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Interactive Effect of Zinc and Boron Application on the Yield, Quality and their Uptake by Green Gram (*Vigna radiate* L.)

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Abstract Green gram is an important *kharif* pulse crop grown extensively in very poor productivity low in available Zn and B. In view of the lack of information on response of crops to added Zn and B, a screen house experiment was conducted to investigate the impact of zinc and boron application on yield and their enrichment of seed and straw of green gram. In pot experiment 4 kg light texture (sand) soil was filled up and 4 level of both zinc (0, 5, 10 and 15 mg kg^{-1}) and boron (0, 0.25, 0.5 and 1.0 mg kg^{-1}) were applied and replicated thrice. The soil used in pot had pH–7.90, EC-0.17 dSm^{-1}, organic carbon–0.09%, DTPA–Zn 0.36 mg kg^{-1} and hot water soluble B–0.5 mg kg^{-1}. Eight seeds of green gram gram were seeded in each pot and after thinning four plants were allowed to grow upto maturity. The result revealed that combined application of zinc and boron have significant antagonistic effect on yield of seed and straw of green gram as well as their on boron and zinc concentration of green gram whereas, individual application of boron response positively for boron concentration whereas zinc application decreases the B concentration but increased zinc concentration in seeds and straw of green gram. Highest seed yield and B and Zn concentration was found at $Zn_{15}B_0$, $Zn_0B_{1.0}$ and $Zn_{15}B_0$ mg kg^{-1} respectively. Zinc and boron application also significantly improve seed protein content and highest protein content was found with the application of 15 mg Zn kg^{-1} along with 0.5 mg B kg^{-1} at $Zn_{15}B_{0.5}$. The uptake of boron and zinc decreases significantly due to their antagonistic interaction where externally applied zinc as well as B increased their uptake.

Keywords Zinc, Boron, Green gram, Yield, Quality.

Introduction

Pulses acquire a unique place in human diet as well as cropping system because pulses are major source of vegetable protein and it helps in biological nitrogen fixation. Pulses also act as effective nutrient recycling agents in nature. Green gram commonly known

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Table 1. Post harvest DTPA extractable zinc (µg pot^{-1}) in soils as affected by both zinc and salinity levels.

Zinc level (mg kg^{-1})	Boron level (mg kg^{-1}) 0	0.25	0.5	1.0	Mean
Seed yield					
0	4.25	4.41	6.16	4.98	4.95
5	5.33	5.10	5.08	4.91	5.11
10	6.37	6.15	5.04	4.19	5.44
15	7.25	6.35	5.23	4.03	5.72
Mean	5.80	5.50	5.38	4.53	
CD at 5%	Zn=0.12	B=0.12	Zn×B=0.24		
Straw yield					
0	30.87	31.73	35.09	32.62	32.58
5	37.31	35.70	35.54	28.96	34.38
10	44.57	43.07	35.26	22.45	36.34
15	50.73	44.45	31.52	21.49	37.05
Mean	40.87	38.74	34.35	26.38	
CD at 5%	Zn=0.97	B=0.97	Zn×B=1.94		

Table 2. Effect of zinc and boron application on green gram seed and straw boron content (mg kg^{-1}).

Zinc level (mg kg^{-1})	Boron level (mg kg^{-1}) 0	0.25	0.5	1.0	Mean
Boron content (mg kg^{-1}) in seed					
0	39.78	42.71	44.79	54.78	45.52
5	39.63	40.08	38.96	43.83	40.63
10	38.17	38.71	36.29	30.63	36.72
15	38.96	34.19	32.05	28.58	33.59
Mean	39.14	38.92	38.02	39.45	
CD at 5%	Zn=1.79	B=NS	Zn×B=3.59		
Boron content (mg kg^{-1}) in straw					
0	67.56	71.96	78.33	80.33	74.40
5	64.02	64.88	66.04	72.08	66.76
10	58.58	59.91	57.92	54.18	57.59
15	55.42	48.95	44.38	44.38	48.23
Mean	61.39	61.43	61.68	62.75	
CD at 5%	Zn=1.66	B=NS	Zn×B=3.32		

as moong dal is one of the important pulse crop and contribute about 11% of total pulse production. Nutrient imbalance is one of the major edaphic constraints limiting productivity of pulses. Some time there is no deficiency of nutrient in soil actually, but presence of other nutrient in excess suppress the availability of other nutrient. In some cases nutrients also behave synergistically and increase the availability of other nutrients.

Among the micronutrients essential for plant next to zinc, the deficiency of boron is quite widespread in soils of India and limiting crop yield. Its deficiency is found in nearly 33% areas of the country which are highly calcareous, leached, sandy, red and laterite soil. In Haryana also about 0.59% of the cultivated area found deficient in boron. Deficiency of boron leads to entire failure of crops thereby resulted much economic loss to the farmers. Green gram requires relatively larger amounts of phosphorus and micronutrients particularly Fe, Zn and B compared to other crops [1]. Zn deficiency is one of the most common widespread disorders in plants and in soils of different regions of India. The Zn essentially is being employed in functional and structural component of several enzymes such as carbonic anhydrase, alcohol dehydrase. Thus, the present investing was planned to study boron and Zn application effect on yield, their concentration and uptake as well as seed protein content.

Materials and Methods

A screen house experiment was conducted during *kharif* season 2013 at CSSHAU, Hisar. Bulk soil samples of (0–15 cm depth) were collected from village Balsamand district Hisar. The soil sample was air dried ground and passed through 2 mm sieve and analyzed for physico-chemical properties and initial nutrients status using standard procedure.

Four kg thoroughly mixed sand soil was filled in each pot and placed in completely randomized block desigh in the screen house. In total the experiment include 16 treatments with three replication in a factorial combination of four levels of zinc 0, 5, 10 and 15 mg Zn kg^{-1} soil through $ZnSO_7 H_2O$ and four level of boron 0. 0.25, 0.5 and 1.0 mg B kg^{-1} soil through borax ($Na_2B_4O_7.10H_2O$). Recommended doses of nitrogen and phosphorus were uniformly applied as basal in each pot.

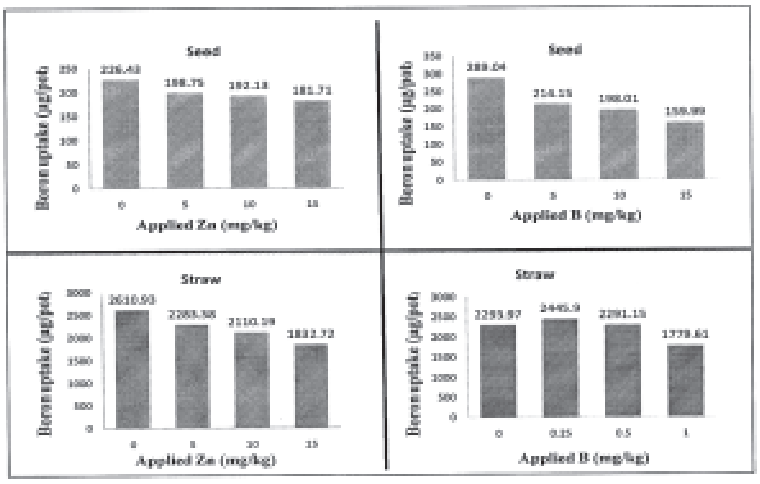

Fig. 1. Effect of zinc and boron application on green gram seed and straw boron uptake (µg pot^{-1}).

Eight seeds of green gram (cv Asha) were seeded in each pot and after thinning four uniform plants per pots were allowed to grow up to maturity and irrigated with deionised water as and when required. At physiological maturity plants samples were collected, air dried and in oven at 65±2°C till a constant weight was obtained. The dry matter and seed yield was also recorded. For the estimation of Zn and B content in plants as well as seed samples were digested with diacid mixture (HNO_3 and $HClO_4$) in 4:1 ratio for analysis of Zn and B content and their uptake was computed accordingly. Seeds were also digested in a di-acid mixture of sulfuric acid and perchloric acid in the ratio of 9:1 for the analysis of total N in colorimetric (Nesslar's reagent) method. Crude protein in green gram seed was computed by multiplying total seed N with 6.25.

Results and Discussion

Soil properties

Soil used in experiment was texturally sand in nature, slightly alkaline with pH (1:2)–7.90 and EC–0.17 d Sm^{-1} low in organic carbon–0.09%, available NPK were–70, 8.1 and 28.3 kg ha^{-1} respectively along with 2% calcium carbonate. Soil was also found deficient in DTPA–Zn 0.36 mg kg^{-1} and marginal in hot water soluble-B (HWS-B) - 0.5 mg kg^{-1}.

Yield

Seed and straw

A significant decrease in seed and straw yield of green gram was recorded with increasing level of boron over control up to 1.0 mg B kg^{-1} when zinc was applied along with boron. But in case of their individual application, boron increases seed and straw yield of green gram upto 0.5 mg B kg^{-1} over control (Table 1). Highest seed yield of green gram 7.25 g pot^{-1} and straw yield 50.73 g pot^{-1} was obtained with the application of highest dose of Zn (15 mg kg^{-1}) without any externally applied B. The yield of seed decreases up to 4.53 g pot^{-1} and straw upto 21.49 g pot^{-1} when boron was applied @ 1.0 mg kg^{-1}. Similar results were also reported by Debnath et al. [2] in green gram crop where, application of Zn along with boron decreases the seed yield and highest seed yield was found when zinc is applied at its higher doses in absences of boron. The interaction effect of zinc and boron on seed and straw yield was also found significant. Similar results were also reported by Tarafder et al. [3] that the yield and yield contributing characters of moong bean responded significantly by single and combined application of Zn and B.

Table 3. Effect of zinc and boron application on green gram seed and straw zinc content (mg kg^{-1}).

Zinc level (mg kg^{-1})	Boron level (mg kg^{-1}) 0	0.25	0.5	1.0	Mean
Zinc content (mg kg^{-1}) in seed					
0	21.90	20.60	17.07	15.70	18.82
5	25.73	25.17	24.23	17.30	23.11
10	37.83	30.67	28.27	25.80	30.64
15	45.30	35.30	34.07	30.60	36.32
Mean	32.69	27.94	25.91	22.35	
CD at 5%	Zn=1.95	B=1.95	Zn×B=3.90		
Zinc content (mg kg^{-1}) in straw					
0	27.27	21.40	21.37	19.47	22.38
5	29.03	22.83	21.90	20.30	23.52
10	31.57	24.47	22.40	20.50	24.74
15	36.30	27.97	24.43	21.57	27.57
Mean	31.04	24.17	22.53	20.46	
CD at 5%	Zn=1.01	B=1.01	Zn×B=2.02		

Table 4. Effect of zinc and boron application on seed protein content (%) of green gram.

Zinc level (mg kg^{-1})	Boron level (mg kg^{-1}) 0	0.25	0.5	1.0	Mean
0	17.03	19.37	22.85	22.50	20.44
5	19.07	21.88	22.71	22.90	21.64
10	21.02	22.59	23.25	21.95	22.20
15	24.33	23.92	24.17	20.66	23.27
Mean	20.36	21.94	23.25	22.00	
CD at 5%	Zn=0.56	B=0.56	Zn×B=1.12		

Nutrient concentration

Seed and straw boron content

Successive doses of zinc application along with boron significantly decreased boron content in seed of green gram about 26.2% and 35.2% in straw at 15 mg Zn kg^{-1} over control (Table 2). The effect of boron application on boron content of seed and straw was not significant. The interaction of zinc and boron influence seed and straw B significantly. The highest boron content 54.78 mg B kg^{-1} in seed of green gram was noticed when B was applied @ 1.0 kg ha^{-1} under no zinc and revealed that as the level of applied zinc increased it helps in counteract the toxic level of boron in both seed and straw (Table 2). Ali et al. [4] repoterd that application of 2 kg B ha^{-1} significantly increased the uptake of Zn (13.6 and 93.8 g ha^{-1}) by Febabean grain and straw over control. Whereas, boron content in grain and straw decreases from 37.6 to 36.8 mg kg^{-1} and 18.9 to 18.1 mg kg^{-1}, respectively with the application of 10 kg Zn ha^{-1}.

Seed and straw zinc content

The increasing level of zinc significantly increases Zn content in seed and straw of green gram (Table 3). Application of 15 mg Zn kg^{-1} of soil, increases seed and straw zinc content of greengram over control. In contrast to this with increased level of boron from 0 to 1.0 mg kg^{-1}, a significant decrease in zinc content was obtained, which ranged from 32.69 mg kg^{-1} and 31.04 mg kg^{-1} (with no boron) to 22.35 mg kg^{-1} and 20.46 mg kg^{-1}, when B was applied @ 1 mg B kg^{-1} in seed and straw, respectively. The interaction of zinc and boron were significantly on zinc content of green gram seed and straw. The highest zinc concentration (45.30 mg kg^{-1}) in seed and (36.30 mg kg^{-1}) in straw was found with the application of 15 mg kg^{-1} under no application of B. The emphases of zinc and boron have an antagonistic relationship and adequate amount of zinc in soil help to alleviate boron toxic effect on crop.

Nutrient uptake

Boron uptake by seed and straw

Boron uptake by seed and straw influenced significantly by the application of zinc as well as boron (Fig. 1). In both seed and straw, B uptake found to decrease with each increasing level of zinc and the highest B uptake was noticed in control (226.43 mg kg^{-1} in seed and 2610.93 mg kg^{-1} in straw) and lowest uptake (181.71 mg kg^{-1} in seed and 1832.72 mg kg^{-1} in straw) with graded level of zinc application upto 15 mg Zn kg^{-1}. Application of boron also significantly influenced B uptake by seed and straw in different manner. In case of seed with each graded level of applied boron its uptake decreased. But straw B uptake in-

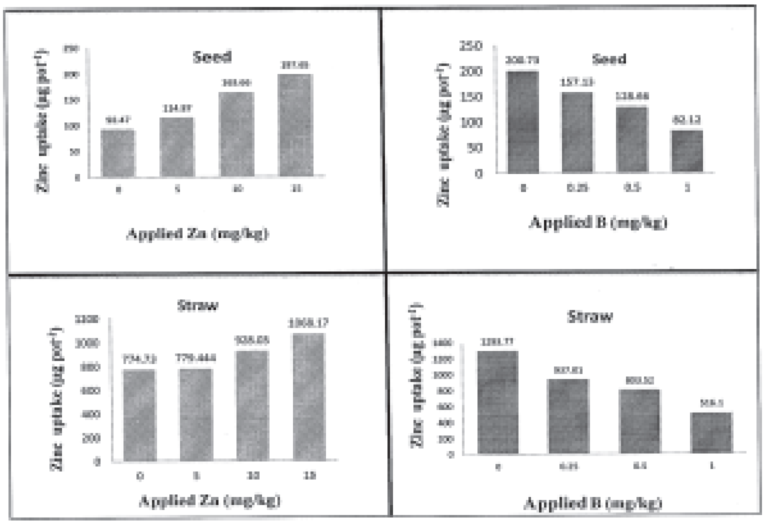

Fig. 2. Effect of zinc and boron application on green gram seed and straw zinc uptake (μg pot^{-1}).

creases (2445.9 mg B kg^{-1}) upto 0.25 mg kg^{-1} level of boron application after that a decreasing trend in B uptake (1779.61 mg kg^{-1}) was followed by control (2293.97 mg kg^{-1}). This might be due to due to dilution effect.

Zinc uptake by seed and straw

Figure 2 revealed that seed zinc uptake of green gram increased with application of increasing level of Zn which ranging from 92.47 μg pot^{-1} under control to 197.65 μg pot^{-1} at 15 mg Zn kg^{-1}. In case of B with increasing level of B the uptake of zinc decreased from 200.73 μg pot^{-1} in control to 82.12 μg pot^{-1} at 1 mg B kg^{-1}. However, in straw the uptake of zinc increases with increasing level of zinc application from 774.73 μg pot^{-1} to 1068.17 μg pot^{-1} whereas, application of boron, decreased Zn uptake from 1293.77 μg pot^{-1} under control to 516.10 μg pot^{-1} at 1 mg kg^{-1}.

Seed protein content

Table 4 on seed protein content of green gram revealed that with the increasing level of Zn from 0 to 15 mg Zn kg^{-1} soil there was a significant increase in crude protein content in seed of green gram from 20.44% to 23.27%. Whereas application of boron, the significant increase in crude protein content in seed of green gram was noticed only up to 0.5 mg kg^{-1} (23.25%) of its application over control and after that there was a decrease in protein content with further increment of boron fertilizer. The results of the present study are in close agreement to the findings of Singh et al. [5] as the deficiency of B and Zn not only influence the productivity of field crops very much, but more so B deficiency affects the fruiting and fruit quality of most of the cereals, pulse, vegetables and plantation crops in red laterite acidics soil of Bihar state. The interactive effect of zinc and boron fertilizer application was also found significant. Maximum crude protein content in seed of green gram was found when Zn was applied @ 15 mg kg^{-1} without any addition of boron.

Conclusion

From the present study it can be concluded that combined application of Zn and B was found to decrease seed and straw yield of green gram. The interaction study of Zn and B, shows an antagonistic relationship and application of zinc help in mitigate boron toxicity. Seed protein content improvement was recorded with their combined application and thereby improves the quality of green gram grown in Zn and B deficient/marginal pulse growing soils of Haryana.

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