	0.333	2.828	1.290	3.498
B Level	0.264	0.092	0.333	2.828	1.290	3.498
(SXB) Interaction	0.528	0.184	0.666	5.656	2.581	6.997
CD (P=0.05)						
S Level	0.76	0.265	0.96	8.17	3.727	10.104
B Level	0.76	0.265	0.96	8.17	3.727	10.104
(SXB) Interaction	NS	NS	NS	NS	NS	NS

Effect of sulphur and boron on available nutrient status of post-harvest soil

Available nitrogen status

Available nitrogen in post-harvest soil was increased over the initial value (225.45 kg ha^{-1}) in all the treatments (Table 5). Increase in sulphur level up to 30 kg ha^{-1} resulted in increase in available nitrogen and thereafter it was decreased. Highest status was recorded with 30 kg S ha^{-1} (239.48 kg ha^{-1}) followed by 45 kg S ha^{-1} (237.13 kg ha^{-1}) and 15 kg S ha^{-1} (235.74 kg ha^{-1}). Available nitrogen was recorded higher with 1.5 kg B ha^{-1}

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(238.84 kg ha^{-1}) followed by 1.0 kg B ha^{-1} (237.42 kg ha^{-1}) and 0.5 kg B ha^{-1} (236.68 kg ha^{-1}).

Available phosphorus status

Available phosphorus in post-harvest soil (Table 5) increased over the initial value (9.68 kg ha^{-1}). Different sulphur level significantly influenced available phosphorus in soil and highest value was observed with 30 kg S ha^{-1} (12.02 kg ha^{-1}) and lowest (10.70 kg ha^{-1}) with 0 kg S ha^{-1} . Available phosphorus was increased with increase in boron level over control (0 kg B ha^{-1}) but did not vary significantly.

Available potassium status

Different boron and sulphur levels did not have significant effect on available potassium (Table 5). Increase in level of sulphur and boron caused decrease in available potassium over the initial value (474 kg ha^{-1}). Highest available potassium (471.37 kg ha^{-1}) was observed with 0 kg S ha^{-1} and lowest (466.66 kg ha^{-1}) with 30 kg S ha^{-1}. Similarly highest available potassium (473.79 kg ha^{-1}) was observed with 0 kg B ha^{-1} and lowest (463.38 kg ha^{-1}) with 1.0 kg B ha^{-1}.

Available sulphur status

In all the treatments available sulphur (Table 5) was increased over the initial value (22.15 kg ha^{-1}). Increase in sulphur level resulted in increase in available sulphur and highest status (27.05 kg ha^{-1}) was recorded with 45 kg S ha^{-1} followed by 30 kg S ha^{-1} (25.00 kg ha^{-1}) and 15 kg S ha^{-1} (23.02 kg ha^{-1}). Available sulphur was recorded highest with 1.5 kg B ha (24.48 kg ha^{-1}) and minimum with 0 kg B ha (23.28 kg ha^{-1}).

Available boron status

Available boron in soil (Table 5) increased over the initial value (0.88 mg kg^{-1}). Different sulphur level influenced available boron in soil and highest value was observed with 45 kg S ha^{-1} (1.08 mg kg^{-1}) and lowest (0.92 mg kg^{-1}) with 0 kg S ha^{-1}. Available boron was increased with increase in boron level over control i.e. (0 kg B ha^{-1}) and highest value (1.17 mg kg^{-1}) was seen with 1.5 kg B ha^{-1} and it was statistically significant. Interaction between sulphur and boron levels was found to have no significant effect on available nitrogen, phosphorus, potassium, sulphur and boron in post-harvest soil.

Table 5: Effect of sulphur and boron on available nutrient status of post-harvest soil

Treatment	Available N(kg ha^{-1})	Available P(kg ha^{-1})	Available K(kg ha^{-1})	Available S(kg ha^{-1})	Available B (mg kg^{-1})
T_1 - S_0 B_0	232.17	10.61	480.22	20.62	0.83
T_2 - S_0 $B_{0.5}$	234.33	10.34	473.09	20.92	0.89
T_3 - S_0 $B_{1.0}$	235.72	11.16	467.81	21.37	0.99
T_4 - S_0 $B_{1.5}$	236.92	10.71	464.37	21.56	1.00
T_5 - S_{15} B_0	233.37	11.24	475.42	22.27	0.86
T_6 - S_{15} $B_{0.5}$	236.68	11.73	468.36	22.57	0.95
T_7 - S_{15} $B_{1.0}$	235.43	11.97	462.85	24.02	0.91
T_8 - S_{15} $B_{1.5}$	237.48	11.54	465.52	23.21	1.30
T_9 - S_{30} B_0	236.82	11.68	472.08	24.42	0.83
T_{10} - S_{30} $B_{0.5}$	239.02	12.02	465.01	25.36	1.00
T_{11} - S_{30} $B_{1.0}$	240.44	12.14	463.13	24.84	1.25

T_{12} - S_{30} $B_{1.5}$	241.66	12.23	463.13	25.38	1.19
T_{13} - S_{45} B_{0}	234.49	11.65	475.42	25.80	0.86
T_{14} - S_{45} $B_{0.5}$	236.68	12.10	468.36	27.10	1.10
T_{15} - S_{45} $B_{1.0}$	238.08	12.15	459.73	27.55	1.18
T_{16} - S_{45} $B_{1.5}$	239.29	12.05	463.13	27.74	1.20
S levels					
0	234.79	10.70	471.37	21.12	0.92
15	235.74	11.62	468.04	23.02	1.00
30	239.48	12.02	465.84	25.00	1.06
45	237.13	11.99	466.66	27.05	1.08
B levels					
0	234.21	11.30	473.79	23.28	0.85
0.5	236.68	11.55	468.70	23.99	0.99
1.0	237.42	11.85	463.38	24.44	1.08
1.5	238.84	11.63	464.04	24.48	1.17
SEm±					
S levels	1.61	0.35	4.426	0.563	0.045
B levels	1.61	0.35	4.426	0.563	0.045
(S x B) Interaction	3.22	0.69	8.853	1.126	0.090
CD (P=0.05)					
S levels	NS	1.00	NS	1.63	NS
B levels	NS	NS	NS	NS	0.13
(SXB) Interaction	NS	NS	NS	NS	NS
Initial Value	**225**	**9.68**	**474**	**22.15**	**0.88**

IV. CONCLUSIONS

From the present study conducted it can be concluded that yield attributes and yield of soybean were as significantly influenced by different sulphur levels and the dose of 30 kg S ha^{-1} was found optimum for getting maximum yield of soybean. Among boron levels, 1.0 kg B ha^{-1} was superior to others for getting higher soybean yield. Sulphur and boron application resulted in increased nutrient uptake by soybean. Maximum nitrogen, phosphorus, potassium, sulphur and boron uptake was observed with 30 kg S ha^{-1} and 1.0 kg B ha^{-1}. Available nitrogen, phosphorus and potassium in post-harvest soil were found higher with application of 30 kg S ha^{-1} and 1.0 kg B ha^{-1}.

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