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Effect of boron, zinc and sulphur on soil fertility and yield of fababean (*Vicia faba* L.)

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ABSTRACT

A field experiment was conducted at R.B.S.College Bichpuri Agra (U.P.) to study the effect of boron (0, 1 and 2 kg ha^{-1}), zinc (0, 5 and 10 kg ha^{-1}) and sulphur (0, 20 and 40 kg ha^{-1}) on soil fertility and yield of fababean. The results revealed that the application of boron, zinc and sulphur did not affect the soil pH and soluble salt concentration in posr harvest soil. There was a marked decline in the amount of organic matter in control. But the status of organic carbon slightly improved with application of boron, zinc and sulphur over control. Available N was not affected by B application but increased with Zn and S addition over control. Boron tended to increase the amount of available P but S and Zn tended to decrease it. Available K content in post harvest soil tended to increase with S and decreased with B and Zn. Available B, Zn and S contents in soil increased significantly with B, Zn and S application, respectively over control. The yields of fababean increased significantly with 1 kg B ha^{-1}, 5 kg Zn ha^{-1} and 40 kg S ha^{-1} over their respective controls. Application of 1 kg B ha^{-1} gave 2.2 and 2.3 q ha^{-1} higher grain and straw yield over control. The highest grain (47.4) and straw (48.0) yields were recorded with 40 kg S ha^{-1}. Application of 5 kg Zn ha^{-1} proved significantly superior to control in respect of yield of grain and straw and protein yield. Boron and S application also improved the protein yield significantly over respective control.

Keywords: Boron, sulphur, zinc, fertility, fababean, yield.

INTRODUCTION

Fababean (*Vicia faba*) is one of the major rabi season pulse crop of India. Average productivity of fababean is low due to several constraints such as improper nutritional management. To sustain high yields of fababean, the application of B, S and zinc is required in optimum amounts. Boron plays an important role in cell wall synthesis, root elongation lignification tissue differentiation and formation of protein. Zinc plays an important role as a metal component of enzymes or as a functional, structural of regulator cofactor of a large number of enzymes. Sulphur has been known for its role in the synthesis of carbohydrates, proteins, vitamins and flavor components. A suitable combination of secondary and micronutrients is, by and large, the most important single factor that affects the yield and quality of the crops. The results from several long term fertilizer experiments conducted in different agro-ecological regions involving diversified cropping systems and soil types have shown that imbalance fertilizer use particularly N alone had a deleterious effect on soil productivity and health. The balanced fertilization improves the physico-chemical properties and maintains soil fertility and productivity. Integration of major, secondary and micronutrients and their efficient management has shown promise in not only sustaining the productivity and soil health but also in meeting a part of chemical fertilizer management of crops. As information is lacking on the effect of B, Zn and S on production of fababean and fertility of post harvest soil. Therefore, the present investigation was conducted to study the effect of B, Zn and S on physico-chemical properties and fertility of alluvial soil and yield of fababean.

MATERIALS AND METHODS

The field experiment was conducted at Research Farm, Raja Balwant Singh College, Bichpuri, Agra (U.P.). The soil was sandy loam in texture having pH (7.8), EC (0.29 dSm^{-1}), organic carbon (4.2 g kg^{-1}), available N (175 kg ha^{-1}), available P (8.5 kg ha-1), available K (120 kg ha-1) S (8 mg kg^{-1}), Zn (0.42 mg kg^{-1}) and B (0.42 mg kg^{-1}). The experiment was laid out in split plot design with three levels of each of B (0, 1.0 and 2.0 kg ha^{-1}), Zn (0, 5 and 10 kg ha^{-1}) and S (0, 20 and 40 kg ha^{-1}) with three replications. A common dose of N, P_2O_5 and K_2O @ 20, 60 and 60 kg ha^{-1} was applied through diammonium phosphate and muriate of potash, respectively at the time of sowing. Boron, Zn and S were applied through borax, zinc oxide and elemental, sulphur, respectively as per treatments. Fababean (cv. Nutan) was sown in rows, 60 cm apart using 40 kg seed ha^{-1} in last week of November in both the years. Other agronomic management practices were followed as per standard recommendations. The crop was harvested at maturity and grain and straw yields were recorded. Nitrogen content in grain was determined by Kjeldahl method. Protein content was computed by multiplying the N content with 6.25. Protein yield was obtained by multiplying the protein content with grain and yield data. The soil samples collected after harvest of crop were processed and analysed for physico chemical properties. The pH was determined in 1:2.5 soil-water suspension using pH meter.Electrical conductivity of the soil was determined in 1:2.5 soil-water suspension with the help of electrical conductivity meter. Organic carbon was determined by following Walkley and Black wet digestion method (Jackson 1973). The available nitrogen content was determined by alkaline $KMnO_4$ method (Subbiah and Asija 1956). The available phosphorus content was determined as per Olsen *et al.* (1954). Available K was determined flamphotometrically in neutral 1N NH_4OAc extract (Jackson 1973). Available S was determined by extracting soil sample with 0.15% $CaCl_2$ and S in the extract was determined by turbidimetric method (Chesnin and Yien 1951). Available B was extracted with hot water and determined by carmine method (Hatcher and Wilcos, 1950).DTPA-extractable (Lindsay and Norvell, 1978) Zn was determined on atomic absorption spectrometer.

RESULTS AND DISCUSSION

Physico-chemical properties

The soil pH was not affected markedly with B, S and zinc application. However, a slight increase in soil pH was noted with 2 kg B ha^{-1} and 5 kg Zn ha^{-1} over control (Table). On the other hand, application of S tended to decrease the soil pH over control and minimum value was recorded with 40 kg S ha^{-1}. It is also observed that soluble salt concentration in soil (EC) did not change markedly due to B, Zn and S application. However, there was a marginal reduction in EC with B levels. Electrical conductivity of soil slightly improved with zinc and S application. The initial organic carbon content of the soil was 4.2 g kg^{-1} which was improved only to 4.3 g kg^{-1} suggesting marginal build in organic carbon content. The organic carbon did not show much increase even after addition of boron which may be due to oxidation of organic matter owing to prevailing high temperature under semi-arid climate. However, the use of zinc and sulphur was found beneficial for maintaining organic carbon compared to use of boron. The organic carbon showed declining trend from its initial value of 4.2 g kg^{-1} to 3.9 g kg^{-1} under no use of these three elements alone (Bonde and Gawandey, 2017).

The cropping under imbalanced use of chemical fertilizers showed depletion of soil nutrients while they were enhanced due to use of boron, S and Zn application. The available N, P and K status was also higher at integrated use of NPK and B, S and Zn. The mean available N status of soil recorded under control (only chemical fertilizers) was (166 kg ha^{-1}) increase to 170, 165 and 172 kg ha^{-1} and 165 to 171 kg ha^{-1} with 2 kg B ha^{-1}10 kg Zn ha^{-1} and 40 kg S ha^{-1}, respectively. Use of sulphur and boron with chemical fertilizers proved beneficial for improving available P status in post harvest soil. Available P in post harvest soil ranged from 7.9 to 8.1 kg ha^{-1} with minimum in control and maximum in the treatmentof 2 kg B ha^{-1}. Zinc application recorded lower value of available P (7.9 kg ha^{-1}) than that of control. The higher dose of Zn (10 kg ha^{-1}) tended to reduce the status of available P over 5 kg Zn ha^{-1} indicating an antagonistic relationship at higher level of zinc. Sulphur application also reduced the status of available P in post harvest soil from 8.2 kg ha^{-1} in control to 7.9 kg ha^{-1} with 40 kg S ha^{-1}. Among these three elements, boron was more effective in improving the status of available P in post harvest soil. The initial available K status of 120 kg ha^{-1} was substantially decreased indicating depletion of soil available K at control. The restoration of soil in available K under zinc and S application is due to the greater availability of native K. Boron application tended to decrease the amount of available K and minimum value was recorded with 2 kg B ha^{-1}. Available K improved with lower level of zinc and all the levels of sulphur. The maximum value of available K was noted with 40 kg S ha^{-1} (Bonde and Gawande, 2017).

Table 1: Effect of boron, zinc and sulphur on physico-chemical properties and yield of fababean (mean of two years)

Treatment	pH	EC (dSm^{-1})	Organic carnon ($g\ kg^{-1}$)	Grain yield ($q\ ha^{-1}$)	% response	Straw yield ($q\ ha^{-1}$)	Protein yield ($q\ ha^{-1}$)
Boron ($kg\ ha^{-1}$)							
0	7.8	0.30	4.0	41.8	-	42.3	10.6
1	7.8	0.29	4.1	44.5	6.40	45.1	11.4
2	7.9	0.28	4.2	44.0	5.26	44.6	11.3
CD (P=0.05)	NS	NS	0.11	0.95		0.53	0.24
Zinc ($kg\ ha^{-1}$)							
0	7.8	0.29	3.9	40.7	-	41.3	10.3
5	7.9	0.28	4.1	45.3	11.3	45.9	10.6
10	7.8	0.30	4.3	44.3	8.84	44.8	11.4
CD (P=0.05)	NS	NS	0.14	1.21		0.40	0.19
Sulphur ($kg\ ha^{-1}$)							
0	7.9	0.29	3.9	39.0	-	39.5	9.9
20	7.8	0.30	4.2	44.0	11.3	44.5	11.2
40	7.8	0.29	4.2	47.4	17.7	48.0	12.2
CD (P=0.05)	NS	NS	0.14	1.21		0.40	0.19

Use of boron, sulphur and zinc with chemical fertilizers was found useful in maintaining available B, zinc and S status of post harvest soil, respectively over control. The use of chemical fertilizers (controls) caused considerable depletion of B, and S which indicates mining of these nutrients under the lack of addition of these three elements. Boron and zinc levels slightly improved the sulphur status of soil. Application of S was more effective in improving the amount of sulphur in post harvest soil. Available B status of soil improved with boron levels over control. On the other hand lower level of Zn and S tended to increase the amount of available boron in soil over control. Available zinc status improved with S levels over control. Available Zn in post harvest soil ranged from 0.36 to 0.41 mg kg^{-1} in different treatments. Available Zn was not affected significantly with boron levels. Application of Zn was more effective in enhancing the status of available Zn in soil and maximum value (0.41 mg kg^{-1}) was recorded with 10 kg Zn ha^{-1}. Zinc application could not improve the status of available Zn to sufficiency level in soil (Bonde and Gawande, 2017).

.*Yield*

The grain and straw yield increased significantly with B application over control. The maximum grain (44.5 q ha^{-1}) and straw yields (45.1 q ha^{-1}) were obtained at 1.0 kg B ha^{-1}. The mean increases in grain and straw yields due to 1.0 kg B ha^{-1} were from 41.8 and 44.5 q ha^{-1}, respectively. At higher dose of B (2.0 kg ha^{-1}), a slight reduction in grain and straw yield was recorded over 1.0 kg B ha^{-1}level. The increase in yield may be because of photosynthetic activity of the plant due to B application. Application 1.0 and 2.0 kg B ha^{-1} initially gave higher response but indiscriminate use of B at more than 2.0 kg ha^{-1} may cause B toxicity in plants and cause deleterious effect on growth and yield of several crops (Kushwaha, *et al.* 2009). Singh *et al.* (2015) reported similar results in lentil.

Application of zinc increased the grain and straw yield significantly up to 5 kg Zn ha^{-1}. The magnitude of increase was 11.3 and 11.1% in grain and straw yield, respectively compared to control. The increase in yield might be due to role of Zn in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial for reproductive parts and partitioning of photosynthates towards them which resulted in better flowering and fruiting (Chaudhary *et al.* 2014).Application of 40 kg S ha^{-1} increased the grain and straw yield by 17.7 and 21.5, respectively over control. The marked response in yield due to sulphur application may be attributed to the deficiency of available S in the experimental soil, as its value were less than the critical limits of 10 mg kg^{-1}. Singh *et al.* (2017) and Singh (2017) reported higher yield of greengram with application on S.The interaction effect of S and Zn level on grain and straw yield of fababean was significant (Table 2). The yields of fababean increased with applied S under all the levels of zinc. Zinc levels also increased the fababean production and the maximum grain and straw yields were recorded under 40 kg S ha^{-1} + 5 kg Zn ha^{-1}.

Table 2: Intieractive effect of S and Zn levels on grain and straw and protein yield of fababean (mean of 2 years)

Sulphur (kg ha^{-1})	Zinc (kg ha^{-1})		
	0	5	10
0	36.1	40.7	40.0
20	41.4	45.8	44.7
40	44.5	49.4	48.1
SEm±		0.68	
CD (P=0.05)		1.89	
	Straw yield (q ha^{-1})		
0	36.6	41.3	40.5
20	42.0	46.4	45.3
40	45.1	50.0	49.0
SEm±		0.22	
CD (P=0.05)		0.62	
	Protein yield (q ha^{-1})		
0	9.13	10.34	10.21
20	10.54	11.71	11.52
40	11.40	12.72	12.49
SEm±		1.08	
CD (P=0.05)		2.99	

Quality

The maximum values of protein yield were recorded at 1.0 kg B ha^{-1}.The protein yield increased from 10.6 q ha^{-1} at control to 11.4 q ha^{-1} with 1.0 kg B ha^{-1}.Similar results were reported by Singh *et al.* (2015). The protein yield was affected significantly due to levels of sulphur. The maximum protein yield was occurred with 40 kg S ha^{-1}. The protein yield is grain increased from 9.9 q ha^{-1} at control to 12.2 q ha^{-1} at 40 kg S ha^{-1}. The protein yield also increased significantly with zinc application. The protein yield increased from 10.3 q ha^{-1} at control to 11.4 q ha^{-1} with 10 kg Zn ha^{-1}.Protein yield is the function of protein content and grain yield.

Table 3: Effect of boron, zinc and sulphur on fertility status of post harvest soil (mean of 2 years)

Treatments	Nitrogen (kg ha^{-1})	Phophours (kg ha^{-1})	Potassium (kg ha^{-1})	Sulphur (mg kg^{-1})	Boron (mg kg^{-1})	Zinc (mg kg^{-1})
Boron (kg ha^{-1})						
0	166	7.9	110	7.5	0.44	0.39
20	168	8.0	108	7.5	0.47	0.39
40	170	8.1	107	7.7	0.50	0.38
CD (P=0.05)	3.5	NS	NS	NS	0.03	0.016
Zinc (kg ha^{-1})						
0	165	8.1	109	7.4	4.6	0.36
20	167	8.0	110	7.7	4.8	0.39
40	172	7.9	106	7.6	4.7	0.41
CD (P=0.05)	4.4	NS	NS	NS	NS	0.020
SulphuR (kg ha^{-1})						
0	1.65	8.2	107	7.1	4.5	0.38
20	1.68	8.0	108	7.6	4.9	0.38
40	1.71	7.9	110	8.0	4.7	0.40
CD (P=0.05)	4.4	NS	NS	0.31	NS	NS

Since variation in protein content has genetic and biochemical limitation, the protein yield is more influenced by grain yield and thus followed almost trend similar to grain yield. (Singh *et al.* 2017 and Chaudhary *et al.* 2014).The S and Zn interaction had a significant effect on protein yield in grain. Increasing lrvels of S and Zn had beneficial effect on protein yield in fababean. The maximum value of prorein yield was recorded at 40 kg S and 5 kg Zn ha^{-1}.

It can, thus, be concluded based on results of experiment that addition of B, Zn and S in balanced form is efficient for building up of their status in post harvest soil. Organic matter in soil enhanced under these treatments. The management practices of balanced use of nutrients involving NPK fertilizers in conjunction with B, Zn and S have shown potential for higher crop production and quality of fababean.

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