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Effect of boron on nutrient availability of soil under groundnut crop grown in coastal sandy soils

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Abstract
A field experiment was conducted at Agricultural College Farm, Bapatla during *rabi,* 2020 to study the effect of boron on growth and productivity of groundnut in coastal sandy soils. The treatments comprised of The treatments comprised of T_1 - RDF, T_2 - RDF + soil application of Borax @ 7.5 kg ha^{-1}, T_3 - RDF + soil application of Borax @ 10 kg ha^{-1}, T_4 - RDF + soil application of Borax @ 12.5 kg ha^{-1}, T_5 - RDF + foliar spray of Borax @ 0.1% at 45 DAS, T_6 - RDF + foliar spray of Borax @ 0.1% at 65 DAS, T_7 - RDF + foliar spray of Borax @ 0.1% @ 45 & 65 DAS, T_8 - T_2 + foliar spray of Borax @ 0.1% at 65 DAS and T_9 - T_3 + foliar spray of Borax @ 0.1% at 65 DAS. The results of the experiment revealed that available boron status of the soil was significantly improved by the application of boron. Whereas physico-chemical properties such as pH, EC, OC and CEC, and available nutrient status of N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu were not affected by the application of boron.

Keywords: Groundnut, boron, micronutrient, soil

Introduction
Groundnut (*Arachis hypogaea* L.) is an important leguminous oilseed crop grown in tropics and subtropics. It is used as oil seed as well as food crop. It is known as "king of oilseeds" owing to its high oil content. It contains about 50% oil, 25-30% protein, 20% carbohydrate and 5% fiber and ash which make a substantial contribution to human. The high-energy value protein content and minerals make groundnut a rich source of nutrition at a comparatively low price. It has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixing bacteria in root nodules thus it requires less N containing fertilizers, it also improve N content in soil which make this plant valuable in crop rotation (Sakarvadia *et al.*, 2019) [8].
India is having the largest area of cultivation in the world, grown throughout on all soil types mainly as a rainfed crop. But the average productivity is low as compared to United States and China mainly due to unreliable weather conditions and mineral deficiencies.
Due to its underground pod bearing habit, the groundnut, is mainly grown in light-textured soils which are generally deficient in macro- and micro-nutrients. Among the micronutrients, the deficiency of boron is a common feature of coastal sandy soils (Elayaraja and Singaravel, 2016) [2]. Boron is an essential micronutrient in vegetative and reproductive stages as well as for improving quality of crops. Most of the light textured soils of India where, groundnut is grown are deficient in boron and there is a good response for boron application in these soils (Ansari *et al.*, 2013; Viswakarma *et al.*, 2008) [1, 12]. Keeping all these points in view an experiment was conducted to evaluate the effect of boron on physico-chemical properties and nutrient availability of soil under groundnut crop grown in coastal sandy soils.

Material and Methods
The experiment was conducted during *rabi*, 2020 at Agricultural College Farm, Bapatla, situated in Krishna Zone of Andhra Pradesh (15^0 55' N latitude and 80^0 30' E longitude) at an altitude of 5 m above mean sea level and about 8 km away from Bay of Bengal. The experimental soil was sandy in texture, neutral (pH 6.77) in reaction and non-saline (EC 0.28 dS m^{-1}). The soil was low in organic carbon (0.13%), available nitrogen (113 kg ha^{-1}), phosphorus (21.79 kg P_2O_5 ha^{-1}) and potassium (112 kg K_2O ha^{-1}), sufficient in sulphur (20 ppm), iron (6.01 mg kg^{-1}), manganese (4.63 mg kg $^{-1}$) and copper (1.85 mg kg^{-1}) and deficient in boron (0.30 mg kg^{-1}) and zinc (0.48 mg kg^{-1}). The experiment was laid out in RBD with nine treatments replicated thrice. The treatments comprised of T_1 - RDF, T_2 - RDF + soil application of Borax @ 7.5 kg ha^{-1}, T_3 - RDF + soil application of Borax @ 10 kg ha^{-1}, T_4 - RDF + soil application of Borax @ 12.5 kg ha^{-1}, T_5 - RDF + foliar spray of Borax @ 0.1% at

45 DAS, T_6 - RDF + foliar spray of Borax @ 0.1% at 65 DAS, T_7 - RDF + foliar spray of Borax @ 0.1% @ 45 & 65 DAS, T_8 - T_2 + foliar spray of Borax @ 0.1% at 65 DAS and T_9 - T_3 + foliar spray of Borax @ 0.1% at 65 DAS.

A common dose of 35 kg nitrogen ha^{-1} was applied as urea, in two equal splits as half at basal and half at 30 DAS by taking the plot size into consideration. A common dose of phosphorus @ 40 kg ha^{-1} in the form of single super phosphate and potassium @ 50 kg ha^{-1} in the form of muriate of potash was applied as basal just before sowing. Boron is applied as soil application of borax @ 7.5 kg ha $^{-1}$, 10 kg ha^{-1} and 12.5 kg ha^{-1} as basal just before sowing and foliar application of borax @ 0.1% at 45 DAS and 65 DAS as per the treatments.

The groundnut variety TAG-24 was planted in the third week of October. The crop was raised with all the standard package of practices and protection measures also timely carried out as they required. Soil samples from 0 to 15 cm depth were collected at peg penetration, pod development and harvest stages of groundnut. These samples were analyzed using standard procedures in the laboratory. Available soil boron was extracted with hot water and estimated by Azomethine-H using spectrophotometer at 430nm (Tandon, 2009) [11]. The data were analyzed statistically following the analysis of variance (ANOVA) technique as suggested by Panse and Sukhathme (1978) [6] for Randomized block design.

Results and Discussion

Effect of Boron on Physico-Chemical Properties of Soil after Harvest

Soil Reaction (pH)

From the results of the experiment it was observed that soil reaction did not differ significantly among the treatments after harvest of groundnut (Table-1). The soil reaction ranged from 6.57 to 6.74 at harvest stage.

Electrical conductivity

The results revealed that electrical conductivity of the soil did not differ significantly among the treatments after harvest of groundnut (Table-1). The electrical conductivity of the soil ranged from 0.16 to 0.20 dSm^{-1} in post harvest soil.

Organic carbon

The application of boron showed a non-significant influence on organic carbon content of soil after harvest of the crop (Table-1). The organic carbon values ranged from 0.15 to 0.19 per cent in post harvest soil.

Cation exchange capacity

The application of boron showed a non-significant influence on cation exchange capacity of soil after harvest of the crop (Table-1). The cation exchange capacity values ranged from 3.11 to 4.01 cmol (p)$^+$ kg^{-1} in post harvest soil.

Effect of boron on available nutrient status of soil at different growth stages of groundnut

Nitrogen

The results of the investigation showed that the application of boron at different rates and methods did not influence the available nitrogen status of soil significantly at different growth stages of groundnut (Table-1). The available nitrogen content in soil ranged from 140.22 to 146.78, 120.42 to 128.49 and 114.15 to 123.49 kg ha^{-1} at peg penetration, pod development and harvest stages of the crop respectively. Hirapara *et al*. (2019) [3] also reported similar results.

Phosphorus

Application of boron had no significant influence on available phosphorus status of soil at any stage of the crop (Table-2). The available phosphorus content in soil ranged from 34.05 to 39.01, 29.36 to 32.81 and 25.39 to 29.37 kg ha^{-1} at peg penetration, pod development and harvest stages of the crop respectively. Kader and Mona (2013) [4] also observed similar results.

Potassium

There was no significant difference in available potassium status of soil among the treatments at all the stages of growth due to the application of boron (Table-2). The available potassium content in soil ranged from 137.85 to 149.78, 127.91 to 138.42 and 115.80 to 125.93 kg ha^{-1} at peg penetration, pod development and harvest stages of the crop respectively. These results were in agreement with Hirapara *et al.* (2019) [3].

Calcium

The exchangeable calcium of soil at peg penetration, pod development and harvest stage of the crop growth was not significantly influenced by with the treatments imposed (Table-3). The exchangeable calcium content in soil ranged from 1.15 to 1.26, 0.93 to 1.08 and 0.71 to 0.86 cmol (p+) kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively.

Magnesium

The application of boron had no significant influence on exchangeable magnesium status of soil at any growth stage of the crop (Table-3). The exchangeable magnesium content in soil ranged from 0.65 to 0.67, 0.63 to 0.66 and 0.60 to 0.65 cmol (p+) kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively.

Sulphur

The application of boron did not influence the available sulphur status of soil significantly at different growth stages of groundnut (Table-4). The available sulphur content in soil ranged from 22.02 to 23.60, 17.51 to 21.97 and 15.93 to 18.01 mg kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively. Similar observations were demonstrated by Kader and Mona (2013) and Hirapara *et al.* (2019) [4, 3].

Iron

The application of boron had no significant influence on available iron status of soil at any growth stage of the crop (Table-4). The available iron content in soil ranged from 5.68 to5.72, 5.10 to 5.16 and 5.03 to 5.13 mg kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively. Hirapara *et al.* (2019) [3] also reported similar results.

Zinc

The available zinc content of soil at peg penetration, pod development and harvest stages of the crop was not significantly influenced with the treatments imposed (Table 5). The available zinc content in soil ranged from 0.34 to 0.37, 0.27 to 0.30 and 0.25 to 0.29 mg kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively.

Similar results were reported by Kamalakannan and Elayaraja (2020) [5].

Manganese

The data revealed that application of boron had no significant influence on available manganese status of soil at any growth stage of the crop (Table-5). The available manganese content in soil ranged from 3.58 to 3.61, 3.04 to 3.08 and 3.02 to 3.07 mg kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively. The results were in agreement with Hirapara *et al.* (2019) [3] and Kamalakannan and Elayaraja (2020) [5].

Copper

The results of the investigation showed that the application of boron did not influence the available copper status of soil significantly at different growth stages of groundnut (Table-6). The available copper content in soil ranged from 1.82 to 1.84, 1.80 to 1.83 and 1.77 to 1.80 mg kg^{-1} at peg penetration, pod development and harvest stages of the crop respectively. Similar observations were demonstrated by Hirapara *et al.* (2019) [3].

Boron

The data revealed that the application of boron significantly influenced the hot water extractable boron content of soil at different growth stages of groundnut (Table-6). The boron concentration of soil increased from the initial levels due to the application of borax, in all the soil applied treatments and then decreased over the crop period. Among the different levels of boron application treatments significant improvement in boron content was recorded as the boron levels increased from 7.5 kg borax ha^{-1} to 12.5 kg borax ha^{-1} at all the stages of the crop growth.

The maximum available boron content (0.73, 0.65 and 0.59 mg kg-1 at peg penetration, pod development and harvest stages respectively) was recorded in soil application of Borax @ 12.5 kg ha^{-1} along with RDF (T4) and this was superior over all other treatments. The lowest available boron content (0.28, 0.27 and 0.26 mg kg^{-1} at peg penetration, pod development and harvest stages respectively) was recorded with T_1 (RDF).

The significant build up of available B status under this boron level might be due to their direct adequate application to soil. Therefore, after meeting the requirement of the crop, the added boron might help to increase the boron status of the soil (Sathya *et al.*, 2009) [9]. The available boron content in the soil was sufficient even after the harvest of the crop which was applied as soil application of borax. Shankhe (2004) and Poonguzhali (2019) [10, 7] supported the significant increase in available boron status of soil by the addition of boron sources.

Table 1: Effect of boron on physico-chemical properties and available nitrogen in soil under groundnut

Treatment	pH	EC (dS m^{-1})	Organic carbon (%)	Cation exchange capacity (cmol $(p)^+$ kg^{-1})	Available nitrogen (kg ha^{-1})		
					Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	6.74	0.20	0.15	4.01	140.22	120.42	114.15
T_2: RDF + soil application of Borax @ 7.5 kg ha^{-1}	6.68	0.18	0.16	3.44	143.18	124.48	120.18
T_3: RDF + soil application of Borax @ 10 kg ha^{-1}	6.62	0.17	0.18	3.30	145.56	126.76	121.47
T_4: RDF + soil application of Borax @ 12.5 kg ha^{-1}	6.57	0.16	0.19	3.11	146.78	128.49	123.49
T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	6.70	0.19	0.16	3.62	140.48	122.18	115.40
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	6.69	0.19	0.16	3.51	139.70	120.46	116.65
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	6.68	0.18	0.17	3.48	139.85	122.69	117.91
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	6.61	0.18	0.18	3.26	143.51	124.22	121.95
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	6.59	0.17	0.19	3.18	145.81	126.51	123.20
S.Em (±)	0.21	0.01	0.01	0.18	6.49	5.63	5.30
CD (P=0.05%)	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.25	9.27	8.44	8.83	7.88	7.86	7.69
Initial	6.77	0.28	0.13	4.62	113		

Table 2: Effect of boron on available phosphorus and available potassium in soil at different growth stages of groundnut

Treatment	Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	Peg penetration stage	Pod development stage	Harvest stage	Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	34.05	30.36	27.82	140.22	132.42	122.53
T_2: RDF + soil application of Borax @ 7.5 kg ha^{-1}	36.59	31.61	27.57	145.18	134.35	120.86
T_3: RDF + soil application of Borax @ 10 kg ha^{-1}	38.79	31.98	27.88	147.56	136.94	125.93
T_4: RDF + soil application of Borax @ 12.5 kg ha^{-1}	39.01	32.81	29.37	149.78	138.42	125.06
T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	35.21	29.36	25.39	138.48	128.59	117.09
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	35.59	31.99	26.05	138.70	131.94	116.09
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	35.81	29.89	25.43	137.85	127.91	115.80
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	36.56	31.57	27.08	145.51	132.56	120.24
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	38.71	31.88	27.67	147.81	136.07	124.18
S.Em (±)	1.94	1.48	1.50	6.06	6.02	5.31
CD (P=0.05%)	NS	NS	NS	NS	NS	NS
CV (%)	9.14	8.16	9.54	7.32	7.82	7.61
Initial	21.79			112		

Table 3: Effect of boron on and exchangeable calcium and magnesium in soil at different growth stages of groundnut

Treatment	Exchangeable calcium (cmol (p+) kg-1)			Exchangeable magnesium (cmol (p+) kg-1)		
	Peg penetration stage	Pod development stage	Harvest stage	Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	1.21	1.08	0.86	0.67	0.66	0.65
T_2: RDF + soil application of Borax @ 7.5 kg ha-1	1.19	0.96	0.77	0.66	0.64	0.62
T_3: RDF + soil application of Borax @ 10 kg ha-1	1.18	0.94	0.76	0.65	0.63	0.61
T_4: RDF + soil application of Borax @ 12.5 kg ha-1	1.15	0.93	0.71	0.65	0.63	0.61
T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	1.26	1.05	0.84	0.66	0.64	0.62
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	1.21	1.06	0.85	0.67	0.65	0.63
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	1.25	1.03	0.83	0.67	0.65	0.62
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	1.18	0.94	0.72	0.66	0.64	0.61
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	1.16	0.94	0.71	0.65	0.63	0.60
S.Em (±)	0.06	0.05	0.04	0.03	0.03	0.03
CD (P=0.05%)	NS	NS	NS	NS	NS	NS
CV (%)	8.39	8.62	8.57	8.58	8.80	9.43
Initial	0.89			0.67		

Table 4: Effect of boron on available sulphur and iron in soil at different growth stages of groundnut

Treatment	Available sulphur (mg kg-1)			Available iron (mg kg-1)		
	Peg penetration stage	Pod development stage	Harvest stage	Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	22.02	18.36	16.54	5.72	5.16	5.13
T_2: RDF + soil application of Borax @ 7.5 kg ha-1	22.32	17.51	15.93	5.70	5.13	5.08
T_3: RDF + soil application of Borax @ 10 kg ha-1	22.92	20.88	17.51	5.69	5.12	5.06
T_4: RDF + soil application of Borax @ 12.5 kg ha-1	23.60	20.89	18.01	5.68	5.10	5.03
T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	22.15	21.55	17.85	5.72	5.13	5.09
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	22.50	20.17	17.71	5.72	5.16	5.10
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	22.22	20.54	17.99	5.72	5.13	5.09
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	22.52	21.28	17.44	5.70	5.13	5.07
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	23.15	21.97	17.01	5.69	5.12	5.05
S.Em (±)	1.22	1.08	0.87	0.26	0.24	0.23
CD (P=0.05%)	NS	NS	NS	NS	NS	NS
CV (%)	9.32	9.24	8.68	7.98	8.02	7.81
Initial	20			6.01		

Table 5: Effect of boron on available zinc and manganese in soil at different growth stages of groundnut

Treatment	Available zinc (mg kg-1)			Available manganese (mg kg-1)		
	Peg penetration stage	Pod development stage	Harvest stage	Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	0.37	0.30	0.29	3.61	3.08	3.07
T_2: RDF + soil application of Borax @ 7.5 kg ha-1	0.35	0.28	0.28	3.60	3.07	3.06
T_3: RDF + soil application of Borax @ 10 kg ha-1	0.34	0.27	0.27	3.59	3.06	3.04
T_4: RDF + soil application of Borax @ 12.5 kg ha-1	0.34	0.27	0.27	3.58	3.04	3.02
T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	0.37	0.28	0.26	3.61	3.07	3.06
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	0.37	0.30	0.27	3.61	3.08	3.06
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	0.37	0.28	0.25	3.61	3.07	3.06
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	0.35	0.28	0.27	3.60	3.07	3.05
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	0.34	0.27	0.27	3.59	3.07	3.04
S.Em (±)	0.02	0.02	0.02	0.18	0.16	0.16
CD (P=0.05%)	NS	NS	NS	NS	NS	NS
CV (%)	9.52	9.41	9.32	8.77	9.33	9.36
Initial	0.48			4.63		

Table 6: Effect of boron on available copper and boron (mg kg-1) in soil at different growth stages of groundnut

Treatment	Available copper (mg kg-1)			Available boron (mg kg-1)		
	Peg penetration stage	Pod development stage	Harvest stage	Peg penetration stage	Pod development stage	Harvest stage
T_1: RDF	1.84	1.83	1.80	0.28	0.27	0.26
T_2: RDF + soil application of Borax @ 7.5 kg ha-1	1.83	1.82	1.79	0.56	0.50	0.48
T_3: RDF + soil application of Borax @ 10 kg ha-1	1.83	1.82	1.79	0.61	0.55	0.52
T_4: RDF + soil application of Borax @ 12.5 kg ha-1	1.82	1.81	1.80	0.73	0.65	0.59

T_5: RDF + foliar spray of Borax @ 0.1% at 45 DAS	1.84	1.80	1.78	0.29	0.28	0.27
T_6: RDF + foliar spray of Borax @ 0.1% at 65 DAS	1.84	1.83	1.79	0.30	0.29	0.27
T_7: RDF + foliar spray of Borax @ 0.1% at 45 & 65 DAS	1.84	1.80	1.77	0.31	0.30	0.26
T_8: T_2+ foliar spray of Borax @ 0.1% at 65 DAS	1.83	1.82	1.78	0.56	0.52	0.50
T_9: T_3+ foliar spray of Borax @ 0.1% at 65 DAS	1.82	1.81	1.77	0.62	0.56	0.53
S.Em (±)	0.10	0.10	0.10	0.02	0.02	0.02
CD (P=0.05%)	NS	NS	NS	0.06	0.06	0.04
CV (%)	9.19	9.30	9.40	7.55	7.80	7.93
Initial	1.85			0.30		

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