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Effect of zinc and boron on growth, yield attributes and productivity of groundnut (*Arachis hypogea* L.)

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Abstract
The field experiment was conducted on sandy loam soils to determine the impact of zinc and boron on groundnut (*Arachis hypogea* L.) var. during the summer season (*Zaid*) of 2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, India. The treatment comprised of ten combinations (*viz.* zinc at 5/10 and 15kg/ha respectively and at boron.0.10%/0.25% and 0.50% kg/ha respectively) and the experiment was laid down in randomized block design and were replicated thrice. The results showed that the application of Zinc15kg/ha + Boron–0.50% (T9) recorded the maximum plant height (62.43 cm), highest plant dry weight (49.81g), no. of nodules per plant (101.1), seed index (41.79 g), no. of pods per plant (29.1), no. of kernels per pod 2.26), Kernal yield (3.05 t/ha), harvest index (48.38%). Therefore, the study reveals that the application of Zinc15kg/ha + Boron–0.50% treatment effectively improves the growth and productivity of summer groundnut.

Keywords: Zinc, boron, growth, yield, groundnut

1. Introduction

Groundnut (*Arachis hypoggaea*) is a legume that is significant as an oilseed and grain. It is known as "The King of Oilseeds" and is a member of the Leguminaceae family. It ranks third among major vegetable protein sources and fourth among noteworthy edible oil sources. For groundnut production volume, India comes in second place, while for output area, it leads the pack. India's 2018–2019 groundnut harvest is expected to reach 40.12 lakh hectares. Comparable projections (Vali *et al*., 2020) [15] put the yield at 37.70 lakh tons per hectare. Also known as peanuts, monkey nuts, and manila nuts, it is the leading oil seed product in India. Around the world, groundnuts are utilized for 50% of oil extraction processes, 37% of confectionary usage, and 12% of seed purposes (Nurezannat *et al*., 2019) [14]. Comparable calculations indicate that the yield is 37.70 lakh tons per hectare. (Vali *et al*., 2020) [15]. India's most widely produced oil seed is groundnut, which is also a significant income crop. Farmers produce it in both kharif and zaid, which has led to sustainable agriculture. About 46.70 percent of groundnuts are utilized to produce oil. Its higher proportion of protein (22.0%), carbs (10.0%), and minerals (3.0%) contribute to its high food value, which is also why it is ingested directly (Satish *et al*., 2011) [17].
Micronutrient deficiencies are one of the main causes of low groundnut yields. The need for micronutrients in soil fertility management has increased because to increased agricultural intensity, the use of direct fertilizers, and rising crop requirements brought on by rising productivity levels. These factors are progressively becoming significant obstacles to achieving agricultural production (Nandi *et al*., 2020) [8]. One of the key elements in plant growth and development is nutrition. Due to its extensive development, this crop takes up a significant amount of nutrients from the soil at various stages. Groundnuts need a lot of nutrients from the soil at different stages of growth and development because of their increased productive potential (Vali *et al*., 2020) [15].
Zinc (Zn) is an important micronutrient for plants since it is involved in many key cellular functions such as metabolic and physiological processes, enzyme activation, and ion homeostasis (Saleem *et al*., 2022) [13].

Zinc catalyses the process of oxidation in plant cells and is vital for transformation of carbohydrates, regulates the consumption of sugar, increases source of energy for the production of chlorophyll, aids in the formation of auxins which produce more plant cells and more dry matter, that in turn, will be stored in seed as a sink and promotes absorption of water. Zinc also acts as a metal activator for enzymes and catalyzes the formation of indole acetic acid, which increases crop yield in the long run. Certain studies asserted that by treating zinc deficiency, foliar zinc spraying might improve groundnut productivity, growth, and seed quality. The production of chlorophyll, pollen function, fertilization, and sprouting all require zinc (Dadhich *et al*., 2019) [16].

Functions of Boron (B) B is one of the essential nutrients for the optimum growth, development, yield, and quality of crops. It performs many important functions in plants and is mainly involved in cell wall synthesis and structural integration. Boron (B) plays an important role in the physiological process of plants, such as cell elongation, cell maturation, meristematic tissue development, and protein synthesis need for B application in groundnut is therefore, to increase the growth, development, and at the same time to increase the yield of crops. Application of B also promotes the absorption of N by groundnut and increases the plant height, plant dry weight, and the total number of pods. (Nandi *et al*., 2020) [8]. In order to facilitate plant fertilization and grain yield, boron helps pollen grains and tubes germinate, grow, and develop. Plants with low boron levels took longer to blossom. The physiological functions of plants, including the regulation of glucose metabolism, protein synthesis, and seed formation, depend on the element boron. Boron was essential for sustaining blooming and regulating fruit development in legumes and the peanut crop. Consequently, selecting a cultivar with an appropriate zinc dosage is essential to increasing groundnut productivity. Therefore, an experiment was designed to investigate the effects of varying doses of zinc and boron on the development and productivity of summer groundnut (*Arachis hypogea* L.).

2. Material and Methods

2.1 Location of experimental site

The experiment was carried out during Zaid season of 2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj which is located at 25o 24' 42" N latitude, 81o 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5km away from Prayagraj city.

2.2 Climate and weather

Prayagraj (Allahabad) has a sub-humid, sub-tropical climate with the monsoon commencing from July and withdrawing by the end of September. The rainfall is unevenly distributed and most of it is received between July and September. Apart from this, a few winter and summer showers are also received. The meteorological data including the weekly average of maximum and minimum temperature, relative humidity, total rainfall and number of rainy days recorded at Meteorological Observatory, College of Forestry, SHUATS, Prayagraj (Allahabad) during the period of experiment is presented in figure 1.

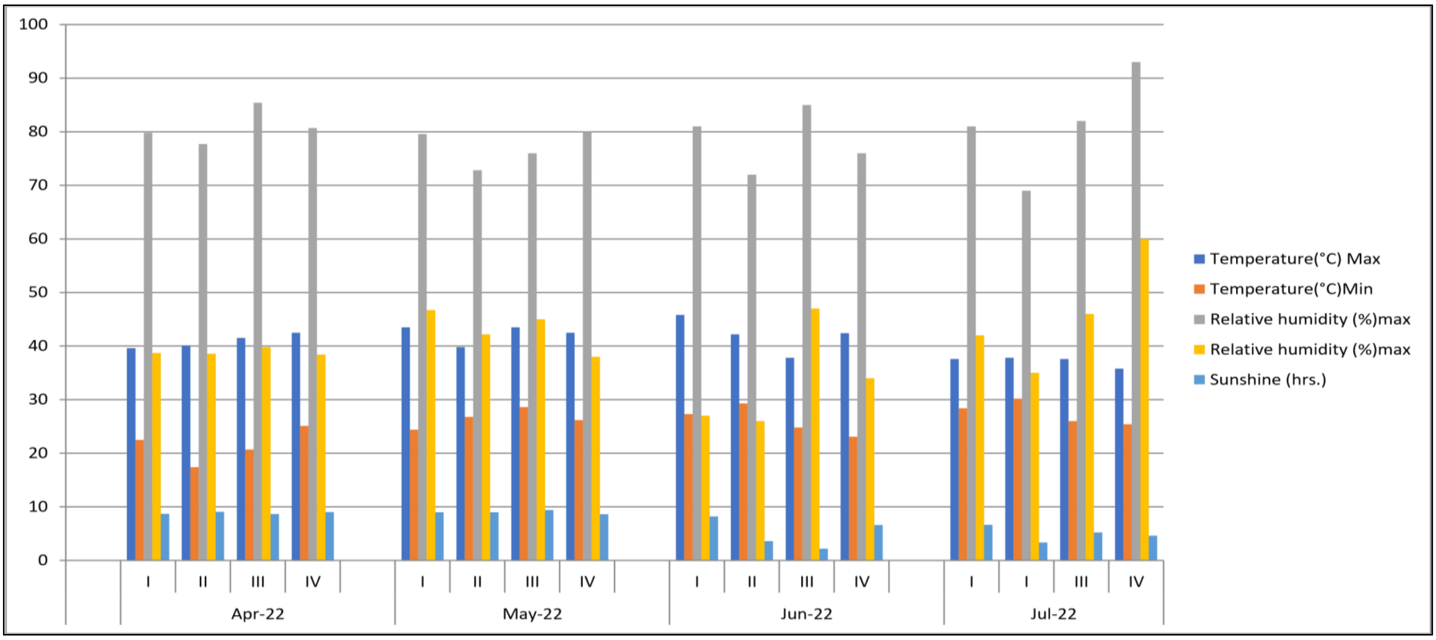

Fig 1: Mean weakly parameter and total rainfall during the cropping season

2.3 Experiment details

The experiment was carried out at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology, and Sciences during the *Zaid* season of 2023. The experiment was laid out in Randomised Block Design with ten treatment were replicated thrice. The treatments comprised of different rates of zinc levels *viz.*, 5,10 and 15 kg/ha with three boron levels *viz.*, 0.10%, 0.25% and 0.50% {1. Zinc 5 kg/ha + Boron– 0.10% foliar 2. Zinc 5 kg/ha + Boron– 0.25%foliar 3. Zinc 5 kg/ha + Boron– 0.50% foliar 4. Zinc 10 kg/ha + Boron– 0.10%foliar 5. Zinc 10 kg/ha + Boron– 0.25% foliar 6. Zinc 10kg/ha + Boron– 0.50% foliar 7. Zinc 15 kg/ha + Boron– 0.10% foliar 8. Zinc 15 kg/ha + Boron– 0.25% foliar 9. Zinc 15 kg/ha + Boron– 0.50% foliar 10. Control (20:40:60 kg/ha N:P: K)} and recommended doses of fertilizer are Nitrogen @20kg/ha, Phosphorus @40kg/ha and potassium @60kg/ha. Seeds are sown at a spacing of 30cm×10cm according to a seed rate of 90kg/ha. Urea, SSP, and MOP were chosen as the N, P, and K fertiliser sources, respectively.

2.4 Observations recorded
2.4.1 Growth and Yield attributing characters
a. **Plant height (cm):** The average height of five plants were recorded at an interval of 20 DAS. The height of plant was measured from the base of the plant up to the tip. Height of the plants was recorded at 20,40, 60 and 80 DAS five plants were randomly selected from each plot which was tagged for observations. The height was measured in cm.
b. **Plant dry weight (g):** Three plants were uprooted from destructive sampling zone from each plot at 20, 40, 60 and 80 DAS. The roots were removed, thereafter the samples were air dried and then kept in oven for 72 hours at 70^0 C and their dry weight was determined by electronic balance (Model No. CB- 50), and the average dry weight (g) was calculated.
c. **Number of nodules/plants:** After digging out three plants from border rows in each plot, the number of nodules were counted at regular intervals of 20, 40,60 and 80 DAS.
d. **No. of pods per plant:** For calculating number of pods/plants, pods of tagged plants were picked separately and then counted.
e. **No. of kernels per pod:** For calculating number of Kernals/pod, some pods were randomly selected and then their kernels were counted.
f. **Seed index (g):** Samples of hundred seeds were randomly collected from each plot and were weighed for further record by electronic balance. Thus, seed index was finally estimated.
g. **Seed yield (kg/ha):** The crop was harvested from the plot. The harvested pods were collected, sun dried and yield was recorded in kg/ha.
h. **Haulm yield (kg/ha):** Stover from harvest area was dried in sun, bundled, tagged and weighed separately from each plot for calculating the haulm yield kg/ha.
i. **Harvest index (%):** Harvest index was obtained by dividing the economic yield (grain) by the biological yield (grain + straw). It was calculated for each of the plots and was represented in percentage.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

2.6 Statistical analysis
The "Analysis of variance technique" (ANOVA) was used to statistically analyze the data that was collected throughout the inquiry. The F-test was used to statistically assess the data in accordance with the methodology outlined by Gomez and Gomez (1984). Different treatment means were found to be significantly different when using CD values at P=0.05. Using the following ANOVA table, the hypothesis was tested.

3. Results and Discussion
3.1 Growth parameters
Significant variations in plant height and plant dry weight were recorded in various levels of zinc and boron is presented in Table 1 and 2.

3.1.1 Plant height
At 20 DAS, significantly higher plant height (13.8 cm) was recorded in the treatment (9) Zinc 15 kg/ha + Boron– 0.50%. Which was superior over all treatments. At 40 DAS maximum plant height respectively were recorded with treatment (9) Zinc 15 kg/ha + Boron– 0.50% (31.7 cm). However, treatment Zinc 15 kg/ha + Boron– 0.25% (30.4 cm) were found to be statistically at par with Zinc 15 kg/ha + Boron– 0.50%. At 60 DAS highest plant height was recorded with treatment (9) Zinc 15 kg/ha + Boron– 0.50% (52.9 cm). However, treatment Zinc 15 kg/ha + Boron– 0.50% were found to be statistically at par with Zinc 15 kg/ha + Boron– 0.50%. At 80 DAS maximum plant height was recorded with treatment (9) Zinc 15 kg/ha + Boron– 0.50% (62.43 cm). However, treatment Zinc 15 kg/ha + Boron– 0.25% (60.63 cm) were found to be statistically at par with Zinc 15 kg/ha + Boron– 0.50%.

The plant height of groundnut increased significantly due to application of zinc and boron levels. Boron (B) plays an important role in the physiological process of plants, such as cell elongation, cell maturation, meristematic tissue development, and protein synthesis results obtained by Abhigna D, *et al.* (2021) [2] and Nandi *et al*., (2020) [8]. The increase in plant height may be attributed to role of zinc as a catalyst or stimulant in most of physiological and metabolic process and it also important in synthesis of trytophane, a component of some protein and a compound needed for production of growth hormones (auxins) like indole acetic acid. Similar results were also reported by Halepyati (2001) [18].

3.1.2. Plant dry weight
At 20 DAS, significantly higher plant height (2.13 g) was recorded in the treatment (9) Zinc 15 kg/ha + Boron– 0.50%. Which was superior over all treatments. At 40 DAS highest plant dry weight was found in treatment (9) Zinc15kg/ha+Boron– 0.50% (13.63g). However, treatment (8) Zinc15 kg/ha + Boron–0.25% (31.21 g) were found to be statistically at par with treatment Zinc15 kg/ha + Boron– 0.50%. At 60 DAS highest plant dry weight was found in treatment (9) Zinc15kg/ha + Boron– 0.50% (42.81g). However, treatment (8) Zinc15 kg/ha + Boron–0.25% (41.53 g) were found to be statistically at par with treatment Zinc15 kg/ha + Boron– 0.50%. At 80 DAS highest plant dry weight was found in treatment (9) Zinc15kg/ha + Boron– 0.50% (49.81 g). However, treatment (8) Zinc15 kg/ha + Boron–0.25% (48.93g) were found to be statistically at par with treatment Zinc15 kg/ha + Boron– 0.50%. The dry weight of groundnut increased significantly due to application of zinc and boron levels. A similar result was reported by Awlad *et al*. (2003) [1] and Halepyati (2001) [18] Further increase in the dry weight might be due to the application of zinc at 15 kg/ha. Zinc is essential for promoting certain metabolic reactions. It is necessary for the production of chlorophyll and carbohydrates.

3.2 Yield attributing characters
Among different levels of Zinc and boron treatments, the significant variations were observed in yield attributing traits such as Number of pods/plant, Number of kernels per pod and seed index was presented in Table 3.

3.2.1 Number of Pods/Plant
Treatment Zinc 15kg/ha + Boron– 0.50% resulted in significantly highest no. of pods per plant (29.1) However, Zinc 15 kg/ha + Boron– 0.10% (27.4) were found to be statistically at par with Zinc 15kg/ha + Boron– 0.50%. The improvement in photosynthesis and carbohydrate metabolism resulting into greater formation of photosynthetic and metabolites in source and later on translocated in the newly formed sinks which ultimately increased number of pods/plants These results are in agreement with the findings of Sharma *et al*. (2010) [10].

3.2.2 Number of kernels per pod: Significant effect was observed by the statistical analysis of number of kernels/pods. Treatment Zinc 15kg/ha + Boron– 0.50% recorded significant and highest number of kernels/pod (2.26).

However, Zinc 15 kg/ha + Boron– 0.25% (2.06) were found to be statistically at par with Zinc 15kg/ha + Boron– 0.50%. The beneficial effect of organic manuring might be due to improvement in the physical condition of soil as well as increased availability of plant nutrients, which results increasing kernels/pod. The availability and optimum regular supply of plant nutrients might have favorable influenced the flowering and kernel formation which ultimately increased pods/plant. Those results are in conformity with those of Naiknaware *et al*. (2015) [7].

3.2.3 Seed Index: The statistical analysis on test weight was found to be significant. However, highest test weight (41.79 g) was recorded with treatment Zinc 15kg/ha + Boron– 0.50%. However, 15 kg/ha + Boron– 0.25% (39.19) were found to be statistically on par with Zinc 15kg/ha + Boron– 0.50%. Seed index was influenced by the application of zinc and boron which might be due to characters highly influenced by its genetic makeup Thalooth *et al*. (2005) [12] and Sharma *et al*. (2010) [10].

3.3 Yield

The significant variations in productivity were observed in among different levels of zinc and boron was depicted in table 4.

3.3.1 Kernel yield

The seed yield showed increasing trend with the application of zinc and boron in groundnut. The highest kernel yield was obtained with the treatment Zinc15kg/ha+Boron–0.50% (3.05 t/ha). However, the Zinc 15 kg/ha + Boron 0.25% (2.52 t/ha) were found to be statistically on par with Zinc 15 kg/ha + Boron– 0.50%. Yield increases with application of zinc and boron might be due to increased growth characters and yield attributes because of its unique role in enhancing quality efficient and growth and development which might have enhanced photosynthesis and synthesis other metabolites for plant use and significantly increased the yield and nutrients uptake by groundnut. Similar finding was reported by Elayaraja D, Singaravel R. (2012) [4].

3.3.2 Haulm yield (kg/ha)

The haulm yield of groundnut was also influenced by the application of zinc and boron. Highest haulm yield (6.2 t/ha) was recorded highest in Zinc15kg/ha+ Boron–0.50% (5.8 t/ha). Treatment with Zinc 15 kg/ha + Boron 0.25% was found to be statistically on par with Zinc 15 kg/ha + Boron– 0.50%. Application of zinc and boron to groundnut which result to slowly releasing available nutrients were had favourable effect on growth and biomass production similar results were reported by Elayaraja D, Singaravel R. (2012) [4].

3.3.2. Harvest index (%)

The data showed significant difference in Zinc15kg/ha+ Boron–0.50%. (48.38) harvest index. However, control was found to be statistically on par with Zinc15kg/ha+ Boron–0.50%. Similar findings were reported by (Susan Poonguzhali *et al.*, 2019).

Table 1: Effect of zinc and boron on plant height at different growth intervals of groundnut

S. No.	Treatment combinations			Plant height (cm)	
		20 DAS	40 DAS	60 DAS	80 DAS
1.	Zinc 5 kg/ha + Boron– 0.10% foliar spray	9.3	19.6	30.9	46.13
2.	Zinc 5 kg/ha + Boron– 0.25% foliar spray	9.7	21.2	36.7	47.37
3.	Zinc 5 kg/ha + Boron– 0.50% foliar spray	10.2	23.7	38.9	51.00
4.	Zinc 10 kg/ha + Boron– 0.10% foliar spray	10.6	25.6	41.6	53.63
5.	Zinc 10 kg/ha + Boron– 0.25% foliar spray	11.2	25.1	39.9	54.13
6.	Zinc 10kg/ha + Boron– 0.50% foliar spray	11.7	24.7	42.57	57.13
7.	Zinc 15 kg/ha + Boron– 0.10% foliar spray	10.9	29.7	46.8	59.03
8.	Zinc 15 kg/ha + Boron– 0.25% foliar spray	12.6	30.4	48.47	60.63
9.	Zinc 15 kg/ha + Boron– 0.50% zinc foliar spray	13.8	31.7	52.9	62.43
10.	Control	10.1	21.4	33.6	49.71
	F-test	NS	S	S	S
	S.Em±	0.37	0.60	0.56	0.56
	CD (P=0.05)	-	1.79	1.67	1.72

Table 2: Effect of and zinc and boron on plant dry weight at different growth intervals of groundnut

S. No.	Treatment combinations		Plant dry weight (g/plant)		
		20 DAS	40 DAS	60 DAS	80 DAS
1.	Zinc 5 kg/ha + Boron– 0.10% foliar spray	1.1	7.59	29.08	42.02
2.	Zinc 5 kg/ha + Boron– 0.25% foliar spray	1.55	8.38	30.16	43.32
3.	Zinc 5 kg/ha + Boron– 0.50% foliar spray	1.41	8.97	32.69	44.70
4.	Zinc 10 kg/ha + Boron– 0.10% foliar spray	1.66	10.69	33.03	44.02
5.	Zinc 10 kg/ha + Boron– 0.25% foliar spray	1.69	11.53	35.45	45.45
6.	Zinc 10kg/ha + Boron– 0.50% foliar spray	1.80	12.17	37.54	47.55
7.	Zinc 15 kg/ha + Boron– 0.10% folia spray	1.74	12.25	39.99	48.23
8.	Zinc 15 kg/ha + Boron– 0.25% foliar spray	1.97	13.21	41.53	48.93
9.	Zinc 15 kg/ha + Boron– 0.50% foliar spray	2.13	13.63	42.81	49.81
10.	Control	1.48	8.24	31.13	42.07
	F test	NS	S	S	S
	S.Em±	0.10	0.36	0.62	0.38
	CD (P=0.05)	-	1.07	1.87	1.13

Table 3: Effect of zinc and boron on number of pods per plant, number of kernels per pod and seed index of groundnut

S. No.	Treatment combinations	Pods/plant No.)	Kernels/pod (No.)	Seed index (g)
1.	Zinc 15 kg/ha + Boron– 0.50% foliar spray	24.1	1.45	34.17
2.	Zinc 5 kg/ha + Boron– 0.25% foliar spray	24.4	1.56	35.47
3.	Zinc 5 kg/ha + Boron– 0.50% foliar spray	28.1	1.56	35.54
4.	Zinc 10 kg/ha + Boron– 0.10% foliar spray	25.2	1.59	36.35
5.	Zinc 10 kg/ha + Boron– 0.25% foliar spray	25.8	1.61	37.98
6.	Zinc 10kg/ha + Boron– 0.50% foliar spray	26.4	1.66	37.73
7.	Zinc 15 kg/ha + Boron– 0.10% foliar spray	27.4	1.81	38.28
8.	Zinc 15 kg/ha + Boron– 0.25% foliar spray	28.2	2.06	39.19
9.	Zinc 15 kg/ha + Boron– 0.50% foliar spray	29.1	2.26	41.79
10.	Control	26.2	1.53	35.76
	F test	S	S	S
	S.Em±	0.92	0.08	0.94
	CD (P=0.05)	2.73	0.25	2.80

Table 4: Effect of zinc and boron on kernel yield, haulm yield and harvest index of groundnut

S. No.	Treatment combinations	kernel yield (t/ha)	Haulm yield(t/ha)	Harvest index (%)
1.	Zinc 5 kg/ha + Boron– 0.10% foliar spray	1.31	3.8	34.21
2.	Zinc 5 kg/ha + Boron– 0.25% foliar spray	1.50	4.3	34.88
3.	Zinc 5 kg/ha + Boron– 0.50%foliar spray	1.73	4.4	38.63
4.	Zinc 10 kg/ha + Boron– 0.10% foliar spray	1.61	4.5	35.55
5.	Zinc 10 kg/ha + Boron– 0.25% foliar spray	1.75	4.6	36.95
6.	Zinc 10kg/ha + Boron– 0.50% foliar spray	1.83	4.4	40.90
7.	Zinc 15 kg/ha + Boron– 0.10% foliar spray	2.10	5.1	41.17
8.	Zinc 15 kg/ha + Boron– 0.25% foliar spray	2.52	5.8	43.10
9.	Zinc 15 kg/ha + Boron– 0.50% foliar spray	3.05	6.2	48.38
10.	Control	1.50	3.6	42.50
	F-test	S	S	S
	S-Em±	0.05	0.10	0.72
	CD (P=0.05)	0.17	0.31	2.15

4. Conclusion

It can be concluded that the application of Zinc15kg/ha + Boron–0.50% revealed the highest growth traits, yield attributing characters and yield of groundnut crop. Therefore combination of different levels of zinc and boron improves the growth and productivity of summer groundnut.

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