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Effects of boron and zinc on nutrients concentration and uptake by seeds in black gram (*Vigna mungo* L.)

Brijesh Kumar Pandey and Awadhesh Kumar Singh

Abstract
Pulses are one of the important segments of Indian agriculture. India and central Asia considered as the primary and the secondary centers of origin of black gram respectively. India and central Asia considered as the primary and the secondary centers of origin of black gram respectively. The field experiment conducted entitled**, "**Effects of Boron and Zinc on nutrients concentration and uptake by seeds in black gram (*Vigna mungo* L.)" at Research farm, Department of Agricultural Chemistry, P.G. College, Ghazipur. The field experiment was laid out in factorial randomized block Design. There were twenty-five treatments combinations consisting of five level of boron and five level of zinc applied to black gram. The treatments were replicated three times. It revealed that highest level of nitrogen. phosphorous, potassium, boron and zinc concentration in seed obtained in 2 kg boron + 4 kg zinc were found significantly superior over other levels of treatments followed by 2.5 kg boron and 4 kg zinc. It also revealed that highest amount of nitrogen, phosphorous, potassium, zinc and boron uptake by seed to be found in 2 kg boron + 3 kg Zinc.

Keywords: Uptake, factorial randomized block design, nutrients and concentration

Introduction

Pulses are one of the important segments of Indian agriculture after cereals and oilseeds. India and central Asia considered as the primary and the secondary centers of origin of black gram respectively. The distribution of black gram is comparatively restricted to tropical regions. The productivity of pulses is quite low since they are mainly cultivated in low fertile soil. Pulses are not only improving soil health by enriching nitrogen status, long term fertility and sustainability of the cropping systems.

Phosphorus is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation. Phosphorus is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation. The yield and nutritional quality of pulses is greatly influenced by application of phosphorus. Phosphorous has referred to as the "Master key element" in crop production.

Materials and Methods

The experiment conducted in Research farm, Department of Agricultural Chemistry, P.G. College, Ghazipur. The soil of the experimental field was originated from alluvial deposits (sandy loam). The field experiment was laid out in factorial randomized block design. There were twenty-five treatment combinations consisting of five level of boron and five level of zinc application to black gram. The treatments were replicated three times.

Treatments

Main Factor (A): Level of Boron		
0 kg ha^{-1}	:	B_0
1 kg ha^{-1}	:	B_1
1.5 kg ha^{-1}	:	$B_{1.5}$
2 kg ha^{-1}	:	B_2
2.5 kg ha^{-1}	:	$B_{2.5}$
Sub Factor (B): Level of Zinc		
0 kg ha^{-1}	:	Zn_0
1 kg ha^{-1}	:	Zn_1
2 kg ha^{-1}	:	Zn_2
3 kg ha^{-1}	:	Zn_3
4 kg ha^{-1}	:	Zn_4

Main Factor (A): Level of Boron		
0 kg ha^{-1}	:	B_0
1 kg ha^{-1}	:	B_1
1.5 kg ha^{-1}	:	$B_{1.5}$
2 kg ha^{-1}	:	B_2
2.5 kg ha^{-1}	:	$B_{2.5}$
Sub Factor (B): Level of Zinc		
0 kg ha^{-1}	:	Zn_0
1 kg ha^{-1}	:	Zn_1
2 kg ha^{-1}	:	Zn_2
3 kg ha^{-1}	:	Zn_3
4 kg ha^{-1}	:	Zn_4

S. No.	Level of boron	Level of Zinc	Treatment combination
1	0 kg ha^{-1}	0 kg ha^{-1}	B_0Zn_0
2	0 kg ha^{-1}	1 kg ha^{-1}	B_0Zn_1
3	0 kg ha^{-1}	2 kg ha^{-1}	B_0Zn_2
4	0 kg ha^{-1}	3 kg ha^{-1}	B_0Zn_3
5	0 kg ha^{-1}	4 kg ha^{-1}	B_0Zn_4
6	1 kg ha^{-1}	0 kg ha^{-1}	B_1Zn_0
7	1 kg ha^{-1}	1 kg ha^{-1}	B_1Zn_1
8	1 kg ha^{-1}	2 kg ha^{-1}	B_1Zn_2
9	1 kg ha^{-1}	3 kg ha^{-1}	B_1Zn_3
10	1 kg ha^{-1}	4 kg ha^{-1}	B_1Zn_4
11	1.5 kg ha^{-1}	0 kg ha^{-1}	$B_{1.5}Zn_0$
12	1.5 kg ha^{-1}	1 kg ha^{-1}	$B_{1.5}Zn_1$
13	1.5 kg ha^{-1}	2 kg ha^{-1}	$B_{1.5}Zn_2$
14	1.5 kg ha^{-1}	3 kg ha^{-1}	$B_{1.5}Zn_3$
15	1.5 kg ha^{-1}	4 kg ha^{-1}	$B_{1.5}Zn_4$
16	2 kg ha^{-1}	0 kg ha^{-1}	B_2Zn_0
17	2 kg ha^{-1}	1 kg ha^{-1}	B_2Zn_1
18	2 kg ha^{-1}	2 kg ha^{-1}	B_2Zn_2
19	2 kg ha^{-1}	3 kg ha^{-1}	B_2Zn_3
20	2 kg ha^{-1}	4 kg ha^{-1}	B_2Zn_4
21	2.5 kg ha^{-1}	0 kg ha^{-1}	$B_{2.5}Zn_0$
22	2.5 kg ha^{-1}	1 kg ha^{-1}	$B_{2.5}Zn_1$
23	2.5 kg ha^{-1}	2 kg ha^{-1}	$B_{2.5}Zn_2$
24	2.5 kg ha^{-1}	3 kg ha^{-1}	$B_{2.5}Zn_3$
25	2.5 kg ha^{-1}	4 kg ha^{-1}	$B_{2.5}Zn_4$

The nutrient content and uptake and physico-chemical properties were recorded at pertinent stages.

Results

Table-1 depicted that boron and zinc on number of seed yield (q ha^{-1}) affected significantly by the application @ 2 kg boron with 4kg zinc, these levels were found significantly superior over other treatments. However, the minimum was observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 1: Effect of boron and zinc on number of seed yield (q ha^{-1}).

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	7.25	7.55	7.54	7.53	7.52	7.48
B_{01}	7.46	7.96	7.95	7.94	7.93	7.85
$B_{1.5}$	8.37	8.35	8.33	8.31	8.29	8.33
B_{02}	8.62	9.28	9.61	10.18	10.43	9.62
$B_{2.5}$	8.61	8.82	9.27	9.88	10.14	9.35
Mean Zn	8.06	8.39	8.54	8.77	8.86	
	Boron		Zinc		Interaction	
SEm±	0.12		0.12		0.26	
CD (P=0.05)	0.33		0.33		0.74	

Table 2: Effect of boron and zinc on nitrogen concentration (%) in seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	3.19	3.29	3.28	3.27	3.26	3.26
B_{01}	3.21	3.33	3.32	3.31	3.30	3.29
$B_{1.5}$	3.38	3.37	3.36	3.35	3.34	3.36
B_{02}	3.40	3.49	3.53	3.59	3.63	3.53
$B_{2.5}$	3.42	3.43	3.48	3.54	3.58	3.49
Mean Zn	3.32	3.38	3.39	3.41	3.42	
	Boron		Zinc		Interaction	
SEm±	0.02		0.02		0.04	
CD (P=0.05)	0.06		0.06		NS	

Table-2 depicted that effect of boron and zinc on nitrogen concentration affected significantly by the application of 2 kg boron + 4 kg zinc and it found significantly superior over other levels of boron and zinc followed by 2.5 kg boron and 4 kg zinc. However, the minimum nitrogen concentration observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 3: Effect of boron and zinc on phosphorous concentration (%) in seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	0.322	0.332	0.331	0.330	0.329	0.329
B_{01}	0.324	0.336	0.335	0.334	0.333	0.332
$B_{1.5}$	0.341	0.340	0.339	0.338	0.337	0.339
B_{02}	0.343	0.352	0.356	0.362	0.366	0.356
$B_{2.5}$	0.345	0.346	0.351	0.357	0.361	0.352
Mean Zn	0.335	0.341	0.342	0.344	0.345	
	Boron		Zinc		Interaction	
SEm±	0.002		0.002		0.005	
CD (P=0.05)	0.006		0.006		NS	

Table-3 depicted that effect of boron and zinc on phosphorous concentration in seed affected significantly 2 Kg boron + 4kg zinc. The application of 2 Kg boron + 4kg zinc obtained significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum phosphorous concentration in seed observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 4: Effect of boron and zinc on potassium concentration (%) in seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	1.389	1.430	1.427	1.420	1.416	1.416
B_{01}	1.400	1.450	1.446	1.440	1.435	1.434
$B_{1.5}$	1.476	1.470	1.466	1.460	1.457	1.466
B_{02}	1.480	1.520	1.535	1.560	1.570	1.533
$B_{2.5}$	1.490	1.495	1.510	1.540	1.557	1.518
Mean Zn	1.447	1.473	1.477	1.484	1.487	
	Boron		Zinc		Interaction	
SEm±	0.009		0.009		0.021	
CD (P=0.05)	0.026		0.026		NS	

Table-4 depicted that effect of boron and zinc on potassium concentration in seeds affected significantly 2 kg boron + 4kg zinc. These were found significantly superior over other levels of treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum potassium concentration in seed observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 5: Effect of boron and zinc on boron concentration (mg kg^{-1}) in seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	26.15	26.39	26.37	26.33	26.31	26.31
B_{01}	26.21	26.53	26.51	26.46	26.45	26.43
$B_{1.5}$	26.75	26.65	26.63	26.61	26.59	26.65
B_{02}	26.77	26.99	27.14	27.32	27.49	27.14
$B_{2.5}$	26.79	26.81	26.98	27.17	27.28	27.01
Mean Zn	26.54	26.67	26.73	26.78	26.82	
	Boron		Zinc		Interaction	
SEm±	0.05		0.05		0.11	
CD (P=0.05)	0.14		0.14		0.31	

Table-5 depicted that effect of boron and zinc on boron concentration in seeds affected significantly the application of 2 Kg boron with 4kg zinc. The application of 2 Kg boron + 4kg zinc were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum boron concentration in seed observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 6: Effect of boron and zinc on zinc concentration (mg kg^{-1}) in seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	33.28	34.11	34.08	34.02	33.94	33.89
B_{01}	33.40	34.27	34.24	34.18	34.14	34.05
$B_{1.5}$	34.92	34.88	34.86	34.81	34.79	34.85
B_{02}	34.98	35.59	36.38	37.06	37.64	36.33
$B_{2.5}$	35.14	35.18	35.58	36.42	37.02	35.87
Mean Zn	34.34	34.81	35.03	35.30	35.51	
	Boron		Zinc		Interaction	
SEm±	0.16		0.16		0.36	
CD (P=0.05)	0.46		0.46		1.03	

Table-6 depicted that effect of boron and zinc on zinc concentration in seeds affected significantly 2 kg boron + 3kg zinc and these were found significantly superior over other levels of treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum zinc concentration in seed observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 7: Effect of boron and zinc on nitrogen uptake (kg ha^{-1}) by seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	23.19	24.84	24.74	24.62	24.51	24.38
B_{01}	23.95	26.51	26.39	26.28	26.18	25.86
$B_{1.5}$	28.29	28.13	27.97	27.83	27.69	27.98
B_{02}	29.31	32.39	33.93	36.53	37.76	33.98
$B_{2.5}$	29.45	30.27	32.27	34.98	36.29	32.65
Mean Zn	26.84	28.43	29.06	30.05	30.49	
	Boron		Zinc		Interaction	
SEm±	0.55		0.55		1.22	
CD (P=0.05)	1.56		1.56		3.48	

Table-7 depicted that effect of boron and zinc on nitrogen uptake by seeds affected significantly by the application of 2 kg boron + 4 kg zinc. These were found significantly superior over other levels of treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum nitrogen uptake by seed observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 8: Effect of boron and zinc on phosphorous uptake (kg ha^{-1}) by seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	2.33	2.51	2.50	2.48	2.47	2.46
B_{01}	2.42	2.67	2.66	2.65	2.64	2.61
$B_{1.5}$	2.85	2.84	2.82	2.81	2.79	2.82
B_{02}	2.96	3.27	3.42	3.68	3.82	3.43
$B_{2.5}$	2.97	3.05	3.25	3.53	3.66	3.29
Mean Zn	2.71	2.87	2.93	3.03	3.08	
	Boron		Zinc		Interaction	
SEm±	0.05		0.05		0.12	
CD (P=0.05)	0.15		0.15		0.34	

Table-8 depicted that effect of boron and zinc on phosphorous uptake by seeds (kg ha^{-1}) affected significantly by the application @ 2 Kg boron + 4 kg zinc. These levels of treatments were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the minimum phosphorus uptake by seeds observed in control (0 kg boron and 0 kg zinc ha^{-1}).

Table 9: Effect of boron and zinc on potassium uptake (kg ha^{-1}) by seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	10.06	10.80	10.77	10.69	10.64	10.59
B_{01}	10.44	11.54	11.49	11.43	11.39	11.26
$B_{1.5}$	12.35	12.27	12.20	12.13	12.08	12.21
B_{02}	12.76	14.11	14.75	15.87	16.38	14.77
$B_{2.5}$	12.83	13.19	14.00	15.22	15.78	14.20
Mean Zn	11.69	12.38	12.64	13.07	13.25	
	Boron		Zinc		Interaction	
SEm±	0.24		0.24		0.53	
CD (P=0.05)	0.67		0.67		1.50	

Table-9 depicted that effect of boron and zinc on potassium uptake by seeds (kg ha^{-1}) was affected significantly with application @ 2 kg boron + 3 kg zinc. These levels of treatments were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the potassium uptake by seed observed in 0 kg boron and 0 kg zinc (control).

Table 10: Effect of boron and zinc on boron uptake (kg ha-1) by seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	189.48	199.22	198.94	198.24	197.77	196.73
B_{01}	195.56	211.18	210.73	210.09	209.85	207.48
$B_{1.5}$	223.87	222.45	221.69	221.02	220.40	221.89
B_{02}	230.79	250.49	260.84	278.02	286.75	261.38
$B_{2.5}$	230.70	236.56	250.22	268.44	276.53	252.49
Mean Zn	214.08	223.98	228.48	235.16	238.26	
	Boron		Zinc		Interaction	
SEm±	3.49		3.49		7.80	
CD (P=0.05)	9.92		9.92		22.17	

Table-10 depicted that effect of boron and zinc on boron uptake by seed (g ha^{-1}) was affected significantly application of 2 kg boron + 3 kg zinc and were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the boron uptake by seeds observed 0 kg boron and 0 kg zinc (control).

Table 11: Effect of boron and zinc on zinc uptake (g ha-1) by seed.

Treatments	Zn_0	Zn_1	Zn_2	Zn_3	Zn_4	Mean B
B_{00}	241.15	257.50	257.10	256.14	255.13	253.40
B_{01}	249.16	272.79	272.17	271.39	270.87	267.28
$B_{1.5}$	292.25	291.14	290.21	289.13	288.37	290.22
B_{02}	301.56	330.28	349.68	377.12	392.66	350.26
$B_{2.5}$	302.56	310.43	329.93	359.87	375.27	335.61
Mean Zn	277.33	292.43	299.82	310.73	316.46	
	Boron		Zinc		Interaction	
SEm±	5.33		5.33		11.91	
CD (P=0.05)	15.15		15.15		33.87	

Table-11 depicted that effect of boron and zinc on zinc uptake by seed (g ha^{-1}) was affected significantly application @2 kg boron + 4 kg zinc and these were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. However, the zinc uptake by seed observed 0 kg boron and 0 kg zinc (control).

Discussion

Seed and stover yield are an ultimate result of growth and yield components. Boron showed significant influence on yield of crop. Significantly higher seed yield, stover yield as well as harvest index was obtained with 2.0 kg boron ha^{-1} as compared to 0 kg boron ha^{-1}. The increase in yield might be due to positive effect of boron on yield attributes *viz.*, pods plant^{-1}, seeds pod^{-1}, and seed weight plant^{-1}. These primary yield components have been shown to be directly correlated with the yield. Boron enriched seeds performs better with respect to flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination, seed development and yield of crops. The results are corroborated with the findings of Devi *et al.* (2012) [20], Shekhawat and Shivay (2012) [21], Singh *et al.* (2015) [18], Movalia *et al.* (2020) [12], Naznin *et al.* (2020) [14], Kumar *et al.* (2020b) [19], and Singh (2022) [13].

A significant increase in nitrogen, phosphorus, potassium, boron and zinc content in seed and stover as well as protein in seed of black gram due to 2.0 kg boron ha^{-1} was observed which might be result of increased availability of N, P, K, B, and Zn to plant, this might due be to improved nutritional environment of the crop. The effect of soil application of boron on nitrogen metabolism and seed composition. The higher nitrate reductase and nitrogenase by soil applied boron were accompanied with higher boron concentration in different plant parts. Higher protein content was recorded due to boron regulates the synthesis of amino acid, protein and also take part in sugar translocation and carbohydrate metabolism. The finding are in close conformity with those of Singh *et al.* (2015) [18], Kumar *et al.* (2020b) [19], Movalia *et al.* (2020) [12] and Naznin *et al.* (2020) [14].

Various levels of boron significantly influenced the nutrient *viz.*, nitrogen, phosphorous, potassium boron and zinc uptake by seed and stover of black gram. Application of 2.0 kg boron ha^{-1} recorded significantly higher nitrogen, phosphorus potassium, boron and zinc uptake by seed and stover of black gram over other treatments. This might be due to improved root system development which helps in improved nutrient transport, cell wall integrity and higher crop yield. Since uptake of nutrient is a function of their content and yield, increase in seed and stover yield of black gram along with higher content of N, P, K, B, as well as Zn in different part of plant might have resulted in higher uptake of those nutrient by the crop. These results are corroborated with the findings of Pandey and Gupta (2013) [17], Singh *et al.* (2015) [18], Kumar *et al.* (2020b) [19], Movalia *et al.* (2020) [12] and Naznin *et al.* (2020) [14].

Summary and conclusion

The field experiment conducted entitled**, "**Effects of Boron and Zinc on nutrients concentration and Uptake by grains in Black Gram (*Vigna mungo* L.)" at Research farm, Department of Agricultural Chemistry, P.G. College, Ghazipur. The field experiment was laid out in factorial randomized block Design. There were twenty-five treatments combinations consisting of five level of boron and five level of Zinc application to black gram. The treatments were replicated three times. It revealed from results that highest level of Nitrogen. Phosphorous, potassium, Boron and Zinc concentration in seeds obtained in 2 kg boron + 3kg zinc were found significantly superior over other treatments followed by 2.5 kg boron and 4 kg zinc. It also revealed and concluded that highest amount of nitrogen, phosphorous, potassium, zinc and boron uptake by seed was observed in treatments @ 2 kg boron + 4kg zinc ha^{-1}.

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