RESEARCH ARTICLE

EFFECT OF SULPHUR AND BORON ON GROWTH, YIELD AND ECONOMICS OF SOYBAEN (*GLYSINE MAX*L.)

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Abstract: An experiment was conducted at Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar Raipur (Chhattisgarh) during *kharif* season 2015 in vertisol with objective to determine the effect of sulphur and boron application on yield and economics of soybean.The experiment was laid out in a RCBD with 16 treatments comprised four levels of sulphur *viz* 0, 15, 30 and 45 kg ha^{-1} and four levels of boron *viz* 0, 0.5, 1.0 and 1.5 kg ha^{-1}. Result revealed that yield of soybean was significantly influenced by different sulphur levels and maximum yield (20.04 kg ha^{-1} Seed yield and 22.55 kg ha^{-1}stover yield) was observed with 30 kg sulphur per hectare. Among boron levels, 1.0 kg boron per hectare was superior to others for getting maximum soybean yield (18.82 Seed yield and 21.05 kg ha^{-1}stover yield). Interaction of sulphur and boron levels had no significant different parameters under study Gross return (68388 `ha$^{-1}$) and net return (42286 `ha^{-1}) was significantly higher with the application of T_{11} ($S_{30}B_{1.0}$) Statistically highest Benefit cost ratio (2.64) was observed also with T_{11} ($S_{30}B_{1.0}$).

Keywords: Boron, Economics, Soybean, Sulphur, Yield

INTRODUCTION

Soybean designated as "miracle bean" has established its potential as an industrially vital and viable oilseed crop in many areas of India. It is a cheapest source of vegetable oil and protein. It contains about 40% protein, well balanced in essential amino acids, 20% oil rich with poly unsaturated fatty acids specially Omega 6 and Omega 3 fatty acids, 6-7% total mineral, 5-6% - area of 12.2 m ha, with production potential of 11.95 million tonnes and average productivity of 979.3 kg ha^{-1} (Anon., 2013a). The productivity of soybean is less in India as compared to world average (2484.1 kg ha^{-1}). Global area and production of soybean is 111.27 m ha and 276.4 million tonnes respectively (Anon., 2013b). The imbalanced and inadequate nutrition is found to be one of the major limiting factors for its poor yield. Among the major nutrients, sulphur is found to be quite important now a day in many soybean-growing areas. It is the 13th most abundant element in the earth crust with an average concentration of 0.06%. It is now considered as the 4th major plant nutrient after nitrogen (N), phosphorous (P) and potassium (K)for oilseeds. Sulphur is an important part of every living cell, required for the formation of chlorophyll and for the activity of ATP-sulphurylase (the enzyme involved in sulphur metabolism). It is involved in several important physiological functions in soybean including oil synthesis and acts as precursor for many amino acids, namely cysteine (26%S), cystine (27%S) and methionine (21%S) which act as building blocks for the synthesis of protein. As soybean is rich in both oil and protein, the requirement of sulphur is quite high. Over the years due to intensive cultivation and use of sulphur free fertilizers, the deficiency of sulphur has begun to appear and it is slowly becoming a major constraint for realizing higher yield in soybean. Sulphur deficiencies are now widespread in Indian soil and reports of more areas found deficient in S are coming in regularly. Recently, soil fertility survey by the Indian Council of Agricultural Research based on the analysis of 47,000 soil samples has shown S deficiencies to be a widespread problem. Besides sulphur, boron is another element, which is highly important in the physiological functions in soybean. Boron's widespread role within the plant includes cell wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, and regulation of plant hormone levels. Boron has particularly attended an important position in intensive agriculture. Boron is required for the proper development of growing tips, phloem and xylem. Boron helps in germination and growth of pollen grains and also development of pollen-tube thus facilitating fertilization in plant and grain yield.

In Chhattisgarh, agriculture is mainly based on rainwater; therefore most of the crops are grown as rainfed in *kharif* season. Soybean occupies 1.52 lac hectares in Chhattisgarh with a productivity of 11.54 q ha^{-1}. More acreage of soybean in Chhattisgarh state is in plain area namely Durg, Bemetara, Rajnandgaon, Mungeli and Kabirdham districts. In Kabirdham district soybean is grown in 44.25 thousand hectare area with a productivity of 12.10 q ha^{-1}. Among the fertilizer elements, sulphur requirement of oilseed crops is quite high as compared to other crops. Oil seed crops respond to liberal application of sulphur and it is involved in the synthesis of fatty acids and also increases protein

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quality through the synthesis of certain amino acids such as cystine, cystein and methionine. Boron is associated with calcium utilization, cell division, flowering and fruiting, water relations, and protein synthesis. The fertility status of soils has been declining continuously due to non-judicious use of chemical fertilizers and intensive cropping without proper replenishment of nutrients and organic matter. Consequently, 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. Many research works have been done on the effect of N, P and K fertilizers on the yield of soybean crop. But, a few works have been carried out on the effect of sulphur and boron on yield of soybean.

MATERIAL AND METHOD

The experiment was carried out during *kharif,* 2015at Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar Raipur (Chhattisgarh) in vertisol with objective to determine the effect of sulphur and boron application on yield and economics of soybean.The experiment was laid out in a RCBD with 16 treatments comprised four levels of sulphur*viz* 0, 15, 30 and 45 kg ha^{-1} and four levels of boron *viz* 0, 0.5, 1.0 and 1.5 $kgha^{-1}$, replicated thrice.Soybean*var.*JS-335 was sown with spacing of 70 x 20 cm, seed rate 20 kg ha^{-1} and RDF 120:60:40 kg ha^{-1}.Height was measured in cm from ground surface to the tip of main stem. Height of five tagged plants in each plot was recorded in cm at harvest and then average was worked out and used for statistical analysis. Total number of pods was recorded from five randomly tagged plants and mean was worked out by dividing the total number of pods by five and used for statistical analysis. Randomly seed samples were taken from each net plot. 100 healthy seeds from the produce of each plot were counted and same were oven dried till constant weight and then weight was recorded in gram accurately by using an electronic digital balance. Seed yield of the net plot was noted down, after threshing, winnowing and drying then calculated in q ha^{-1} with appropriate multiplication factor. The harvested produce from each net plot was tied in bundles separately. Stover yield of plot was calculated after subtraction of seed yield from bundle weight. Bundle weight was recorded with the help of spring balance and converted into qha^{-1}.The harvest index was determined by using the formula given by Donald (1962).Gross return and cost of cultivation was calculated for each treatment, using current purchase price of inputs and the selling price of outputs prevailing in local market. Net profit was calculated as gross income subtracted by cost of cultivation. Benefit cost ratio was computed as the ratio of net return and cost of cultivation in the following formula:

Gross return (\`$ha^{-1}$) = Income received from sale of grain, stover and stone (\`ha^{-1})

Net return (\`$ha^{-1}$) = Gross return (\`ha^{-1}) - cost of cultivation (\`ha^{-1})

$$\text{B:C ratio} = \frac{\text{Net return (`ha}^{-1}\text{)}}{\text{Cost of cultivation (`ha}^{-1}\text{)}}$$

Analysis of variance method (Gomez and Gomez, 2003) was followed for statistical analysis of various data. Significance of different sources of variations was tested by “error mean square method” of Fisher Snedecor’s ‘F’ test at probability level 5%. In the tables of result the standard error of mean (SEm±) and the value of least significant difference (critical difference) at 5% between mean have been provided. Data on weed count and weed biomass were subjected to square root transformation $\sqrt{X+0.5}$ to make the analysis of variance valid (Gomez and Gomez, 2003).

RESULT AND DISCUSSION

Effect on growth

Plant height of soybean (Table - 1) ranged from 35.43 cm to 43.90 cm. Irrespective of the boron level, application of sulphur significantly affected plant height and maximum height (42.89 cm) was observed with application of 45 kg S ha^{-1} followed by 30 kg S ha^{-1} (41.63 cm) and 15 kg S ha^{-1} (39.18 cm). Plant height with application of 0, 0.5, 1.0 and 1.5 kg B ha^{-1} were 38.03, 40.99, 40.75 and 40.98 cm respectively and were statistically *at par*. Maximum plant height (43.90cm) was observed in the treatment T16 ($S_{45}B_{1.5}$) and minimum (35.43 cm) in control where no sulphur and boron were applied i.e. T1 (S_0B_0). Interaction effect between sulphur and boron level was found to be non-significant. Similar findings were reported by Chaubey*et al.* (2000)

Effect on yield attributes

Number of pods $plant^{-1}$(Table - 1) significantly varied due to application of different sulphur levels. Number of pods$plant^{-1}$ ranged from 42.00 to 50.04. Minimum number was associated 0 kg S ha^{-1}. Which was increased with increasing level of sulphur and maximum number was observed with 45 kg S ha^{-1}. Maximum number of pods $plant^{-1}$ (47.17) was recorded due to application of 1.5 kg B ha^{-1} followed by 1.0 kg B ha^{-1} (46.92), 0.5 kg B ha^{-1} (46.75) and minimum number with 0 kg B ha^{-1} (44.33). However, number of pods $plant^{-1}$ under different boron levels did not differ significantly. Interaction of sulphur and boron level did not have any significant effect on the number of pods $plant^{-1}$ and maximum (50.04) and minimum (42.00) value were associated with T_{16} ($S_{45}B_{1.5}$) and T_1 (S_0B_0) respectively.

Table 1. Effect of sulphur and boron on growth, yield attributes and yield of 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_0B_0	35.43	42.00	10.31	13.72	15.57	46.51
T_2 - $S_0B_{0.5}$	38.57	44.67	10.34	13.77	15.98	46.30
T_3 - $S_0B_{1.0}$	37.13	43.00	10.73	14.52	16.96	46.16
T_4- $S_0B_{1.5}$	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
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 Level	0.90	0.93	0.43	0.74	0.78	0.58
B Level	0.90	0.93	0.43	0.74	0.78	0.58
(SXB) Interaction	1.80	1.86	0.86	1.47	1.55	1.17
CD (P=0.05)						
S Level	2.59	2.69	1.24	2.13	2.24	NS
B Level	NS	NS	1.24	2.13	2.24	NS
(SXB) Interaction	NS	NS	NS	NS	NS	NS

Different level of sulphur had significant effect on 100 seed weight (Table-1). The highest weight of 100 seed (12.32 g) was found with 30 kg S ha^{-1} and the lowest 100 seed weight (10.55 g) was found with 0 kg S ha^{-1}. 100 seed weight with application of 30 kg S ha^{-1} and 45 kg S ha^{-1} (11.79 g) were found to be statistically *at par* with each other but significantly higher than that of 15 kg S ha^{-1} (11.47 g) and 0 kg S ha^{-1} (10.55 g) Irrespective of the sulphur level, boron level had significant effect on 100 seed weight. 100 seed weight of soybean was increased with increase in boron level up to 1.0 kg B ha^{-1} and beyond this level 100 seed weight was decreased. 100 seed weight with 0 kg B ha^{-1}, 0.5 kg B ha^{-1}, 1.0 kg B ha^{-1} and 1.5 kg B ha^{-1} were 10.41, 11.53, 12.25 and 11.94 respectively. Interaction of sulphur and boron level did not have any significant effect on 100 seed weight. Highest 100 seed weight (12.92 g) was observed with T_{11} ($S_{30}B_{1.0}$) and lowest 100 seed weight (10.31 g) was recorded in T_1 (S_0B_0).Highest harvest index was associated with 30 kg S ha^{-1} (48.25 %), 0.5 kg B ha^{-1} (47.49 %) and T_{10} - $S_{30}B_{0.5}$ (48.94 %).Result confirmed by Chaubey *et al*. (2000) and also supported by Halepyati (2001) and Singaravel *et al.* (2006).

Effect on yield

Seed yield of soybean ranged from 13.72 to 21.83 q ha^{-1}(Table 1). The highest seed yield (21.04 q ha^{-1}) was obtained with 30 kg S ha^{-1} followed by (19.67 q ha^{-1}) was obtained from 45 kg S ha^{-1}. The lowest one 14.15 q ha^{-1} was associated with 0 kg S ha^{-1}Seed yield of soybean was significantly influenced by boron level. Significantly higher seed yield was (18.82 q ha^{-1}) with 1.0 kg Bha^{-1} followed by 1.5 kg B ha^{-1} (18.71 q ha^{-1}) and 0.5 kg B ha^{-1} (18.23 q ha^{-1}) whereas the lowest seed yield (16.02 q ha^{-1}) was obtained from 0 kg B ha^{-1}.

The highest seed yield (21.83 q ha^{-1}) was recorded with T_{11} ($S_{30}B_{1.0}$) and the lowest one (13.72 q ha^{-1}) with T_1 (0 kg B ha^{-1} and 0 kg S ha^{-1}). But interaction effect between sulphur and boron level was found to be non-significant. Stover yield of soybean significant influence with different sulphur level. The highest stover yield of 22.55 q ha^{-1} was recorded with 30 kg S ha^{-1} and the lowest one (16.29 q ha^{-1}) was found with 0 kg S ha^{-1}. Boron level showed significant influence on stover yield of soybean. The stover yield was more (21 .05q ha^{-1}) with 1.0 kg B ha^{-1} as compared to the stover yield of 20.88 and 20.06 q ha^{-1} which was associated with 1.5 and 0.5 kg B ha^{-1} respectively and lowest stover yield (17.94 q ha^{-1}) was obtained from 0 kg B ha^{-1}. The stover yield of soybean did not vary significantly by the interaction effect of sulphur and boron level. The sum total effect will be higher seed yield. The results confirm the findings of Kumar *et al.* (1992) and Sarkar*et al.* (2002).These finding were also supported by Halepyati (2001) and Singaravel *et al.* (2006). 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) also reported that seed yield of cowpea increased significantly with the increase in boron application.

Effect on economics

Cost of cultivation of soybean was significantly varied due to application of different sulphur levels. Cost of cultivation(\`$ha^{-1}$)of soybean ranged from 22557 to 27286. Significantly lowest cost of cultivation \` 22557 $ha^{-1}$was applied in T_3 ($S_0B_{1.0}$) and maximum cultivation \` 27286 $ha^{-1}$was applied in $T_{13}$($S_{45}B_0$).Gross return (68388 \`ha^{-1}) and net return (42286 \`$ha^{-1}$) was significantly higher with the application of $T_{11}$ ($S_{30}B_{1.0}$) which was *at par with* $T_{10}$ ($S_{30}B_{0.5}$) as compare to rest of treatments and significantly lowest gross (43547\`ha^{-1}) and net return (17543 \`ha^{-1}) found in control. Statistically highest Benefit cost ratio (2.64) was observed also with T_{11} ($S_{30}B_{1.0}$) which was *at par* being with T_{10} ($S_{30}B_{0.5}$) and T_{15} ($S_{45}B_{1.0}$). Similar findings were observed by Singaravel *et al.* (2006) and Singh *et al.* (2003).

Table 2. Effect of sulphur and boron on economics of soybean

Treatment	Cost of Cultivation (\`ha^{-1})	Gross Return (\` ha^{-1})	Net Return (\` ha^{-1})	B:C Ratio
T_1 - S_0B_0	23914	43457	17543	1.61
T_2 - $S_0B_{0.5}$	22926	43792	20866	1.93
T_3 - $S_0B_{1.0}$	22557	46232	23675	2.05
T_4- $S_0B_{1.5}$	24270	46280	22010	1.91
T_5 - $S_{15}B_0$	24956	44420	19464	1.78
T_6 – $S_{15}B_{0.5}$	26093	52668	26789	2.03
T_7 – $S_{15}B_{1.0}$	26323	57122	30799	2.17
T_8 – $S_{15}B_{1.5}$	27061	59536	32475	2.20
T_9 – $S_{30}B_0$	24680	61948	37268	2.51
T_{10} – $S_{30}B_{0.5}$	25830	67880	42050	2.62
T_{11} – $S_{30}B_{1.0}$	26102	68388	42286	2.64
T_{12} – $S_{30}B_{1.5}$	25938	65731	39793	2.53
T_{13} – $S_{45}B_0$	27286	52663	25377	1.93
T_{14} – $S_{45}B_{0.5}$	27156	65448	38292	2.41
T_{15} – $S_{45}B_{1.0}$	25834	66112	40278	2.55
T_{16} – $S_{45}B_{1.5}$	26521	64797	38276	2.51
S levels (kg ha^{-1})				
0	23916	44940	21023	1.87
15	26108	53436	27381	2.05
30	25637	65986	40349	2.58
45	26699	62255	35555	2.35
B levels (kg ha^{-1})				
0	25709	50622	24913	1.96
0.5	25501	57447	31999	2.25

1.0	25204	59463	34259	2.35
1.5	25947	59086	33138	2.29
SEm±				
S Level	413.24	206.62	208.41	0.03
B Level	413.24	206.62	208.41	0.03
(SXB) Interaction	826.48	413.24	416.82	0.06
CD (P=0.05)				
S Level	1193.53	596.77	601.94	0.09
B Level	NS	596.77	601.94	0.09
(SXB) Interaction	NS	S	S	S

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