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Response of Sulphur and Boron interaction on fertility status of Inceptisols of Prayagraj, India

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ABSTRACT

The Research was conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P during the *Kharif* 2020-2021 in which maize is sown. The experiment was laid out in Factorial-Randomized Block Design with Sixteen treatments and three replications includes four levels of Sulphur and Boron that leads to the non-significant findings *i.e* B.D, P.D, % pore space WHC and pH and remaining macro-micro nutrients such as OC, N, P, K, S and B were found significantly low to medium range, which comprises yellowish brown sandy loam textured neutral to alkaline soil that is non-saline in nature among all the sixteen treatment combination applied the treatments T_{16} has shown the synergistically best results in improvising the soil nutritional status that leads to increased crop yield and increased morphological parameters as well.

Key words : *Sulphur, Boron, Synergistic effect, Soil Fertility*

Introduction

In Uttar Pradesh, 53% of the soils are deficient in sulphur, 60% deficient in zinc and 12% deficient in boron. The current yield trends are insufficient to meet forecasted food production which implies a daunting challenge to limiting the use of fertilizers and increasing yields. This problem reveals the great potential to increase the nutrient use efficiency thus fertility of Indian soils could be enhanced by efficient use of inputs. For sustainable crop production, integrative effect of organic, inorganic and bio-fertilizers is important. Biofertilizers and organic manures play a significant role in sustaining soil health. Nitrogen, phosphorous and potassium as major nutrients and Sulphur, boron among the secondary nutrients play an important role in influencing the yield and qualityof the crops (Indira 2021). Interaction is also required for designing the fertilizers with right nutrient composition in which negative or antagonistic interaction should be minimized whereas the positive or synergistic interaction should be appreciated for increasing the nutrient use efficiency. The interaction effect between B and S synergistically effect on plants as well as in soil due to anions adsorption process their forms changes in relation to some microbial and biochemical attributes in an inceptisol. Interactions between nutrients occur when the supply of one nutrient affects the uptake, distribution, or function of another nutrient (Kumar 2020).

Depending on the nutrient supply, the interaction can modify plant growth and yield. Availability of S and B to plants is affected by a variety of soil factors including soil pH, texture, moisture, temperature, oxide content, carbonate content, organic matter

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content and clay mineralogy. Boron is generally less available in clay soils and availability increases with increasing temperature. Adequate application of Sulphur facilitates the nitrogenous component to metabolites into nitrate easily which, promotes the chlorophyll present in the leaf, plant height, drymatter, leaf perplant, greater seed weight and most important the flavour in seed (Sultana, 2020) It is reported that farmers do not apply Sulphur fertilizers as popular fertilizer like N, P, K which, caused in the expansion of Sulphur deficient area. Boron plays an important role in sugar translocation, root growth and pollination, RNA metabolism, IA A metabolism, phenol metabolism, membranes metabolism, cell wall structure, cell wall synthesis, sugar translocation, cell division, enzymatic reactions, indirectly involved in activation of dehydrogenase enzyme and plant growth regulation (Hossain, 2011).

Materials and Method

A field experiment conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the *Kharif* season of two years (2020-2021) growing maize *var*. Prabhat applied 4 levels of sulphur-boron respectively Sulphur = 0 kg ha^{-1}, 20 kg ha^{-1}, 40 kg ha^{-1}, 60 kg ha^{-1} and Boron = 0 kg ha^{-1}, 1 kg ha^{-1}, 2 kg ha^{-1}, 3 kg ha^{-1} including RDF for Maize = 120:60:40 kg ha^{-1} experiment is lead to observe the physical parameters by applying the following formulae through graduated measuring cylinder process.

b) $$\text{Bulk density } (Mgm^{-3}) = \frac{\text{Weight of oven dried soil (Mg)}}{\text{Volume of soil } (m^{-3})}$$

c) $$\text{Particle density } (Mgm^{-3}) = \frac{\text{Mass of soil solid (Mg)}}{\text{Volume of solids } (m^{-3})}$$

d) $$\% \text{ pore space} = (1-) \frac{\text{Bulk Density}}{\text{Particle Density}} \times 100$$

In chemical parameters through method by-

d) Soil pH - by using Digital pH meter of globe instruments given by (Jackson, 1967)
e) Soil EC (dSm^{-1})-Digital EC meter of globe instruments.
f) Organic Carbon (%) - through titration given by Walkley and Black method (1934)
g) Available Nitrogen (Kg ha^{-1})-Kjeldhal Method (Subbaih and Asija, 1956)
h) Available Phosphorus (Kg ha^{-1})- Colorimetric method by using Jasper single beam U.V Spectrophotometer at 660nm wavelength given by (Olsen *et al.*, 1954)
i) Available Potassium (Kg ha^{-1})- Flame photometric method by using Metzer Flame Photometer.
j) Available Sulphur (kg ha^{-1}) – Turbidimetric method by using Jasper single beam U.V Spectrophotometer at 440-470 nm wavelength.
k) Available Boron (mg kg^{-1})- Azomethine-H method by using Jasper single beam U.V Spectrophotometer at 420 nm wavelength.

Results and Discussion

Physical Properties

As result represented in Table 1 and 2 that consists soil physical properties such as (B.D, P.D, % Pore space, WHC) at both the depths 0-15 and 15-30 cm found non-significantly positively interactive in both the years the bulk density was found best in sulphur level (60 kg ha^{-1}) which is 1.295 (mgm^{-3}) at 0-15 cm depth and 1.302 (mgm^{-3}) at 15 30 cm depth in year 2020 also 1.302 (mgm^{-3}) at 0-15 cm depth 1.306 (mgm^{-3}) at 15 30 cm depth in year 2021 the particle density was found best *i.e* 2.572 (mgm^{-3}) at 0-15 cm depth and 2.576 (mgm^{-3}) at 15 30 cm depth in year 2020 also 2.593 (mgm^{-3}) at 0-15 cm depth 2.597 (Mgm^{-3}) at 15 30 cm depth in year 2021. and in boron level (3 kg ha^{-1}) bulk density was max. 1.292 (mgm^{-3}) at 0-15 cm depth 1.297(mgm^{-3}) at depth 15-30 cm also 1.297 (mgm^{-3}) at 0-15 cm depth 1.302(mgm^{-3}) at 15 30 cm depth in year 2021 the particle density was 2.520 (mgm^{-3}) at 0-15 cm depth 2.525 (mgm^{-3}) at 15 30 cm depth in year 2020 also 2.540(mgm^{-3}) at 0-15 cm depth 2.545(mgm^{-3}) at 15 30 cm depth in year 2021 the percent pore space was found best in sulphur level (60 kg ha^{-1}) which is 49.64 (%) at 0-15 cm depth and 49.48 (%) at 15 30 cm depth in year 2020 also 49.80 (%) at 0-15 cm depth 49.72 (%) at 15 30 cm depth in year 2021 increasing according to the depths the water holding capacity was found best, *i.e.* 51.08 (%) at 0-15 cm depth and 49.96 (%) at 15 30 cm depth in year 2020 also 51.49 (%) at 0-15 cm depth 50.36 (%) at 15 30 cm depth in year 2021. and in boron level (3 kg ha^{-1}) percent pore space was max. 48.70 (%) at 0-15 cm depth 48.62 (%) at depth 15 30 cm 48.93 (%) at 0-15 cm depth 48.80 (%) at 15-30 cm depth in year 2021. The water holding capacity was 50.71 (%) at 0-15 cm depth 49.63 (%) at 15 30

cm depth in year 2020 also 51.11 (%) at 0-15 cm depth 50.02 (%) at 15 30 cm depth in year 2021 respectively by Arbad *et al*. (2008).

Chemical Properties

As result represented in Table 3 and 4 that consists soil chemical properties such as (pH, E.C, O.C, N, P,

Table 1. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of Bulk Density and Particle Density of two years

Treatment	2020				2021			
	BD (mgm^{-3})		PD (mgm^{-3})		BD (mgm^{-3})		PD (mgm^{-3})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S Levels (kg ha^{-1})								
0	1.280	1.286	2.449	2.453	1.286	1.290	2.469	2.473
20	1.286	1.291	2.502	2.506	1.291	1.297	2.522	2.526
40	1.293	1.297	2.563	2.567	1.297	1.303	2.583	2.587
60	1.295	1.302	2.572	2.576	1.302	1.306	2.593	2.597
B Levels (kg ha^{-1})								
0	1.286	1.290	2.498	2.502	1.290	1.296	2.518	2.522
1	1.287	1.293	2.533	2.537	1.293	1.298	2.553	2.557
2	1.290	1.295	2.535	2.539	1.295	1.300	2.555	2.559
3	1.292	1.297	2.520	2.525	1.297	1.302	2.540	2.545
Sem±								
S Levels	0.0082	0.0094	0.0138	0.0206	0.0107	0.0089	0.0172	0.0160
B Levels	0.0082	0.0094	0.0138	0.0206	0.0107	0.0089	0.0172	0.0160
(S×B) Interaction	0.0165	0.0187	0.0276	0.0413	0.0214	0.0178	0.0343	0.0320
CD (P=0.05)								
S Levels	NS	NS	NS	NS	NS	NS	NS	NS
B Levels	NS	NS	NS	NS	NS	NS	NS	NS
(S×B) Interaction	NS	NS	NS	NS	NS	NS	NS	NS

B.D- Bulk Density P.D- Particle Density

Table 2. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of Percent pore space and Water holding capacity of two years

Treatment	2020				2021			
	Pore Space (%)		WHC (%)		Pore Space (%)		WHC (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S Levels (kg ha^{-1})								
0	47.75	47.60	49.18	47.82	47.93	47.83	49.57	48.20
20	48.57	48.49	50.25	49.09	48.81	48.66	50.65	49.48
40	49.54	49.45	50.94	49.87	49.78	49.62	51.34	50.27
60	49.64	49.48	51.08	49.96	49.80	49.72	51.49	50.36
B Levels (kg ha^{-1})								
0	48.52	48.42	49.49	48.25	48.74	48.61	49.88	48.64
1	49.17	49.02	50.68	49.45	49.34	49.25	51.08	49.85
2	49.11	48.97	50.58	49.41	49.30	49.19	50.98	49.80
3	48.70	48.62	50.71	49.63	48.93	48.80	51.11	50.02
Sem±								
S Levels	0.3872	0.3377	0.4224	0.2999	0.2782	0.3513	0.3479	0.2906
B Levels	0.3872	0.3377	0.4224	0.2999	0.2782	0.3513	0.3479	0.2906
(S×B) Interaction	0.7744	0.6755	0.8447	0.5998	0.5564	0.7027	0.6959	0.5811
CD (P=0.05)								
S Levels	NS	NS	NS	NS	NS	NS	NS	NS
B Levels	NS	NS	NS	NS	NS	NS	NS	NS
(S×B) Interaction	NS	NS	NS	NS	NS	NS	NS	NS

% Pore Space- Percent Pore Space WHC- Water Holding Capacity

K, S, B) at both the depths 0-15 and 15-30 cm pH, N, K found non-significantly positively interactive in both the years whereas the E.C, O.C, P, S, B has shown the significantly positively interactive in both the years the pH was found best in sulphur level (60 kg ha^{-1}) which is at 0-15 cm depth and at 15 30 cm

Table 3. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of pH and E.C of two years

Treatment	2020				2021			
	pH 0-15 cm 15-30 cm		EC (dSm^{-1}) 0-15 cm	15-30 cm	pH 0-15 cm 15-30 cm		EC (dSm^{-1}) 0-15 cm	15-30 cm
S Levels (kg ha^{-1})								
0	7.54	7.57	0.347	0.400	7.60	7.63	0.362	0.367
20	7.66	7.70	0.366	0.370	7.72	7.76	0.372	0.376
40	7.86	7.87	0.384	0.388	7.92	7.94	0.391	0.395
60	7.99	8.03	0.397	0.400	8.06	8.09	0.403	0.407
B Levels (kg ha^{-1})								
0	7.60	7.63	0.359	0.362	7.66	7.69	0.364	0.368
1	7.76	7.80	0.374	0.427	7.82	7.86	0.389	0.394
2	7.79	7.82	0.375	0.379	7.85	7.89	0.382	0.385
3	7.90	7.92	0.386	0.390	7.96	7.98	0.393	0.396
Sem±								
S Levels	0.0539	0.0418	0.0024	0.0029	0.0643	0.0554	0.0032	0.0023
B Levels	0.0539	0.0418	0.0024	0.0029	0.0643	0.0554	0.0032	0.0023
(S×B) Interaction	0.1079	0.0836	0.0048	0.0059	0.1286	0.1108	0.0063	0.0047
CD (P=0.05)								
S Levels	NS	NS	0.0069	0.0085	NS	NS	0.0091	0.0068
B Levels	NS	NS	0.0069	0.0085	NS	NS	0.0091	0.0068
(S×B) Interaction	NS	NS	0.0138	0.0170	NS	NS	0.0183	0.0135

pH – Potenz of hydrogen E.C- Electrical Conductivity

Table 4. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of Organic carbon and Available Nitrogen of two years -

Treatment	2020				2021			
	OC (%) 0-15 cm	15-30 cm	N (kg ha^{-1}) 0-15 cm	15-30 cm	OC (%) 0-15 cm	15-30 cm	N (kg ha^{-1}) 0-15 cm	15-30 cm
S Levels (kg ha^{-1})								
0	0.597	0.467	219.98	201.24	0.602	0.470	223.06	205.53
20	0.488	0.483	223.30	203.82	0.492	0.486	226.43	208.92
40	0.507	0.502	224.52	204.46	0.511	0.506	227.66	210.17
60	0.521	0.516	227.11	206.66	0.525	0.520	230.29	212.81
B Levels (kg ha^{-1})								
0	0.480	0.475	221.16	201.20	0.484	0.478	224.26	206.73
1	0.500	0.496	224.64	205.04	0.504	0.500	227.78	210.28
2	0.500	0.494	224.04	204.55	0.503	0.498	227.17	209.67
3	0.634	0.502	225.08	205.40	0.639	0.506	228.23	210.73
Sem±								
S Levels	0.0042	0.0043	1.5447	1.4342	0.0046	0.0036	1.8494	1.2305
B Levels	0.0042	0.0043	1.5447	1.4342	0.0046	0.0036	1.8494	1.2305
(S×B) Interaction	0.0084	0.0085	3.0893	2.8683	0.0092	0.0071	3.6988	2.4609
CD (P=0.05)								
S Levels	0.0122	0.0123	4.4613	4.1421	0.0133	0.0103	5.3414	3.5539
B Levels	0.0122	0.0123	NS	NS	0.0133	0.0103	NS	NS
(S×B) Interaction	0.0243	0.0247	NS	NS	0.0267	0.0205	NS	NS

O.C- Organic Carbon N- Available Nitrogen

depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021 the particle density was found best, *i.e* at 0-15 cm depth and at 15 30 cm depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021 and in boron level (3 kg ha^{-1}) bulk density was max. at 0-15 cm depth at depth 15-30 cm also at 0-15 cm depth at 15 30 cm depth in year 2021 the particle density was at 0-15 cm depth at 15 30 cm

Table 5. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of Available Phosphorus and Available Potassium of two years

Treatment	2020				2021			
	P (kg ha^{-1})		K (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S Levels (kg ha^{-1})								
0	12.73	10.11	196.58	185.28	12.90	9.99	199.33	187.87
20	13.84	11.40	201.39	189.48	14.03	11.50	204.21	192.13
40	14.87	12.78	204.85	192.70	15.07	12.95	207.71	195.40
60	15.73	13.58	208.08	195.69	15.95	13.77	210.99	198.43
B Levels (kg ha^{-1})								
0	13.35	10.77	200.04	187.37	13.53	10.66	202.84	189.99
1	14.40	12.10	202.58	191.08	14.60	12.27	205.42	193.75
2	14.45	12.22	203.73	192.08	14.65	12.39	206.58	194.77
3	14.96	12.78	204.53	192.62	15.16	12.95	207.40	195.31
Sem±								
S Levels	0.1167	0.1035	1.2408	1.3986	0.1082	0.0876	1.7278	1.4563
B Levels	0.1167	0.1035	1.2408	1.3986	0.1082	0.0876	1.7278	1.4563
(S×B) Interaction	0.2335	0.2071	2.4816	2.7972	0.2165	0.1753	3.4556	2.9126
CD (P=0.05)								
S Levels	0.3372	0.2991	3.5837	4.0395	0.3126	0.2531	4.9902	4.2064
B Levels	0.3372	0.2991	NS	NS	0.3126	0.2531	NS	NS
(S×B) Interaction	0.6743	0.5981	NS	NS	0.6253	0.5063	NS	NS

P- Phosphorus K- Potassium

Table 6. Interactive Effects of different levels of Sulphur and Boron at different depths on Cumulative values of Available Sulphur and Available Boron of two years

Treatment	2020				2021			
	S (kg ha^{-1})		B (kg ha^{-1})		S (kg ha^{-1})		B (kg ha^{-1})	
	0-15 S	15-30	0-15 B	15-30	0-15 S	15-30	0-15 B	15-30
S Levels (kg ha^{-1})								
0	15.82	13.88	0.754	0.614	16.04	14.07	0.765	0.622
20	20.27	17.08	1.302	0.858	20.55	17.32	1.048	0.870
40	22.99	19.35	1.120	0.985	23.31	19.62	1.135	0.999
60	25.07	21.04	1.267	1.097	25.42	21.33	1.285	1.112
B Levels (kg ha^{-1})								
0	18.33	15.48	0.854	0.725	18.59	15.69	0.866	0.735
1	21.84	18.20	1.057	0.917	22.14	18.45	1.072	0.920
2	21.60	18.59	1.051	0.925	21.90	18.85	1.065	0.938
3	22.38	19.08	1.280	0.986	22.69	19.35	1.329	1.000
Sem±								
S Levels	0.1656	0.1292	0.0081	0.0067	0.1591	0.1402	0.0253	0.0069
B Levels	0.1656	0.1292	0.0081	0.0067	0.1591	0.1402	0.0253	0.0069
(S×B) Interaction	0.3313	0.2585	0.0162	0.0135	0.3182	0.2805	0.0503	0.0139
CD (P=0.05)								
S Levels	0.4784	0.3733	0.0234	0.0195	0.4595	0.4051	0.0729	0.0200
B Levels	0.4784	0.3733	0.0234	0.0195	0.4595	0.4051	0.0729	0.0200
(S×B) Interaction	0.9568	0.7466	0.0468	0.0389	0.9189	0.8101	0.1459	0.0401

depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021 the percent pore space was found best in sulphur level (60 kg ha^{-1}) which is at 0-15 cm depth and at 15 30 cm depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021 increasing according to the depths the water holding capacity was found best *i.e* at 0-15 cm depth and at 15 30 cm depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021. and in boron level (3 kg ha^{-1}) percent pore space was max. at 0-15 cm depth at depth 15 30 cm at 0-15 cm depth at 15-30 cm depth in year 2021. The water holding capacity was at 0-15 cm depth at 15 30 cm depth in year 2020 also at 0-15 cm depth at 15 30 cm depth in year 2021 respectively. Mathew *et al*. (2013) and Jat and Mehra, (2007).

Conclusion

The above research revealed that nutrient interactions can guide fertilization trials and optimization of fertilization strategies for high yields and high nutrient use efficiencies, a balanced fertilization of macronutrients can exploit the synergisms. As both Sulphur and Boron uptake by plants is done in anionic forms therefore due to anionic adsorption of both the synergist interaction is observed on plants as well as in soil thus it influence the enhancement of soil physico-chemical properties and other nutrients uptake.

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