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Sulphur and Boron Fertilization on Yield Quality and Nutrient Uptake by Bangladesh Soybean-4

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Abstract: Effect of S and B fertilization on yield, quality and nutrient uptake by soybean was investigated. Experiment comprised five levels of both sulphur and boron viz. 0, 10, 20, 30 and 50 kg S ha^{-1} and 0, 0.5, 1.0, 2.0 and 4.0 kg B ha^{-1}. Yield and yield attributes were significant when S and B were applied individually but their interaction were not significant. The highest biological yield and most of the yield attributes were obtained for the treatment combination of 30 kg S and 1.0 kg B ha^{-1}. Grain yield was found to be significantly and positively correlated with effective pod and seed per plant. Grain yield was directly proportional to harvest index. Grain S and B uptake was significant by both S and B application individually but their content was not significant. Protein and oil contents of soybean grain were increased with increasing levels of both S and B though their effects were not significant. A positive and significant correlation was observed between protein and oil contents of Bangladesh soybean-4. The overall results suggested that S and B @ 30 and 1.0 kg ha^{-1} alone or in combination proved to be the best in respect of the parameters studied.

Key words: Sulphur, boron, soybean, protein, oil and nutrient uptake

Introduction

The fertility status of Bangladesh soils has been declining continuously due to intensive cropping without proper replenishment of nutrients and organic matter. Consequently, in addition to N, P and K deficiencies, some other nutrients such as S, Zn and B deficiencies are being observed in many parts of the country (Jahiruddin *et al.*, 1995). Among the fertilizer elements, sulphur (S) requirement of oilseed crops is quite high as compared to other crops (Das and Das, 1994). Oil seed crops response to liberal application of sulphur. Sulphur is involved in the synthesis of fatty acids and also increased protein quality through the synthesis of certain amino acids such as cystine, cystein and methionine (Havlin *et al.*, 1999). In general, about 97% soils of Bangladesh are deficient in S. Use of non-judicious chemical fertilizers, intensive cultivation of modern rice, higher cropping intensity and limited use of organic matter are the most probable reasons for S deficiency. Recently farmers of Bangladesh are being advised to use S containing fertilizer along with urea for higher yield (Anonymous, 1997).

Boron (B) deficiency is also reported in some soils and crops (Islam *et al.*, 1999). In Bangladesh, about one million-hectare of land has boron deficiency problem (Ahmed and Hossain, 1997) causing low yields of crops. Boron is involved in the synthesis of protein (Sauchelli, 1969) and oil (Malewar *et al.*, 2001). Many research works have been done on N, P and K fertilizers for rice and other crops. But a few works have been carried out on the effect of sulphur and boron on rice and other crops, although it has been experimentally proved that sulphur and boron are very much conducive to increase the production of soybean in different parts of Bangladesh as well as in many parts of the world. With the above mentioned facts in mind, the study has been undertaken to investigate the effect of S and B on yield attributes, yield and quality of soybean.

Materials and Methods

A field experiment was conducted in the Horticulture Farm, Bangladesh Agricultural University, Mymensingh, during the period from December 2001 to April 2002. Bangladesh soybean-4 (G-2) was used as the test crop. The soil was silt loam in texture having pH 6.7, 1.71% organic matter, 0.09% total N, 11.5 $\mu g\ g^{-1}$ available P, 0.06 meq exchangeable K 100 g^{-1} soil, 8.0 $\mu g\ g^{-1}$ available S and 0.25 $\mu g\ g^{-1}$ available B. There were 25 treatment combinations consisting of five rates of both S (0, 10, 20, 30 and 50 kg S ha^{-1}) and B (0, 0.5, 1.0, 2.0 and 4.0 Kg B ha^{-1}). The experiment was laid out in a factorial combination of S and B following randomized complete block design. Sulphur and Boron fertilizers were applied as per design and treatments and all other fertilizers were applied according to the fertilizer recommendation guide (Anonymous, 1997). Seed were sown @ 40 kg ha^{-1} in line on December 13, 2001. Intercultural operations were done as and when necessary. The crop was harvested on 13th April, 2002. Grain and straw yields were recorded from the whole plot harvest. Soybean grain from every plot was chemically analyzed for the determination of total N, oil, S and B contents. The grain samples were digested in nitric-perchloric acids to determine S and B. Sulphur was determined by turbidimetrically (Page *et al.*, 1989) and boron by azomethine-H method (Hunter, 1984). Total N was determined by Micro-Kjeldahl method (Page *et al.*, 1989). Protein was calculated by % total N × 6.25 (Morrison, 1956). Oil content was determined by Folsch method (Folsch *et al.*, 1957). The uptake of S and B were calculated by multiplying the concentration of S and B with grain yield. The data were analyzed statistically and significant differences among the treatment means were determined by least significant difference (Steel and Torrie, 1980) test for interpretation of results.

Results and Discussion

Yield components: All yield attributing characters viz. plant height, branches $plant^{-1}$, effective pod $plant^{-1}$, pod length, seed $plant^{-1}$ and 100-seeds weight of the experimental crop varied significantly with different sulphur levels (Table 1). The highest yield components were found when the crop was fertilized with 30 kg S ha^{-1} except plant height and pod length. The tallest plant height and pod length was found by the application of 10 kg S and 50 kg S ha^{-1}, respectively. In all the cases control treatment produced the lowest. From the above findings, it is clear that yield attributing characters were greatly affected by sulphur application. The above results are in conformity with the results of Chaubey *et al.* (2000) who reported that number of primary branches, pod $plant^{-1}$, plant height, 100-kernel weight of groundnut were significantly higher by the application of sulphur. Similar result was on put forward by Dubey *et al.* (1997) who reported that sulphur enhanced the branches $plant^{-1}$, capsules $plant^{-1}$, seeds $capsule^{-1}$ and 1000-grains weight of lentil. Chowdhury *et al.* (1995) reported that number of effective tillers $hill^{-1}$ and 1000-grains weight of rice were increased by sulphur. Sulphur application also increased the pod length of soybean (Hemantarajan and Trivedi, 1997).

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Table 1: Effect of sulphur and boron on yield and yield attributes of Bangladesh soybean-4 (G-2)

Treatments	Plant height (cm)	Branches $plant^{-1}$ (No.)	Effective pod $Plant^{-1}$ (No.)	Pod length (cm)	Seed $plant^{-1}$ (No.)	100-seeds weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
S_0	66.1	3.18	38.5	3.66	86.5	8.0	1806	2726	39.9
S_{10}	75.0	3.29	39.6	3.79	89.9	9.2	1842	2748	39.6
S_{20}	71.3	3.42	42.3	3.85	90.0	10.7	1879	2762	39.6
S_{30}	68.1	3.61	44.1	3.89	91.6	11.5	2048	2812	41.1
S_{50}	72.6	3.46	42.1	3.95	88.1	10.8	1925	2791	39.9
B_0	68.5	3.11	39.2	3.64	82.7	9.3	1792	2745	39.5
$B_{0.5}$	71.3	3.48	42.2	3.92	87.0	10.0	1884	2760	39.8
$B_{1.0}$	69.4	3.56	43.8	3.86	93.7	10.4	2037	2797	41.1
$B_{2.0}$	70.9	3.43	41.9	3.88	91.1	10.9	1939	2781	40.1
$B_{4.0}$	73.1	3.60	39.5	3.85	91.6	9.7	1825	2769	39.4
LSD (0.05)	2.9	0.16	1.8	0.17	2.2	0.3	50.2	61.2	0.8
$S_0 B_0$	64.5	3.01	35.6	3.50	79.7	7.3	1750	2563	39.4
$S_0 B_{0.5}$	66.3	3.25	39.8	3.69	83.1	11.4	1800	2747	39.6
$S_0 B_{1.0}$	65.1	3.26	41.2	3.71	85.9	8.8	1870	2819	39.9
$S_0 B_{2.0}$	65.9	3.21	39.6	3.66	83.3	10.6	1840	2800	39.7
$S_0 B_{4.0}$	68.7	3.17	36.0	3.70	81.2	11.0	1770	2702	39.6
$S_{10} B_0$	72.9	3.08	37.0	3.59	84.3	9.5	1750	2701	39.3
$S_{10} B_{0.5}$	75.5	3.35	40.6	3.81	87.3	9.2	1840	2812	39.5
$S_{10} B_{1.0}$	73.7	3.41	42.7	3.89	89.5	10.2	1970	2902	40.4
$S_{10} B_{2.0}$	75.1	3.32	40.1	3.81	87.8	8.3	1850	2862	39.2
$S_{10} B_{4.0}$	77.8	3.27	37.4	3.84	86.1	8.7	1800	2792	39.2
$S_{20} B_0$	69.5	3.12	40.7	3.64	88.1	10.9	1760	2790	38.7
$S_{20} B_{0.5}$	71.7	3.50	42.9	3.88	91.8	10.6	1880	2872	39.6
$S_{20} B_{1.0}$	70.4	3.58	44.2	3.96	93.4	11.3	2021	2931	40.8
$S_{20} B_{2.0}$	71.2	3.46	42.5	3.87	92.2	10.1	1931	2901	39.9
$S_{20} B_{4.0}$	73.9	3.42	41.0	3.91	90.1	10.3	1801	2832	38.9
$S_{30} B_0$	65.3	3.20	42.1	3.69	91.7	8.4	1880	2831	39.9
$S_{30} B_{0.5}$	68.9	3.75	45.1	3.93	94.8	8.0	2000	2921	40.6
$S_{30} B_{1.0}$	66.7	3.94	46.2	3.98	95.3	12.6	2301	3010	43.3
$S_{30} B_{2.0}$	68.5	3.64	44.6	3.93	94.2	11.9	2100	2951	41.6
$S_{30} B_{4.0}$	70.8	3.51	42.5	3.94	92.3	7.7	1901	2871	39.8
$S_{50} B_0$	70.3	3.15	40.4	3.76	88.7	11.0	1821	2840	39.1
$S_{50} B_{0.5}$	73.9	3.57	42.6	3.97	92.2	10.8	1901	2901	39.6
$S_{50} B_{1.0}$	70.8	3.60	44.4	4.01	93.7	11.5	2081	2961	41.3
$S_{50} B_{2.0}$	73.6	3.54	42.3	4.04	92.6	10.1	1974	2931	40.2
$S_{50} B_{4.0}$	74.3	3.43	40.6	3.96	90.6	10.5	1850	2850	40.6
CV (%)	5.7	6.55	4.9	6.08	3.3	4.0	3.61	2.93	2.6

Different levels of boron also brought a significant variation in respect of yield components (Table 1). Boron @ of 4.0 kg ha^{-1} produced the highest plant height and branches $plant^{-1}$, 1.0 kg ha^{-1} produced effective pod $plant^{-1}$ and seed $plant^{-1}$, 0.5 kg ha^{-1} produced pod length and 2.0 kg ha^{-1} produced 100-seeds weight and lowest from control in all the yield components. Earlier works mark the evidence that application of boron influenced the yield components. Tripathy *et al.* (1999) conclusively suggested that application of boron increased pod $plant^{-1}$. Havlin *et al.* (1999) also reported that flowering and fruit development were restricted by a shortage of boron. It is revealed from the results that yield components were not significantly affected by S and B interaction. However, the highest value for most of the yield components was obtained when the crop was fertilized with 30 kg S in combination with 1.0 kg B ha^{-1} except plant height and pod length. The tallest plant height and pod length were found by the application of $S_{10}B_{4.0}$ and $S_{50}B_{2.0}$, respectively and control treatment produced the lowest.

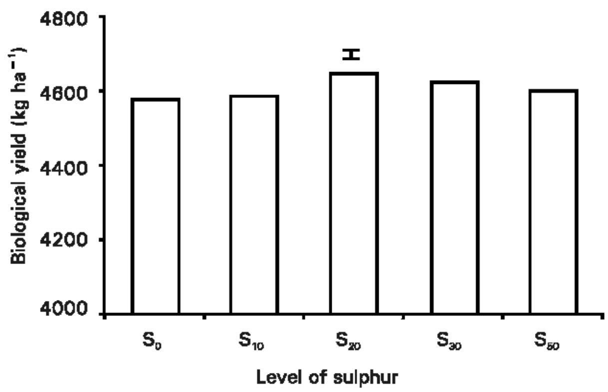

Fig. 1: Effect of sulphur on biological yield of Bangladesh soybean-4 (G-2)

Grain yield: Grain yield showed a significant variation for different sulphur levels (Table 1). Among the treatment 30 kg S ha^{-1} produced the highest grain yield (2048 kg ha^{-1}) and lowest (1806 kg ha^{-1}) was found from control. Higher grain yield in S_{30} might have resulted from the cumulative favourable effect of the number of effective pod $plant^{-1}$ and number of seed $plant^{-1}$ (Figs. 3, 4) and also helps plant metabolism which produced higher yield (Tiwari *et al.*, 1997). The result obtained in this regard is in accordance with the findings of Chowdhury *et al.* (1995) who reported that S increased the grain yield of rice. Present result shows that grain yield increased with S application up to 30 kg ha^{-1} and then decreased. Tripathy *et al.* (1999) also stated that high rates of S slightly decreased the yield of gram.

Boron showed a significant variation on grain yield. The grain yield was highest (2037 kg ha^{-1}) when the crop received 1.0 kg B ha^{-1} and lowest (1792 kg ha^{-1}) was found from control. This might be due to boron deficiency which helps seed formation (Brady, 1996). Results of this study is consistent with that of Chowdhury *et al.* (2000) who reported that seed yield increased significantly with each increment of boron. Results also noticed that interaction of sulphur and boron was not significant regarding grain yield. The highest grain yield was recorded in $S_{30}B_{1.0}$ and lowest was found from control. It is clear from the above trial that S in conjunction with B produced higher grain yield. Similar opinion was on put forward by Ahmed *et al.* (1991) who reported that S and B produced higher seed yield.

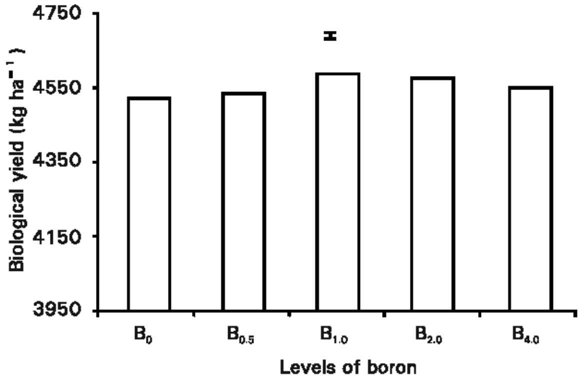

Fig. 2: Effect of boron on biological yield of Bangladesh soybean-4 (G-2)

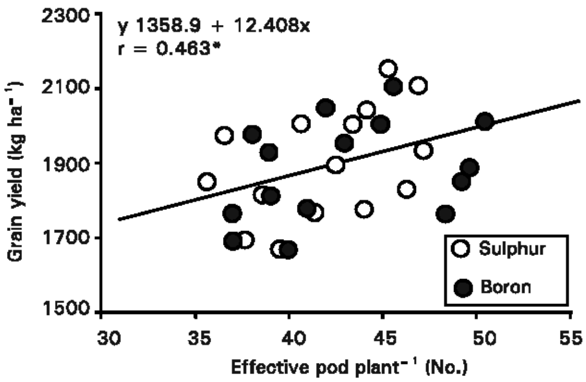

Fig. 3: Relationship between grain yield and effective pod $plant^{-1}$ of Bangladesh soybean-4 (G-2)

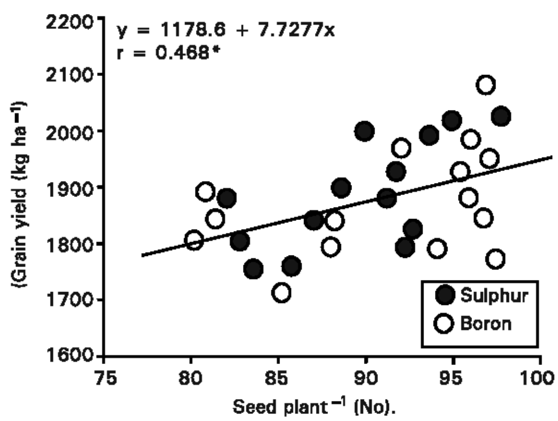

Fig. 4: Relationship between grain yield and seed $plant^{-1}$ of Bangladesh soybean-4 (G-2)

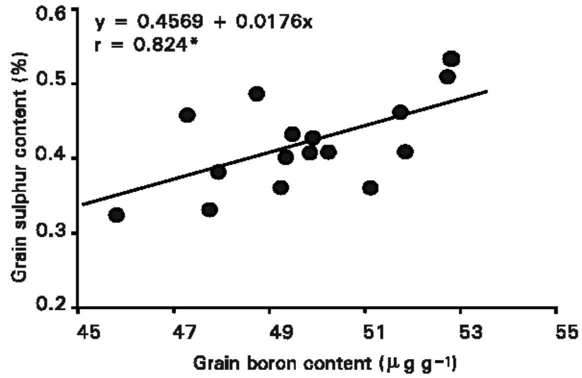

Fig. 5: Relationship between sulphur and boron content of the grain of Bangladesh soybean-4 (G-2)

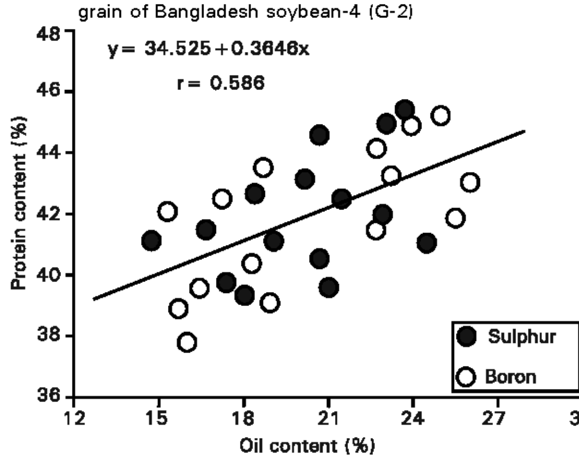

Fig. 6: Relationship between protein and oil content the grain of Bangladesh soybean-4 (G-2)

Straw yield: Different levels of sulphur on straw yield were also showed the same trend as did the grain yield (Table 1). The production of higher straw yield in 30 kg S ha^{-1} might be due to the fact that S tends primarily to encourage above ground vegetative growth. On the other hand, S has also the most pronounced effect on plant growth. The findings for this character agree with the result obtained by Tomar *et al.* (1997) who observed that straw yields of mustard increased with increase in S rates. Results showed that straw yield was significantly influenced by boron application. The highest and lowest straw yields were obtained by boron as same to the grain yield. The results indicated that straw yield was influenced by boron fertilization. The present result is in concurrent with the findings observed by Bhuiyan *et al.* (1998) who reported that B produced the higher straw yield of lentil. On the other hand, the results differ from that of Panwar *et al.* (1998) who reported that straw yield was less effected by high levels of B. The interaction effect of sulphur and boron in relation to straw yield was found the same trend as obtained by grain yield (Table 1). From this discussion, it is clear that $S_{30}B_{1.0}$ had the best performance for straw yield.

Biological yield and harvest index: The total yield of plant material is known as biological yield and the ratio of yield of the grain to biological yield is harvest index (Donald and Hamblin, 1976). Biological yield and harvest index were found to be significant due to different levels of sulphur (Fig. 1) and (Table 1), respectively. However, the highest biological yield and harvest index were found from S_{30} and lowest from control. Different levels of boron also showed a significant variation in relation to biological yield and harvest index. The highest biological yield and harvest index were found when the crop was fertilized with 1.0 kg B ha^{-1} and lowest from control (Fig. 2). Grain yield was directly proportional to harvest index, where, r = 0.9079 which was significant at 1% level of probability and regression equation Y =1421.1 + 11.089X.

Grain nutrient uptake: Grain sulphur and boron uptake showed a significant variation by the application of different levels of sulphur (Table 2). The highest S and B uptake were found when sulphur was applied @ 10 and 20 kg ha^{-1}, respectively and lowest uptake were obtained from no sulphur application. The above results

Table 2: Effect of sulphur and boron on sulphur, boron, protein and oil content of the grain of Bangladesh soybean-4 (G-2)

	Grain sulphur		Grain boron			
Treatments	Content (%)	Uptake (kg ha^{-1})	Content (μg g^{-1})	Uptake (g ha^{-1})	Protein content (%)	Oil content (%)
S_0	0.411	7.42	49.3	88.9	41.2	20.0
S_{10}	0.425	8.71	49.5	91.3	41.9	20.2
S_{20}	0.419	7.86	50.2	102.0	42.3	20.8
S_{30}	0.416	7.67	49.8	93.5	42.6	21.2
S_{50}	0.422	8.11	49.9	95.9	42.9	20.9
B_0	0.412	7.38	49.3	88.3	41.6	20.2
$B_{0.5}$	0.418	7.88	49.8	93.9	42.2	20.6
$B_{1.0}$	0.415	7.57	49.9	96.8	42.9	21.1
$B_{2.0}$	0.421	8.14	50.3	104.0	42.4	20.9
$B_{4.0}$	0.423	8.61	49.5	90.4	41.9	20.4
LSD (0.05)	-	0.44	-	3.2	-	-
$S_0 B_0$	0.401	7.01	48.7	85.2	40.3	19.5
$S_0 B_{0.5}$	0.413	7.43	49.4	88.9	41.1	20.0
$S_0 B_{1.0}$	0.419	7.83	49.1	86.9	42.4	20.6
$S_0 B_{2.0}$	0.415	7.63	49.5	91.0	41.5	20.3
$S_0 B_{4.0}$	0.408	7.22	49.7	92.9	40.8	19.8
$S_{10} B_0$	0.418	7.85	49.1	85.9	41.4	19.8
$S_{10} B_{0.5}$	0.424	8.48	49.5	91.1	41.9	20.2
$S_{10} B_{1.0}$	0.430	9.89	49.4	88.9	42.6	20.7
$S_{10} B_{2.0}$	0.425	8.85	49.7	91.9	42.1	20.5
$S_{10} B_{4.0}$	0.420	7.98	50.0	98.5	41.7	20.0
$S_{20} B_0$	0.417	7.58	49.8	93.7	41.8	20.4
$S_{20} B_{0.5}$	0.421	7.99	50.3	100.0	42.3	20.8
$S_{20} B_{1.0}$	0.429	8.92	50.0	95.0	42.8	21.3
$S_{20} B_{2.0}$	0.424	8.35	50.4	105.0	42.6	21.1
$S_{20} B_{4.0}$	0.418	7.73	50.7	116.0	42.1	20.6
$S_{30} B_0$	0.411	7.19	49.4	86.4	42.4	20.9
$S_{30} B_{0.5}$	0.417	7.67	49.8	93.7	43.0	21.2
$S_{30} B_{1.0}$	0.423	8.33	49.5	89.1	43.3	21.6
$S_{30} B_{2.0}$	0.418	7.73	50.0	96.5	43.2	21.3
$S_{30} B_{4.0}$	0.413	7.43	50.3	101.0	42.7	21.0
$S_{50} B_0$	0.414	7.28	49.6	90.2	42.0	20.6
$S_{50} B_{0.5}$	0.417	7.83	50.0	95.0	42.5	21.0
$S_{50} B_{1.0}$	0.426	8.60	49.4	91.9	43.5	21.4
$S_{50} B_{2.0}$	0.422	8.14	50.1	98.6	42.8	21.1
$S_{50} B_{4.0}$	0.415	7.47	50.4	104.0	42.2	20.8
CV (%)	5.700	4.60	3.6	7.6	4.2	7.4

revealed that S dose increases its uptake due to high S content and high grain yield. These 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. But the results differed from that of Krishna (1995) who stated that S uptake decreased with its increased application. Boron had significant variation in relation to B and S uptake by soybean (Table 2). The highest B and S uptake was achieved by the application of 2.0 and 4.0 kg B ha^{-1}, respectively and lowest from control. In this study it might be concluded that boron uptake was influenced by B application, this probably due to the application of boron in the field and high grain yield. The results are in concurrent with the findings observed by Kumar *et al.* (1996) who reported that uptake of boron increased due to boron application. A significant and positive correlation was found between grain sulphur and boron content (Fig. 5). Data shows that there was no significant effect on S and B uptake due to sulphur and boron interaction. However, the highest S and B uptake was found from the treatment combination of $S_{10}B_{1.0}$ and $S_{20}B_{4.0}$, respectively and lowest from control (Table 2).

Protein and oil content: Seed protein and oil content was not significantly influenced by different levels of S (Table 2). Sulphur @ 50 kg and 30 kg ha^{-1} produced the highest protein and oil content, respectively and lowest was in control. It is evident from the results that S had remarkable influence on protein and oil content. Because S is required for the synthesis of fatty acids and S-containing amino acids, such as cystine, cysteine and methionine which are essential components of protein (Havlin *et al.*, 1999). The above results are consistent with some reports that protein (Tomar *et al.*, 1995) and oil content (Babhulkar *et al.*, 2000) was increased with increase in S rate. In contrast, Khatik *et al.* (1992) reported that S application decreased seed oil content. The result exhibits that boron application did not significantly affect the protein and oil contents (Table 2). The highest and lowest protein and oil content was found from 1.0 kg B ha^{-1} and control treatment, respectively. It is evident from the results that protein and oil content was influenced by boron fertilizer. The above result confirms that of Brady (1996) who reported that B is involved in the synthesis of protein while Malewar *et al.* (2001) and Noor *et al.* (1997) observed that oil is synthesized by boron. Tamak *et al.* (1997) reported that B decreased the protein content. A significant and positive correlation was observed between protein and oil content of soybean (Fig. 6). Interaction of S and B failed to show any significant variation on protein and oil content (Table 2). The highest protein and oil content was found by the application of 50 kg S in combination with 1.0 kg B ha^{-1} and $S_{30}B_{1.0}$, respectively. This result substantiates the findings of Patgiri (1995) that highest protein content was in the treatment of B + S. Sinha *et al.* (1990) obtained highest oil yield with 20 kg S in conjunction with 1.2 kg B ha^{-1}.

From the above discussion, it may be concluded that 30 kg S and 1.0 kg B ha^{-1} individually or in combination along with the recommended rates of NPK and Zn fertilizers should be applied for increased yield and quality of Bangladesh soybean-4 under the agro-climatic condition of Bangladesh Agricultural University.

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