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EFFECT OF SULPHUR AND BORON ON HYBRID SUNFLOWER

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Abstract

The Field investigations were conducted in two locations *viz.*, at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu during March – June 2013 and at farmers field at Ko-Chathiram village, Kurinjipadi block, Cuddalore district, Tamil Nadu during July- October 2013 to study the effect of different levels of sulphur and boron on growth, yield attributes and yield of hybrid sunflower cv. Sunbred. The treatment consisted of sulphur with five levels (0, 15, 30, 45, 60 kg S ha^{-1}) and three levels of boron (0, 0.5, 1.0 kg B ha^{-1}). Totally fifteen treatments were tested and were laid out in factorial concept of randomized block design with three replications. The results revealed that growth, yield attributes and yield, quality, nutrient uptake, post harvest soil nutrient status and sulphur use efficiency was significantly influenced by various S levels in the B levels. Among the different levels of sulphur tried, application of 60 kg S ha^{-1} with B @ 1 kg ha^{-1} was significantly recorded maximum growth, yield attributes and yield, quality, nutrient uptake, post harvest soil nutrient status and sulphur use efficiency of hybrid sunflower while 0 kg S ha^{-1} with B @ 1 kg ha^{-1} registered minimum values for growth and yield of sunflower. Among the treatment combinations tried, 60 kg S ha^{-1} with B @ 1 kg ha^{-1} has a spectacular effect on growth and yield attributes, ultimately leading to maximum seed yield (2573.25 and 2673.84 kg ha^{-1}) in both the crops. The lowest values of growth and yield attributes and yield were recorded by 0 kg S ha^{-1} with B @ 1 kg ha^{-1}.

Key words : Hybrid Sunflower, Yield attributes, Sulphur, Boron.

Introduction

In the agricultural economy of India, oilseeds are important next only to food grains in terms of acreage, production and value. India is the largest producer of oilseeds in the world in terms of output. Tamil Nadu is one of the major oilseeds producing state in India. The major edible oilseed crops grown in this state are peanut, sesame, sunflower etc., Among the oilseed crops, sunflower (*Helianthus annuus* L.) is an all season crop. Holds great promise as an oilseed crop because of its short duration, photo-in-sensitivity and wide adaptability to different agro-climatic regions and soil types. Sunflower seed contains about 48-53 percent edible oil. Sunflower oil is a rich source of linoleic acid (64 percent) which is good for heart patients. The oil is also used for manufacturing hydrogenated oil. Sunflower can play an important role in meeting out the shortage of edible oils in the country. With the improvement of crop productivity through the adoption of high-yielding varieties and multiple cropping systems, fertilizer use has become more and more important to increase crops yield and quality. After N, P and K, S is the fourth nutrient, whose deficiency is widespread in India (Sakal *et al.*, 2001). Sulphur deficiency is observed primarily due to high crop yield and therefore higher rate of S removal by crops, and lesser use of S containing fertilizers (Messick, 2003). S is an essential plant nutrient for crop production. For oil crop producers, S fertilizer is especially important because oil crop require more S than cereal grains. S is best known for its role in the formation of amino acids methionine (21% S) and cysteine (27% S); synthesis of proteins and chlorophyll; oil content of the seeds and nutritive quality of forages (Jamal *et al.*, 2005). An sufficient S supply can affect yield and quality of the crops, caused by the S

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requirement for protein and enzyme synthesis as well it is a constituent of the amino acids, methionine and cysteine. As like sulphur, boron (B) is also one of the micronutrients required for normal growth and development of many crops. The role of B in plant has been proposed including functions in cell wall structure, cell wall synthesis sugar translocation, cell division, enzymatic reactions and plant growth regulation (Blevins and Lukaszewski, 1998). Sunflower is one of the most sensitive crops to B deficiency. B deficiency symptoms in sunflower become evident on leaves, stems, reproductive parts, dry matter, yield components and seed yield (Blamey *et al.,* 1997). Asad *et al*., (2002) reported that B requirement of sunflower during reproductive growth is higher than during vegetative growth. Boron foliar spray may help in the processes of pollination and better seed filling of sunflower. With above said points, the experiment was conducted to enhance growth and yield, quality, nutrient uptake, post harvest soil nutrient status and sulphur use efficiency of sunflower by using sulphur and boron.

Materials and Methods

Field investigations were conducted during March – June 2013 at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu and at farmers field at Ko-Chathiram village, Kurinjipadi block, Cuddalore district, Tamil Nadu during July- October 2013. The soil of the experimental field is clay loam and sandy clay loam in texture. The nutrient status of the experimental soil was low in nitrogen, medium in phosphorus, high in potassium and low in sulphur. Sunflower hybrid sunbred was chosen for this study. The experiment consisted of fifteen treatments and was laid out in factorial randomized block design with three replications. The treatments imposed in the experiment with different sulphur levels (0, 15, 30, 45, 60 kg S ha^{-1}) through gypsum were tried along with different boron levels (0, 0.5, 1.0 kg B ha^{-1}) through Borax. Recommended dose of 60:90:60 kg of N, P and K ha^{-1} was applied in the form of Urea and DAP and MOP respectively. Half the dose of N and entire dose of P and K were applied basally. The remaining quantity of N was applied at 30 DAS.

Results and Discussion

Growth attributes (Table 1)

Application of different levels of sulphur was found to influence the growth attributes *viz.,* plant height, LAI, DMP, CGR, RGR, chlorophyll content and days to fifty percent flowering. The growth attributes were significantly enhanced by application of sulphur @ 60 kg S ha^{-1}. This response is due to deficiency of sulphur in experimental soil. This might be due to synthesis of more amino acids, increase in chlorophyll content in growing region and enhanced photosynthetic activity, ultimately enhancing cell division which by increased the crop growth rate. This was evidenced through the studies of Indodia and Tomer (1997).

Among the different levels of boron, application of boron @ 1 kg B ha^{-1}(B_2) significantly influenced the growth attributes over other levels. This might be due to location of sugar, cell wall synthesis and maintenance of membrane integrity, RNA, IAA and phenol metabolism. External application of boron was found to increase the vegetative and reproductive growth of the sunflower plant (Asad *et al.,* 2003).

The interaction effect between sulphur and boron was significant on growth attributes at all stages of crop growth. The highest values for growth attributes *viz.,* plant height, LAI, DMP, CGR, RGR, chlorophyll content and days to fifty percent flowering was recorded under the treatment combination of S_4B_2 (60 kg S ha^{-1} with B @ 1 kg ha^{-1}). The minimum values for growth attributes recorded under the treatment S_0B_0 (0 kg S ha^{-1} with B @ 0 kg ha^{-1}) which could be due to inadequate availability of nutrients.

Yield attributes (Table 2)

Application of sulphur influenced significantly the yield attributes in both crops. Application of 60 kg S ha^{-1} significantly increased the head diameter, number of seeds $head^{-1}$, number of filled seeds $head^{-1}$, seed filling percent and 100 seed weight over other levels. Sulphur is known to play a vital role in the formation of amino acids, had favourable effect on yield attributes due to proper portioning of photosynthetic from source to sink. These findings are in conformity with reports of Syed Shuja Hussain *et al.,* (2011).

Boron levels significantly influenced the yield attributes in both crops. Application of boron @ 1 kg B ha^{-1}(B_2) significantly influenced the yield attributes over other levels. This might be due to the role of boron in cell elongation, photosynthesis, translocation of sugars and transpiration. These results are in harmony with those obtained by Renukadevi *et al.,* (2003).

The interaction between sulphur and boron levels was found significant in both the crops. The higher seed yield was registered under the treatment combination of S_4B_2 (60 kg S ha^{-1} with B @ 1 kg ha^{-1}). This might be due to availability of sulphur, boron and other nutrients at both vegetative and reproductive stages. These findings were earlier reported by Raja *et al.,* (2007).

Table 1: Effect of different levels of sulphur and boron on growth attributes of sunflower.

Treatments	Plant height (cm)		LAI at flowering stage		DMP (Kg ha^{-1}) (at harvest)		CGR at flowering stage		RGR at flowering stage		Total Chlorophyll (mg g^{-1})		Days to 50% flowering	
	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop
Sulphur														
S_0	126.94	149.20	3.80	3.88	4039.72	4139.79	13.39	14.44	0.0779	0.0735	0.60	0.56	60.33	61.37
S_1	140.86	151.45	3.97	4.05	4273.54	4374.65	13.64	14.72	0.0821	0.0765	0.68	0.69	58.37	59.16
S_2	142.10	153.39	4.06	4.14	4572.91	4672.88	13.77	14.92	0.0866	0.0803	0.72	0.71	56.12	57.09
S_3	150.60	155.22	4.20	4.28	4814.71	4914.60	14.34	15.28	0.0892	0.0824	0.77	0.79	54.51	55.28
S_4	153.18	156.58	4.35	4.42	4996.11	5093.34	14.92	15.97	0.0899	0.844	0.84	0.83	51.14	52.31
S.Ed	1.01	0.62	0.018	0.018	21.14	14.97	0.022	0.05	0.0002	0.0004	0.008	0.007	0.32	0.35
CD(P=0.05)	2.4	1.25	0.038	0.037	42.51	30.10	0.046	0.12	0.0006	0.0010	0.017	0.015	0.65	0.71
Boron														
B_0	133.41	149.58	3.83	3.91	4061.24	4159.54	13.76	14.51	0.0783	0.0737	0.61	0.58	57.14	58.17
B_1	146.55	154.37	4.18	4.25	4699.79	4799.79	14.24	15.22	0.0874	0.0819	0.75	0.77	56.04	57.00
B_2	148.25	155.56	4.22	4.30	4857.16	4957.83	14.34	15.47	0.0897	0.0826	0.80	0.80	55.10	55.96
S.Ed	0.74	0.55	0.017	0.014	20.71	14.60	0.021	0.05	0.0002	0.0002	0.007	0.006	0.29	0.34
CD (P=0.05)	1.5	1.11	0.036	0.028	41.64	29.35	0.044	0.25	0.0005	0.0005	0.016	0.014	0.60	0.70

Table 2: Effect of different levels of sulphur and boron on yield attributes and yield of sunflower.

Treatments	Head diameter (cm)		Number of seeds head^{-1}		Number of filled seeds head^{-1}		Seed filling percent		100 seed weight (g)		Seed yield (Kg ha^{-1})		Stalk yield (Kg ha^{-1})	
	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop
Sulphur														
S_0	13.25	15.15	640.33	666.51	504.01	530.13	78.64	79.48	5.54	5.45	1109.39	1209.42	3207.73	3307.39
S_1	15.22	16.58	695.22	722.53	562.00	586.95	80.83	81.24	5.69	5.95	1483.05	1583.08	3402.32	3503.32
S_2	16.27	17.24	787.11	788.20	639.52	648.85	81.91	82.29	5.77	6.07	1707.43	1808.79	3721.85	3764.19
S_3	17.38	18.24	807.33	815.87	665.27	675.19	82.37	82.69	5.99	6.38	2012.27	2111.25	3961.99	4095.31
S_4	17.48	18.63	818.22	847.21	688.14	715.43	84.05	84.42	6.03	6.54	2115.59	2215.95	4180.03	4273.20
S.Ed	0.12	0.12	5.06	7.52	5.11	6.85	0.14	0.17	0.015	0.017	29.10	29.92	17.16	20.59
CD(P=0.05)	0.25	0.26	10.18	15.12	10.28	13.78	0.30	0.35	0.032	0.036	58.51	60.15	33.26	41.39
Boron														
B_0	14.22	15.76	652.53	666.03	529.69	543.41	81.03	81.48	5.56	5.59	1135.67	1235.02	3257.10	3356.91
B_1	16.72	17.74	792.00	809.05	642.21	662.18	81.32	81.67	5.90	6.29	1919.96	2020.05	3855.24	3970.34
B_2	16.82	18.07	804.40	829.11	663.37	688.35	82.33	82.88	5.94	6.35	2001.00	2102.03	3932.01	4038.80
S.Ed	0.09	0.11	4.78	7.01	4.54	6.18	0.13	0.16	0.014	0.016	25.47	27.91	16.54	20.03
CD (P=0.05)	0.19	0.24	9.61	14.11	9.14	12.43	0.29	0.34	0.030	0.034	51.21	56.10	33.26	40.28

Yield (Table 2)

Application of S @ 60 kg ha^{-1} recorded maximum seed yield of 2115.59 and 2215.95 kg ha^{-1} and stalk yield of 4180.03 and 4273.20 kg ha^{-1} in first and second crops, respectively. The yield increase might be also due to increased growth, which resulted in increased photosynthesis and assimilation rates, cell division which turn in increased the seed yield. Sulphur application increased the chlorophyll content in leaf gave significant positive correlation between chlorophyll content in leaf crop yield (Sinha *et al.*, 1995).

Boron levels significantly influenced the seed and stalk yield in both the crops. Application of B @ 1 kg ha^{-1} recorded the maximum seed yield of 2001.00 and 2102.03 kg ha^{-1} and stalk yield of 3932.01 and 4038.80 kg ha^{-1} in first and second crop, respectively. This is due to the role of boron in cell division, sugar transport and hormone development (Khalifa, 2005).

The interaction effects between sulphur and boron levels was significant. Application of S_4B_2 (60 kg S ha^{-1} with B @ 1 kg ha^{-1}) recorded higher seed yield (2573.25 and 2673.84 kg ha^{-1}) and stalk yield (4582.73 and 4689.73 kg ha^{-1}) in both the crops. Increased seed yield due to application of sulphur and boron was reported by Sumathi

Table 3: Effect of different levels of sulphur and boron on quality of sunflower.

Treatments	Oil content (%)		Crude protein content (%)	
	I crop	II Crop	I crop	II Crop
Sulphur				
S_0	37.67	38.19	23.76	24.51
S_1	38.47	39.26	25.04	26.04
S_2	38.62	39.68	25.53	27.49
S_3	39.48	40.34	26.39	28.04
S_4	40.68	41.65	26.85	28.65
S.Ed	0.19	0.22	0.07	0.10
CD(P = 0.05)	0.40	0.46	0.16	0.22
Boron				
B_0	37.83	38.45	24.18	25.20
B_1	39.29	40.15	26.05	27.60
B_2	39.82	40.87	26.26	28.04
S.Ed	0.18	0.21	0.06	0.09
CD (P = 0.05)	0.38	0.43	0.14	0.20

Table 4: Effect of different levels of sulphur and boron on nutrient uptake, post harvest soil nutrient status and of sunflower.

Treatments	Nutrient uptake (Kg ha^{-1})								Nutrient availability (Kg ha^{-1})							
	N		P		K		S		N		P		K		S	
	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop	I crop	II Crop
Sulphur																
S_0	70.94	73.00	17.22	16.06	68.94	65.84	10.47	11.49	233.26	237.17	21.74	20.68	339.22	337.37	16.85	17.78
S_1	72.50	74.39	17.94	16.67	66.99	66.62	11.81	11.49	224.85	229.51	19.64	18.54	330.05	327.87	20.28	21.27
S_2	74.05	76.18	18.81	18.02	68.25	68.83	12.75	12.87	218.23	223.33	17.87	17.22	324.21	322.19	19.23	20.54
S_3	76.11	77.78	19.75	19.26	70.00	70.30	13.52	14.53	210.34	214.30	17.22	16.30	312.83	311.06	17.60	18.70
S_4	77.40	79.18	20.60	20.65	70.71	71.53	13.81	14.89	193.66	197.65	15.59	14.49	306.18	304.31	16.54	17.51
S.Ed	0.41	0.42	0.17	0.18	0.32	0.33	0.13	0.16	0.70	0.72	0.21	0.24	0.52	0.60	0.16	0.33
CD(P = 0.05)	0.83	0.85	0.36	0.38	0.65	0.68	0.27	0.34	1.42	1.45	0.43	0.50	1.05	1.21	0.34	0.68
Boron																
B_0	71.26	73.25	16.98	15.97	65.08	66.26	10.73	11.88	217.59	221.65	19.46	18.30	324.98	323.04	17.06	18.02
B_1	75.26	76.92	19.55	16.71	69.45	69.37	13.27	14.23	216.69	220.64	18.47	17.67	322.46	320.46	17.98	19.18
B_2	76.09	78.15	20.08	19.72	69.94	70.24	13.42	14.62	213.91	218.28	17.30	16.37	320.06	318.18	19.26	20.36
S.Ed	0.39	0.40	0.13	0.14	0.22	0.23	0.10	0.15	0.69	0.71	0.20	0.23	0.51	0.59	0.15	0.32
CD (P = 0.05)	0.80	0.82	0.28	0.30	0.45	0.47	0.21	0.32	1.40	1.44	0.41	0.48	1.04	1.20	0.32	0.66

et al., (2005).

Quality characters (Table 3)

Oil content

The oil content of sunflower seeds was significantly influenced by sulphur application. The highest oil content of 40.68 and 41.65 per cent was recorded with sulphur @ 60 kg S ha^{-1} and the least value recorded under no S applied plot. Increase in oil content by sulphur application might be attributed to involvement of sulphur in the biosynthesis of oil (Mudd, 1967)

Oil content of sunflower seeds was significantly influenced by boron application. The maximum oil content of 39.82 and 40.87 per cent was recorded with application of boron @ 1 kg B ha^{-1} and the least value recorded under the treatment 0 kg B ha^{-1} applied plot. The increase in oil content in this treatment might be due to enhanced uptake of boron in the seed and had a significant effect on oil content in sunflower seeds. Similar results was reported by Battachary and Mandal (2009).

With regard to interaction, 60 kg S ha^{-1} along with B @ 1 kg ha^{-1} (S_4B_2) recorded higher oil content in both the crops. The enhance sulphur and boron content in seed had a positive and significant effect on oil content. Similar trend was observed by Survase *et al.*, (1986). The lesser oil content was recorded under the treatment S_0B_0 (0 kg S ha^{-1} with B @ 0 kg ha^{-1}) might be due to poor uptake of sulphur and boron in the sunflower seed.

Crude protein content

Among the different S levels, the higher protein content of 27.31 and 29.36 per cent were registered with S @ 60 kg ha^{-1} in both the crops than the other S levels. The lowest protein content was observed at 0 kg S ha^{-1} in both the crops. The relative increase in protein content with S application might be due to increased availability of S for subsequent synthesis of oil and protein. Similar findings were reported by Chitkala and Reddy (1991).

Among the different B levels, the maximum crude protein content of 27.06 and 29.05 per cent was recorded in the treatment received B @ 1 kg ha^{-1} over the other levels. The increased protein content in this treatment

Table 5: Effect of different levels of sulphur and boron on sulphur use efficiency of sunflower.

Treatments	Sulphur use efficiency					
	Response ratio		Apparent S recovery (%)		Agronomic efficiency	
	I crop	II Crop	I crop	II Crop	I crop	II Crop
Sulphur						
S_0	-	-	-	-	-	-
S_1	30.63	30.64	23.66	23.50	98.86	105.53
S_2	22.79	22.83	14.86	15.86	56.91	60.28
S_3	21.97	21.94	11.63	11.52	44.71	46.91
S_4	17.92	18.20	9.20	9.24	35.25	36.90
S.Ed	0.12	0.15	0.16	0.17	0.35	0.69
CD(P = 0.05)	0.25	0.31	0.33	0.35	0.71	1.40
Boron						
B_0	3.15	3.13	8.38	8.53	38.68	42.13
B_1	32.59	32.69	17.93	17.50	68.23	71.69
B_2	34.15	34.39	18.21	19.06	69.89	73.39
S.Ed	0.11	0.14	0.15	0.16	0.34	0.68
CD (P = 0.05)	0.24	0.30	0.32	0.33	0.70	1.38

might be due to the highest uptake nitrogen by seed and N, might have been incorporated in the protein molecule of the protein content of seed was significantly higher for agribor compared to boric acid. Similar findings were reported by (Ramamoorthy and Sudrasan, 1992).

Among the different treatment combination, 60 kg S ha^{-1} with B @ 1 kg ha^{-1} produced maximum protein content. The least protein content was observed in S_0B_0 (0 kg S ha^{-1} with B @ 0 kg ha^{-1}).

Nutrient uptake (Table 4)

Maximum N, P, K and S uptake was registered under 60 kg S ha^{-1}. This might be due to optimum rate of sulphur application. This may be attributed to increased uptake of N, P, K and S, ultimately more utilization of these nutrients, which enhanced their concentration and uptake (Bhagat *et al.,* 2003).

Among the boron levels, maximum N, P, K and S uptake was recorded under the B @ 1 kg ha^{-1}. The least uptake of N, P, K and S was observed with 0 kg B ha^{-1}. The results are in conformity with the findings of Kumar *et al.,* (1996).

The interaction effects between sulphur and boron were significant. The highest nutrient uptake of N, P, K and S was noticed under S @ 60 kg ha^{-1} with B @ 1 kg ha^{-1}. This could be due to optimum quantity of sulphur and boron application and their easy availability to the crops. Increased uptake of S was mainly due to increase of its concentration in plant tissues (Martre *et al.,* 2009).

Post harvest soil nutrient available nutrients (Table 4)

Application of sulphur @ 0 kg ha^{-1} registered maximum post harvest soil nutrient available N, P, K while sulphur at 15 kg ha^{-1} recorded maximum S in post harvest soil. This might be due to poor uptake of N,P and K under no sulphur applied plot compared to other S levels. 15 kg S ha^{-1} recorded poor sulphur uptake and hence it increased the availability sulphur. Similar results were also reported by Krishnaprabhu (2006).

Among the B levels, 0 kg B ha^{-1} recorded the highest post harvest soil available nutrient of N, P, K and recorded B_2 recorded highest S availability. The least values for N,P,K were recorded under B_2 and S is minimum in B_0.

The interaction effect between sulphur and boron was found to be significant. The maximum amount of N,P,K and S was available in S @ 15 kg ha^{-1} with B @ 0.5 kg ha^{-1}. The least value was recorded under 60 kg S ha^{-1} with 1 kg B ha^{-1} due to maximum uptake of N,P,K and S.

Sulphur use efficiency (Table 5)

Application of sulphur @ 15 kg ha^{-1} recorded higher response ratio, apparent S recovery and agronomic efficiency and sulphur use efficiency decreased with increased rates of added S. Similar findings were earlier reported by Kalaiyarasan *et al.,* (2003).

Among B levels, boron @ 0.5 kg ha^{-1} recorded higher response ratio, apparent S recovery and agronomic efficiency.

The interaction effect between sulphur and boron was significant. Application of 15 kg S ha^{-1} with 0.5 kg B ha^{-1} recorded maximum response ratio, apparent S recovery and agronomic efficiency. Similar findings were earlier reported by Jawahar (2003).

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