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Effect of different levels and source of boron fertilizers on the growth and yield of groundnut in coastal saline soil

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Abstract

In determining the growth, yield and quality of groundnut, the role of boron is much pronounced. Restricted availability of this nutrient in coastal saline soil greatly impairs the yield of groundnut. Therefore, a field experiment was conducted to find out the effect of different levels and source of boron fertilizers on the growth and yield of groundnut in coastal saline soil. The experiment was carried out in a farmer's field at Singarakuppam coastal village near Chidambaram, Cuddalore district of Tamilnadu during June –Aug, 2020. The texture of the soil was sandy and taxonomically classified as *Typic usticpsaments* with pH-8.23, EC- 4.14 dS m^{-1} and represented low status of organic carbon (2.32 g kg^{-1}). The soil had low alkaline $KMnO_4$-N (139.50 kg ha^{-1}), low in Olsen- P (9.57 kg ha^{-1}), medium in NH_4OAc-K (164.78 kg ha^{-1}) and available B (Hot water-B) content (0.23 mg kg^{-1}). The fifteen treatments consisted of five levels of boron *viz.*, 0, 0.5, 1.0, 1.5 and 2.0 kg B ha^{-1} as factor-L and three different sources of boron fertilizers like S_1– Borax; S_2– Solubor and S_3– Boro-Humate as factor-S. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications, using groundnut variety VRI 2 as test crop. The results revealed that the combined application of B @ 1.5 kg ha^{-1} through Boro-Humate significantly increased the growth, yield characters and yield of groundnut.

Keywords: borax; solubor and boro-humate, growth, yield, groundnut, coastal saline soil

Introduction

Coarse textured sandy soil dominates majority of the coastal regions and pose great challenge to sustainable crop production. Soil fertility is the most limiting factor for crop production in coastal saline soil. Sandy soils have specific soil constraints *viz.*, light texture, poor exchange property, low nutrients and water retention capacity, low status of organic carbon and deficiency of both macro and micronutrients. These problems severely affect the productivity of crops in this region (Arulrajasekaran *et al.*, 2021). Even the applied nutrients are leached to the lower layers due to poor physical properties, poor nutrient retention and low organic carbon content, which further aggravates the problem of nutrient deficiency. The coastal farmers are cultivating the lands by adopting traditional management practices and realizing very low yield of crops as compared to other regions (Singaravel *et al.*, 2019) [23]. In addition to that the light texture coastal saline sandy soils are also well known for the deficiency of micronutrients especially boron. In groundnut production the boron plays a vital role in promoting growth, peg formation, quality of seeds and yield of groundnut. It also arrest flower drop and plays a pivotal role in cell division in the process of nodule formation besides its involvement in carbohydrate and fat synthesis (Kamalakannan and Elayaraja. 2020) [13]. Several earlier works has emphasized the need for application of these nutrients for increasing the growth, yield and quality of groundnut (Yakup cikli *et al.*, 2015; Haneena, *et al.*, 2021) [28, 8]. Hence, in the present investigation, an attempt has been made to study the effect of different levels and source of boron fertilizers on the growth and yield of groundnut in coastal saline soil.

Meterials and Methods

A field experiment was conducted in the farmer's field at Singarakuppam coastal village near Chidambaram in Cuddalore district, Tamilnadu during June – Aug, 2020. The experimental soil had sandy texture with pH- 8.23; EC- 4.14 d Sm^{-1}; organic carbon-2.32g kg^{-1}, and boron status of 0.23 mg kg^{-1}. The alkaline $KMnO_4$ – N; Olsen- P and NH_4OAc-K, were low, low and medium status, respectively. The treatments consisted of different levels of boron like L_0-control, L_1- 0.5 kg B ha^{-1}, L_2 – 1.0 kg B ha^{-1}, L_3 – 1.5 kg B $ha^{-1}$and L_4 – 2.0 kg B ha^{-1} as factor-L and different sources of boron fertilizers `., S_1- Borax ($Na_2[B_4O_5(OH)_4].8H_2O$), S_2- Solubor ($Na_2B_8O_{13}.4H_2O$) and S_3- Boro-Humate as factor-S. The experiment was conducted in a Factorial Randomized Block Design (FRBD) with three replications, using groundnut var. VRI–2 as test crop. Calculated amount of Borax, Solubor and Boro-Humate was applied as basal as per the treatment schedule. Gypsum @ 400 kg ha^{-1} was applied at all the experimental plots. Soil test based fertilizer recommendation of 17:34:54 kg of N: P_2O_5: K_2O per hectare was applied to all experimental plots uniformly. Half of the N and entire P_2O_5 and K_2O were applied as basal and the remaining half dose of N was applied in two splits at flowering and peg formation stage. Various growth components like plant height, number of branches $plant^{-1}$, dry matter production (DMP) and yield components *viz.*, number of pods $plant^{-1}$, 100 pod weight, 100 kernel weight, and shelling percentage were recorded at harvest stage. The yield of pod, kernel and haulm yield was recorded separately and expressed in kg ha^{-1}.

Results and Discussion

Growth characters (Table 1)

Application of different levels of B through different sources favourably increased the growth characters of groundnut *viz.*, plant height, number of branches $plant^{-1}$ and dry matter production. Irrespective of the sources of B, groundnut responded to boron application upto 1.5 kg B ha^{-1} in coastal saline sandy soil. Among the different levels of B evaluated, application of B @ 2.0 kg ha^{-1} recorded the maximum plant height (51.31cm), number of branches $plant^{-1}$ (9.80) and dry matter production (4723 kg ha^{-1}) of groundnut at harvest stage. However, it was found to be on par with B @ 1.5 kg ha^{-1}, which recorded a comparable plant height of 51.10 cm, number of branches $plant^{-1}$ of 9.74 and dry matter production of 4703 kg ha^{-1}. Among the three sources of boron fertilizers tried, application of boron through Boro-Humate (S_3) was found to be superior in increasing the growth characters *viz.*, plant height (47.48 cm), number of branches $plant^{-1}$ (9.07) and dry matter production (4465 kg ha^{-1}) of groundnut at harvest stage, respectively. However, it was found to be equally efficacious with application of boron through solubor (S_2). This was followed by the application of boron through borax (S_1).

Interaction effect due to different sources and levels of B fertilizers on the growth characters of groundnut was significant. Application of B @ 2.0 kg ha^{-1} through Boro-Humate (L_4S_3) registered the highest plant height (52.49 cm), number of branches $plant^{-1}$ (10.01) and dry matter production (4801 kg ha^{-1}). However, it was found to be on par with Boro-Humate @ 1.5 kg B ha^{-1}(L_3S_3). This was followed by (L_4S_2) which received 2.0 kg B ha^{-1} through solubor. The lowest plant height, number of branches $plant^{-1}$ and dry matter production was noticed in control.

The combined application of Boro-Humate @ 2.0 kg B ha^{-1} along with recommended dose of NPK registered highest plant growth characters of groundnut. This might be due to the effect of boron required for the proper development and differentiation of tissues particularly growing tips, phloem and xylem. These results are in conformity with the findings of Hirpara *et al.* (2019) [10] and Ramprosad Nandi *et al.* (2020) [19]. Furthermore, betterment in growth characters of groundnut might be due to the combined application of NPK along with borax increased the plant dry matter production. The applied nutrients by their effect on metabolism of cell, promoted the meristematic activity of the crop and its better uptake would result in increased dry matter accumulation. The result obtained in the present investigation was in agreement with the findings of Rezaul Kabir *et al.,* (2013) [21] The highest growth parameters of groundnut due to application of Boro-Humate could be due to the reason that boron is an important constituent of nucleotides, chlorophyll and enzymes involved in various metabolic processes which had a direct impact on vegetative phase of plants (Novita Rahman *et al.*, 2019) [16]. Further, adequate supply of N and P increased root growth through better absorption and utilization of all the plant nutrients, thus resulting in increased plant height and DMP associated with better growth of plants (Susan Poonguzhali *et al.*, 2019) [24]. further More, the improvement in growth characters namely plant height as a result of application of boro-humate + recommended dose of NPK might be due to the greater availability of macro and micronutrients in Boro-Humate applied plots which might have enhanced photosynthetic and other metabolic activities. This led to an increase in various plant metabolites responsible for cell division and elongation (Mehmet Rustu Karaman *et al.*, 2013) [14]. The increase in number of branches may be due to higher nutrient use efficiency, N-physiological efficiency and photosynthetic rates (Harikrishna Balla *et al.*, 2020) [9], whereas, dry matter accumulation increased due to increase in plant height, number of branches and greater nutrient availability and increase in photosynthetic rate. The result obtained was in accordance with the findings of Ansari *et al.* (2013) [1], Venkatakrishnan *et al*. (2019) [26]

Table 1: Effect of different levels and sources of boron fertilizers on the growth characters of groundnut

L S	Plant height (cm)						No. of branches $plant^{-1}$						Dry matter production (kg ha^{-1})					
	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean
S_1	37.01	43.33	46.16	49.15	49.33	44.99	7.05	8.48	8.91	9.39	9.46	8.65	3705	4172	4362	4563	4594	4279
S_2	37.12	46.22	48.97	51.92	52.11	47.26	7.02	8.95	9.33	9.86	9.93	9.01	3785	4351	4545	4759	4775	4443
S_3	37.02	46.37	49.31	52.25	52.49	47.48	7.01	8.97	9.42	9.97	10.01	9.07	3780	4385	4574	4789	4801	4465
Mean	37.05	45.30	48.14	51.10	51.31		7.02	8.80	9.22	9.74	9.80		3756	4302	4493	4703	4723	
	SE_D				CD (p=0.05)		SE_D				CD (p=0.05)		SE_D					CD (p=0.05)
L	0.30				0.62		0.04				0.09		28					58
S	0.64				1.32		0.11				0.25		58					119
L × S	0.89				1.83		0.21				0.33		78					160

Yield characters (Table 2&3)

Yield components of groundnut such as number of pods $plant^{-1}$, 100 pod weight, 100 kernel weight and shelling percentage were significantly increased due to different levels and source of boron fertilizers. Among the different levels of B studied, the application of B @ 2.0 kg ha^{-1} recorded the highest mean number of pods $plant^{-1}$ (28.12), 100 Pod weight (87.28 g), 100 kernel weight (47.45 g), and shelling percentage (72.89) of groundnut. However, it was found to be equally efficacious with application of B @ 1.5 kg ha^{-1}, which recorded 27.99 number of pods $plant^{-1}$, 86.77 g of 100 pod weight, 47.19 g of 100 kernel weight, and 72.53% of shelling percentage. Among the three different sources of boron fertilizers tried, Boro- Humate excelled the other two sources of boron fertilizer in improving the yield components of groundnut. The interaction effect between levels and sources of B on yield characters of groundnut was significant. The treatment (L_4S_3), which received B @ 2.0 kg ha^{-1} through Boro-Humate, recorded a highest number of pods $plant^{-1}$ (28.53), 100 pod weight (88.53 g), 100 kernel weight (48.23 g), and shelling percentage (74.13 %). However, it was found to be on par with Boro-Humate @ 1.5 kg B ha^{-1}(L_3S_3). This was followed by the treatment pairs (L_4S_2), (L_3S_2) and (L_4S_1).

A significant increase in the yield characters like number of pods plant^{-1}, 100 pod weight, 100 kernel weight, and shelling percentage of groundnut due to the application of Boro-Humate was clearly observed in the present investigation. All the yield characters increased with the increased level of boron upto 1.5 kg B ha^{-1}. The increased yield characters might be due to the involvement of B in producing growth promoting substances (Mekdad. 2019) [15]. The overall improvement in yield attributing characters of groundnut was obtained when B through Boro-Humate was applied along with NPK. Addition of 100 per cent recommended dose of NPK + Boro-Humate @ 1.5 kg B ha^{-1} outperformed all other treatments in increasing number of pods plant^{-1}, 100 pod weight, 100 kernel weight, and shelling percentage of groundnut. The betterment in yield characters might be ascribed to the effect of B which enhanced the photosynthetic activity resulting in the production and accumulation of fats and essential fatty acids synthesis which enhanced the yield parameters and yield of groundnut. Similar results were reported by Kader and Mona (2013) [12].

Moreover, the humic substances released during the dissociation of Boro-Humate forms complex with other nutrients and benefit the crop during entire growth period and improved the nutrient availability in soil. The humic acid substances released during the dissociation might have also entered into the plant system and behaved with a growth promoter and improved the growth and yield of groundnut. This was followed by B through B-Solubor was found to be next best treatment, in respect of yield. The higher yield characters of groundnut obtained with 100 per cent recommended dose of NPK + Boro-Humate @ 1.5 kg B ha^{-1}. This might be due to better root growth, nitrogen assimilation with higher nodulation, enzyme activity, and grain formation which involved in carbohydrate metabolism and increases the uptake of nutrients that have a potential to increasing the yield (Jamal Nasar *et al.*, 2018) [11]. The result of the study clearly brought out the beneficial effect of Boro-Humate application to groundnut. These results are in conformity with Mehmet Rustu Karaman *et al.* (2013) [14], Geethanjali *et al.* (2015) [17], Jamal Nasar *et al.* (2018) [11], Prashantha *et al.* (2019) [17], Sathiyamurthi *et al.* (2021) [22]

Table 2: Effect of different levels and sources of boron fertilizers on the yield characters of groundnut

L S	Number of pods plant^{-1}						100 Pod Weight(g)					
	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean
S_1	24.22	25.61	26.46	27.32	27.49	26.22	80.11	81.62	83.58	84.93	85.69	83.18
S_2	24.82	26.44	27.33	28.18	28.34	27.02	80.27	83.49	85.35	87.09	87.64	84.76
S_3	24.85	26.55	27.52	28.49	28.53	27.18	80.51	84.16	85.92	88.29	88.53	85.48
Mean	24.63	26.20	27.10	27.99	28.12		80.29	83.09	84.95	86.77	87.28	
	SE_D			CD (p=0.05)			SE_D			CD (p=0.05)		
L	0.10			0.21			0.46			0.95		
S	0.25			0.52			0.52			1.07		
L × S	0.35			0.73			0.66			1.37		

Table 3: Effect of different levels and sources of boron fertilizers on the yield characters of groundnut

L S	100 kernel weight (g)						Shelling %					
	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean
S_1	40.05	42.14	43.73	45.93	46.18	43.60	61.02	64.88	67.72	70.56	70.97	67.03
S_2	40.95	43.89	45.54	47.61	47.96	45.19	61.56	67.53	70.27	73.35	73.59	69.26
S_3	40.92	44.12	45.96	48.04	48.23	45.45	61.22	68.27	70.81	73.69	74.13	69.62
Mean	40.64	43.38	45.07	47.19	47.45		61.26	66.89	69.60	72.53	72.89	
	SE_D			CD (p=0.05)			SE_D			CD (p=0.05)		
L	0.28			0.58			0.44			0.91		
S	0.58			1.19			0.83			1.72		
L × S	0.73			1.51			1.06			2.18		

Yield of Groundnut (Table 4)

The crop responded well for the different levels and sources of B fertilizer application. The effect was very clearly reflected in pod, kernel and haulm yield of groundnut. The effect of different levels of boron fertilizers increasing the groundnut yield was well evidenced in the present study. Increased level of B from 0 to 2.0 kg B ha^{-1} in increased the pod, kernel and haulm yield from 1317 to 1845 kg ha^{-1}, 961 to 1365 kg ha^{-1} and 2001 to 2501 kg ha^{-1}, respectively. Among the various levels of boron, application of B @ 2.0 kg ha^{-1} was excelled the other four levels. Application of B @ 2.0 kg ha^{-1} (L_4) registered the highest pod, kernel and haulm yield of 1808, 1317 and 2452 kg ha^{-1}, respectively. This was on par with application of B @ 1.5 kg ha^{-1} (L_3) by registering 1794, 1302 and 2432 kg ha^{-1} of pod, kernel and haulm yield of groundnut, respectively. Among the different sources of boron fertilizers, the application of boron through Boro-Humate (S_3) recorded the highest mean pod (1693 kg ha^{-1}), kernel (1210 kg ha^{-1}) and haulm yield (2334 kg ha^{-1}) of groundnut. This was equally efficient with the treatment S_2 (application of B-Solubor) and followed by treatment S_1 (application of B-Borax).

The interaction effect due to levels and sources of boron significantly increased the pod, kernel and haulm yield of groundnut. Application of Boro-Humate @ 2.0 kg B ha^{-1} (L_4S_3) recorded the highest pod, kernel and haulm yield of 1845 kg ha^{-1}, 1365 kg ha^{-1} and 2501kg ha^{-1} of groundnut which was 28.61, 29.59 and 19.99 per cent increase over control (without boron). This treatment was closely on par with the treatment which received Boro-Humate @1.5 kg B ha^{-1} (L_3S_3), Application of Boro-Humate @ 1.5 kg B ha^{-1} registered a kernel, pod and haulm yield of 1351,1833 and 2479 kg ha^{-1} which was 28.86, 28.15 and 19.28 per cent increase over control (without boron application).

The yield improvement in pod, kernel and haulm yield of groundnut due to application of Boro-Humate @ 1.5 kg B ha^{-1} was positive. This could be attributed to the fact that the nutrients in the B-humate are released gradually through the process of mineralization, maintaining optimal soil B levels over prolonged periods of crop growth. Some of the humic substances are released during mineralization and may act as a chelating agent, which helps in increasing the absorption of boron and other essential plant nutrients. The earlier report of Elayaraja and Singaravel (2012) [5], Swetha Reddy *et al.* (2020) [25] supports the present findings. Further, the Boro-Humate derived from humic acids is known form chelates with B and other micronutrients such as Zn, Fe etc. Further, it improves translocation of the nutrient cations within the plant system and may improve the nutrient use efficiency by providing more balanced supply of nutrients to groundnut. The increased groundnut yield due to the application of different forms of humic substance and NPK fertilizer have already been well documented by Vetriselvan (2011) [27], Mehmet Rustu Karaman *et al.* (2013) [14], Fakeerappa Arabhanvi *et al.* (2015) [6] and Rajitha *et al.* (2018) [18], Ramamoorthy *et al.* (2021) [20].

Further, improvement of groundnut yield with combined application of recommended dose of NPK along with Boro-Humate could be due to boron acts as basic role in enhancement of cell division, tissue differentiation and metabolism of nucleic acid, carbohydrate, protein, auxin and phenols (Venkatakrishnan *et al*., 2019) [26]. Efficient metabolism and translocation of carbohydrates from source of sink might have increased the yield of groundnut. These results are in accordance with Dhanasekaran and Priyarani (2013) [3]; Elayaraja and Jawahar (2020) [4]

Table 4: Effect of different levels and sources of boron fertilizers on the yields (kg ha^{-1}) of groundnut

L	Pod yield						Kernel yield						Haulm yield					
S	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean	L_0	L_1	L_2	L_3	L_4	Mean
S_1	1317	1571	1641	1740	1752	1604	961	1002	1117	1225	1244	1109	2001	2145	2243	2362	2378	2225
S_2	1382	1649	1716	1811	1827	1677	973	1120	1202	1330	1343	1193	2051	2242	2337	2456	2477	2312
S_3	1389	1666	1735	1833	1845	1693	975	1136	1226	1351	1365	1210	2069	2260	2364	2479	2501	2334
Mean	1362	1628	1697	1794	1808		969	1086	1181	1302	1317		2040	2215	2314	2432	2452	
	SE_D				CD (p=0.05)		SE_D				CD (p=0.05)		SE_D				CD (p=0.05)	
L	10				22		9				20		14				30	
S	22				46		20				43		30				62	
L × S	29				61		37				77		40				83	

L- Levels; L_0– control; L_1 – 0.5 kg ha^{-1}; L_2 –1.0 kg ha^{-1}; L_3 –1.5 kg ha^{-1}and L_4 – 2.0 kg ha^{-1}

S- Sources; S_1– Borax; S_2 – Solubor and S_3 – Boro humate.

Conclusion

The results of the present investigation was clearly indicated that application of Boro-Humate @ 1.5 kg B ha^{-1} would be beneficial for increasing the growth, yield characters and yield of groundnut in coastal saline soil.

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