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Yield responses of groundnut genotypes as influence by boron and zinc

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Abstract
Groundnut (*Arachis hypogaea)* is one of the most important cash crops as it is a low-priced commodity but a valuable source of all the nutrients for human nutrition. The contribution of micronutrients like boron and zinc has their pivotal role in determining the yield of groundnut., therefore the experiment was laid out to venture the effects of boron and zinc on quantity parameters. Six groundnut genotypes (TG 26, TG 51, TG 71, TG 72, BARC 150 and BARC 200) were tried with nine different treatment combinations with three levels of each of boron (boric acid) and zinc (zinc sulphate) [B_0 = no boron, B_L = boric acid @ 0.25% and B_H = boric acid @ 0.5%, Z_0 = no zinc sulphate, Z_L = zinc sulphate @ 0.5% and Z_H = zinc sulphate @ 1%]. All together treatments were: B_0Z_0 (T_1), B_LZ_0 (T_2), B_HZ_0 (T_3), B_0Z_L (T_4), B_LZ_L (T_5), B_HZ_L (T_6), B_0Z_H (T_7), B_LZ_H (T_8) and B_HZ_H (T_9). All yield parameters except the number of productive nodes per plant were substantially influenced by the foliar treatments of boron and zinc. The response of the genotypes to the different treatments was not uniform. TG 26, TG 51 and TG 71 performed substantially better in T_8 (BLZH), T_3 (BHZ0) and T_6 (BHZL), respectively than any other treatments including the control. Hence, with appropriate treatment of boron and zinc yield of groundnut can be enhanced and in some cases quality of the yield also can be augmented.

Keywords: Boron, foliar, groundnut, pods yield, seed yield, zinc

Introduction
Groundnut (*Arachis hypogaea)* also known as monkey-nut or peanut is an annual herb of indeterminate growth habit which has been divided into two sub-species, *hypogaea* and *fastigiata*, each with several botanical varieties. Sub-specific and varietal classifications are mostly based on the location of flowers on the plant, patterns of reproductive nodes on branches, number of trichomes and pod morphology (abd and Gregory, 1994) [8]. Groundnut crop is one of the most important cash crops as it is a low-priced commodity but a valuable source of all the nutrients which include protein, calories, essential fatty acids, vitamins, and minerals for human nutrition (Ojiewo *et al*. 2020) [11].
Micronutrients play a significant role in increasing the yield of pulses and oilseed crops. Boron is one of the essential micronutrients which play a pivotal role in cell division and pod and seed formation (Vitosh *et al*. 1997) [18] which can enhance crop yield. The inadequate supply of B decreased the economic yield of legumes (Raj, 1985) [12]. Pollen germination and pollen tube growth as well as the viability of pollen grains are severely affected by boron deficiency (Dugger, 1973) [3]. Zinc is involved in auxin formation; activation of dehydrogenase enzymes; and stabilization of ribosomal fractions (Obata *et al*. 1999) [10]. It is also required for carbohydrate and nitrogen metabolism, leading to higher yield and yield components. Therefore, deficiency of micronutrients cannot be fulfilled merely by soil application alone and needs to be supplemented through foliar application as it enables plants to absorb the applied nutrients through their leaf surface and thus, may result in the economic use of fertilizer. Foliar absorption is the most effective, and the rate of absorption is generally higher in younger points of branches or stem tips (Helmy and Shaban, 2008) [4].

Materials and Methods

The experiment was conducted during pre- kharif season of 2019 in the district seed farm (D Block farm) of the Bidhan Chandra Krishi Viswavidyalaya at Kalyani, West Bengal. The farm is situated in the New Alluvial Zone of West Bengal and is geographically located at 22.56°N latitude and 88.32°E longitude at an altitude of 9.75m above mean sea level. The soil farm is sandy loam with a pH of 6.9-7.0. Six genotypes namely TG 26, TG 51, TG 71, TG 72, BARC 150 and BARC 200 were taken for the experiment and subjected to nine different treatments which were applied singly either as boric acid or zinc sulphate or in combination with both. This experiment was designed in factorial randomized block design with three replications for evaluation of crop parameters and the mean data in all cases were subjected to statical analysis using OPSTAT software version 7.1.

Treatment details

T_1	B_0Z_0	Control.
T_2	B_LZ_0	Boric acid @ 0.25%.
T_3	B_HZ_0	Boric acid @ 0.5%.
T_4	B_0Z_L	Zinc sulphate @ 0.5%.
T_5	B_LZ_L	Boric acid @ 0.25% + Zinc sulphate @ 0.5%.
T_6	B_HZ_L	Boric acid @ 0.5% + Zinc sulphate @ 0.5%.
T_7	B_0Z_H	Zinc sulphate @ 1%.
T_8	B_LZ_H	Boric acid @ 0.25% + Zinc sulphate @1%.
T_9	B_HZ_H	Boric acid @ 0.5% + Zinc sulphate @1%.

Results and Discussions

Number of productive nodes per plant: The number of productive nodes per plant in all the genotypes varied widely with the treatments (Table 1). In TG 26, the best treatment wasobserved in B_LZ_H (60.67) and lowest in B_HZ_H (32.67); In TG 51, the best treatment was B_HZ_0 (67.00) and lowest in B_HZ_L (32.00); In TG 71, the best treatment was B_HZ_L (88) and lowest in B_0Z_L (56.67); in TG 72, the best treatment was B_HZ_0 (87.33) and lowest in B_0Z_L (44.33); In BARC 150, the best treatment was B_LZ_0 (77.67) and lowest in B_HZ_0 (29.33); In BARC 200, the best treatment was B_0Z_L (65.33) and lowest in B_0Z_H (36.67). The variations among treatments in each of the genotypes were statistically non-significant. The results are similar to the findings of Sowmya and Ganapati (2021) [17] where the application of micronutrients had an impact on producing productive nodes in groundnut in coastal sandy soil.

Table 1: Effect of boron and zinc treatments on the number of productive nodes per plant of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	52.33	46.67	78	62.33	39.67	47.33
B_LZ_0	58	41	87	80.33	77.67	56
B_HZ_0	40	67	79.67	87.33	29.33	56
B_0Z_L	39.33	31.67	56.67	44.33	58.33	65.33
B_LZ_L	36	55	60	59.33	43.33	65
B_HZ_L	52.67	32	88	66	69.67	64.67
B_0Z_H	58.33	41	71.67	67	55	36.67
B_LZ_H	60.67	36.33	83	64	63.67	65
B_HZ_H	32.67	51	58.67	55.33	61	48.33
CD	N/S	N/S	N/S	N/S	N/S	N/S

Number of pods per plant: The number of pods per plant in all the genotypes were also varied widely with the treatments (Table 2). In TG 26, the best treatment was observed in B_LZ_H (113); in TG 51, the best treatment was B_HZ_0 (95.67); in TG 71, the best treatment was B_HZ_L (140.33); in TG 72, the best treatment was B_HZ_0 (133.67) and B_LZ_0 (131.33) was also significantly better than the control; in BARC 150, the best treatment was B_LZ_0 (111.33), the other treatments significantly better than the control were B_LZ_H (90), B_HZ_H (89) and B_0Z_H (88.67); in BARC 200, the best treatment was B_HZ_L (103.67). Abdo (2001) [1] reported a similar increase in the number of pods per plant with foliar spray of Zn and B. Maximum number of pods per plant were also observed by Alam *et al*. (2020) [2] in Garden pea with application of zinc.

Table 2: Effect of boron and zinc treatments on the number of pods per plant of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	72	73.67	119	104.67	116	71.33
B_LZ_0	79	78.33	118.67	131.33*	111.33*	82.33
B_HZ_0	47	95.67*	95	133.67*	51.33	63.33
B_0Z_L	83	79.33	68.33	83.67	80.67	81.33
B_LZ_L	85.33	75.67	89.67	104.33	62.33	100
B_HZ_L	73	73	140.33*	111.33	85.33	103.67*
B_0Z_H	86.67	61.67	86.67	85.33	88.67	49
B_LZ_H	113*	78	74.33	91	90	88.67
B_HZ_H	44.67	82.33	64.67	111	89	69.33
CD	31.88	20.21	30.23	25.06	32.63	25.79

Single pod weight (g): The single pod weight (g) per plant in all the genotypes were also varied widely with the treatments (Table 3). In TG 26, the best treatment was observed in B_LZ_H (0.889) and lowest in B_LZ_L (0.701) ; in TG 51, the best treatment was B_HZ_L(0.846) and lowest in B_0Z_H (0.657); in TG 71, the best treatment was B_0Z_L (0.823) and lowest in B_0Z_H (0.607); in TG 72, the best treatment was B_HZ_L(0.780) and was significantly better than the control; in BARC 150, the best treatment was B_LZ_0 (0.905) and lowest in B_HZ_H (0.665); in BARC 200, the best treatment was B_0Z_L(0.988) and lowest in B_0Z_0 (0.746).

Table 3: Effect of boron and zinc treatments on single pod weight (g) of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	0.821	0.761	0.769	0.602	0.738	0.746
B_LZ_0	0.718	0.795	0.765	0.697	0.905*	0.884*
B_HZ_0	0.766	0.833*	0.627	0.694	0.796*	0.834*
B_0Z_L	0.750	0.675	0.823*	0.731	0.677	0.786
B_LZ_L	0.701	0.757	0.685	0.653	0.727	0.837*
B_HZ_L	0.779	0.846*	0.736	0.78*	0.768	0.948*
B_0Z_H	0.830	0.657	0.607	0.655	0.765	0.988*
B_LZ_H	0.889*	0.670	0.685	0.691	0.685	0.986*
B_HZ_H	0.764	0.726	0.759	0.707	0.665	0.93*
CD	0.076	0.067	0.061	0.057	0.052	0.082

Pod yield per plant (g): The pod yield per plant in all the genotypes also varied widely with the treatments (Table 4): TG-26 between 37.21 and 100.53; TG-51 between 43.64 and 79.96; TG-71 between 49.19 and 94.61; TG-72 between 45.98 and 89.07; BARC-150 between 73.11and 135.5 and BARC 200 between 62.58 and 118.31. In TG 26, the best treatment was B_LZ_H (100.53); in TG 51, the best treatment was B_0Z_H (79.96); in TG 71, the best treatment was B_HZ_L (94.61); in TG 72, the best treatment was B_HZ_0 (89.07); in BARC 150, the best treatment was B_0Z_H (135.5), the other treatments significantly better than the control were B_LZ_0 (127.51); in BARC 200, the best treatment was B_LZ_L (118.31) and other best treatments were B_HZ_L (111.93) and B_LZ_L (107.93). Application of boron has been reported to produce an additional pod yield in French bean (Singh and Singh, 1990) [16], black gram and chickpea (Sakal *et al*. 1988) [14].

Table 4: Effect of boron and zinc treatments on the pod yield per plant (g) of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	59.58	62.05	80.52	63.14	85.67	87.12
B_LZ_0	58.46	68.84	82.69	85.77	127.51*	77.81
B_HZ_0	37.21	79.96*	57.47	89.07*	109.12	62.58
B_0Z_L	67.15	55.31	54.37	45.98	81.93	79.86
B_LZ_L	62.29	61.79	56.93	71.52	77.82	107.93*
B_HZ_L	58.32	65.65	94.61*	76.59	101.96	111.93*
B_0Z_H	72.88	43.64	49.19	48.79	135.5*	75.91
B_LZ_H	100.53*	56.12	53.99	57.92	73.1	118.31*
B_HZ_H	37.63	66.58	53.18	79.06	98.53	89.37
CD	15.655	12.473	11.438	16.316	26.725	17.623

Number of seeds per plant: The number of seeds per plant in all the genotypes (Table 5) ranged in TG-26 between 52.67 and 126.67; TG-51 between 37.33 and 111; TG-71 between 69.33 and 132; TG-72 between 74.33 and 136.67; BARC-150 between 121.33 and 38.33 and BARC 200 between 55 and 127.33. The variations among treatments in each of the genotypes were statistically significant. In TG 26, the best treatment was observed in B_LZ_H (126.67); in TG 51, the best treatment was B_HZ_0 (111); in TG 71, the best treatment was B_HZ_L (132); in TG 72, the best treatment was B_LZ_0 (136.67) and B_LZ_0 (135) was also significantly better than the control; in BARC 150, the best treatment was B_LZ_0 (121.33) in BARC 200, the best treatment was B_LZ_L (127.33). Kamaleshwaran *et al*. (2021) [6] reported a similar increase in the number of seeds per plant while working on different levels of boron.

Table 5: Effect of boron and zinc treatments on the number seeds per plant of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	78.33	79.33	104.67	97.33	38.33	81.33
B_LZ_0	63	85	124.33	136.67*	121.33*	95
B_HZ_0	41.33	111*	83.67	135*	48	76.33
B_0Z_L	86	58.33	77.67	74.33	74.33	87.33
B_LZ_L	68.33	74.33	82.67	96.67	55.33	127.33*
B_HZ_L	64.33	57	132*	107	73.33	119.67
B_0Z_H	99.67	52.33	69.33	92	91.67*	55
B_LZ_H	126.67*	37.33	73.67	109	80.33	115
B_HZ_H	52.67	73.33	80.13	85.33	78.33	79
CD	40.751	31.193	25.326	28.548	32.843	30.254

Single seed weight (g): The single seed weight (g) per plant in all the genotypes (Table 6) varied widely with the treatments. TG-26 ranged between 0.415 and 0.506; TG-51 between 0.404 and 0.517; TG-71 between 0.379 and 0.449; TG-72 between 0.381 and 0.459; BARC-150 between 0.306 and 0.487 and BARC 200 between 0.401 and 0.483. In TG 26, the best treatment was B_LZ_H (0.506); in TG 51, the best treatment was B_LZ_0 (0.517); in TG 71, the best treatment was B_LZ_H (0.449); in TG 72, the best treatment was B_HZ_L (0.459) was significantly better than the control; in BARC 150, the best treatment was B_LZ_0 (0.487); in BARC 200, the best treatment was B_0Z_L (0.483). Application of ZnSo4 had a positive impact on seed weight as reported by Ram and Katiyar (2013) [13] in mungbean, Khrogamy and Farnia (2009) [7] in Chickpeas and Shah *et al*. (2016) [15] in Pigeonpea.

Table 6: Effect of boron and zinc treatments on the single seed weight (g) of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	0.448	0.469	0.43	0.387	0.383	0.409
B_LZ_0	0.479	0.517*	0.401	0.432	0.487	0.472
B_HZ_0	0.415	0.472	0.379	0.437	0.324	0.445
B_0Z_L	0.462	0.462	0.438	0.404	0.397	0.483*
B_LZ_L	0.505	0.455	0.412	0.381	0.385	0.47
B_HZ_L	0.476	0.446	0.44	0.459*	0.318	0.467
B_0Z_H	0.442	0.404	0.397	0.425	0.485	0.401
B_LZ_H	0.506*	0.487	0.449*	0.455	0.441	0.458
B_HZ_H	0.448	0.468	0.424	0.441	0.306	0.426
CD	0.047	0.042	0.046	0.042	0.067	0.05

Seed yield per plant (g): The seed yield per plant in all the genotypes also found to varied widely with the treatments (Table 7): TG-26 between 18.31 and 64.27; TG-51 between 21.52 and 53.08; TG-71 between 28.25 and 58.38; TG-72 between 30.74 and 57.47; BARC-150 between 21.36 and 57.63 and BARC 200 between 24.56 and 59.33. In TG 26, the best treatment was B_LZ_H (64.27); in TG 51, the best treatment was B_HZ_0 (53.08); in TG 71, the best treatment was B_HZ_L (58.38); in TG 72, the best treatment was B_HZ_0 (57.47) and B_LZ_0 (56.04) was also significantly better than the control; in BARC 150, the best treatment was B_LZ_0 (57.63); in BARC 200, the best treatment was B_LZ_L (59.33). Krishna *et al*. (2022) [9] also reported an increase in seed yield increased with the intervention of boron and zinc. Application of boron also markedly increases the yield and quality of oil seed crops (Sakal *et al*. 1988) [14] where the application of 2.0 and 2.5 kg B ha-1 resulted in an increase in grain yield of black gram and chickpea by 33 and 38% respectively.

Table 7: Effect of boron and zinc treatments on the seed yield per plant (g) of different groundnut genotypes

Genotypes→ Treatments↓	TG-26	TG-51	TG-71	TG-72	BARC- 150	BARC- 200
B_0Z_0	39.57	43.33	47.18	37.96	32.02	36
B_LZ_0	29.05	28.70	49.77	56.04*	57.63*	45.02
B_HZ_0	18.31	53.08*	34.27	57.47*	23.67	34.32
B_0Z_L	20.51	34.37	34.41	30.74	31.53	42.14
B_LZ_L	23.62	35.79	33.77	38.01	21.36	59.33*
B_HZ_L	33.13	29.16	58.38*	47.22	35.45	55.94*
B_0Z_H	44.95	24.37	28.25	39.78	45.23*	24.56
B_LZ_H	64.27*	21.52	31.66	50.70	35.89	53.73*
B_HZ_H	20.07	39.14	34.61	36.87	25.96	35.52
CD	10.90	8.96	10.87	13.71	11.27	14.29

Conclusion

All crop parameters except number of productive nodes per plant were substantially influenced by the foliar treatments of boron (boric acid) and zinc (zinc sulphate). The response of the genotypes to the different boron and zinc treatments was not uniform. TG 26, TG 51 and TG 71 performed substantially better in T_8 (BLZH), T_3 (BHZ0) and T_6 (BHZL), respectively than any other treatments including the control. In case of TG 72, T_3 (BHZ0) and T_2 (BLZ0) were better than control and at par with each other. In case of BARC150, the best treatment was T_2 (BLZ0), though T_7 (B0ZH) was also better than the control. In case of BARC 200, T_5 (BLZL) was the best treatment, though T_6 (BHZL) and T_8 (BLZH) were at par with it and statistically better than the control. The better-performing treatments improved pod or seed yield by improving one or more than one yield parameters. The variations among treatments in each of the genotypes were mostly statistically significant indicating substantial effect – positive or negative – of foliar application of boron (boric acid) and zinc (zinc sulphate). Finally, it can be concluded that, with appropriate treatment of boron and zinc, the yield of groundnut can be enhanced.

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Competing interests
The authors have declared that no competing interests exist

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