Growth of Groundnut (*Arachis hypogaea* L.) and its Yield as Influenced by Foliar Spray of Boron along with Rhizobium Inoculation

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ABSTRACT: A field experiment was conducted on groundnut for two kharif seasons during 2009 and 2010 at crop research farm of SHIATS, Allahabad to find out the effect of foliar spray of boron in combination of rhizobium inoculation on growth and yield of groundnut. Inoculation with rhizobium along with application of boron as foliar spray at flowering and pod formation stage had significant and positive effect on growth and yield of groundnut with increased plant height, number of branches, plant dry weight, number of pods/plant, 100 pod weight, seed index and pod yield. Excess spray of boron foliar nutrition led to decrease in the above mentioned parameters.

Key words: Groundnut, boron, foliar, yield, rhizobium, flowering stage

Groundnut is an important oilseed crop of India. In 2011-12, it was cultivated in an area of 5.26 mha with production of 6.96 mt (DAC, 2013). The crop is predominantly rainfed, with less than one fourth of the area under irrigation. At 1.32 t/ha, the average yield/hectare of groundnut in India is low. One of the reasons for low yield is nutrient deficiencies. Availability of nutrients in optimum amount is an important factor which influences crop growth and yield. Rising crop requirements due to increasing productivity levels and use of straight fertilizers have increased the demand for secondary and micronutrients and deficiencies of these micronutrients are increasingly becoming major constraints in groundnut production. Introduction of high yielding varieties and adoption of agricultural technology for exploiting their potential have led to wide spread deficiencies of micronutrients, especially boron (B). Boron helps in root and nodule development which directly helps in nitrogen fixation in plant tissues acting as regulator for other substances (Agrawal, 1965). The deficiency of B in soils and in groundnut plants leads to the formation of hollow heart, which results poor quality and low yield of kernels. Coarse texture sands have lower levels of boron due to less absorption on soil particle and possible leaching losses. Keeping this in view, field experiments were conducted for the present study (i) to find out the optimum dose of boron as foliar spray for improving groundnut productivity, (ii) to study the effect of Rhizobium inoculation on growth and yield of groundnut and, (iii) to evaluate the interaction effect of boron levels as foliar spray with Rhizobium on yield and quality of groundnut.

Materials and Methods

Two field experiments were conducted at Allahabad Agricultural Institute Crop Research Farm, situated at an elevation of 98 m above mean sea level at 25.57^0 North latitude and 81.5^0 East longitude during the *kharif* seasons of 2009 and 2010. The experimental soil (0-30 cm depth) was analyzed using standard methods (Jackson, 1973). The soil is a sandy loam having the following characteristics: pH 7.8, organic carbon 0.70%, available N 200 kg/ha, available P 23 kg/ha, available K 123 kg/ha and B 0.118 ppm which was low in soil.

The experimental plot was laid out in factorial randomized block design, consisting of 10 treatments each replicated thrice. There were two levels of inoculations viz. inoculation with Rhizobium and no inoculation, and five concentrations of foliar spray viz., no boron (B_0), 0.5 ppm (B_1) , 1.0 ppm (B_2), 2.0 ppm (B_3) and 3.0 ppm (B_4) in the form of Folibor (*Di sodium octa borate tetra hydrate -*$Na_2B_8O_{13}4H_2O$).

Urea, single superphosphate and muriate of potash as a source of nitrogen, P_2O_5 and K_2O, respectively were applied at the rate of 20:40:40 kg/ha at the time of sowing as basal application. Gypsum was applied at flowering stage as band row placement at about 5 cm away from the plant. Boron was applied as foliar spray at flowering and pod development stages as per treatments.

Seeds of Kaushal (G-201) variety were treated with fungicide *Thiram* at 2g/kg seed and then the seeds that were to be inoculated were separated and inoculated with *rhizobium* NC- 92 strain. In both the years, sowing was done in third week of July on well prepared bed at a depth of 5 cm and maintaining a spacing of 35 cm x 15 cm. Pre-harvest observations were made at 30, 60, 90 DAS intervals in respect of growth parameters. The crop was harvested when the leaves started turning yellow in color along with leaf shedding in both the years, by digging out the plants with the help of spade. The pulled out plants were stacked in a safe place for a few days to dry and pods were stripped manually and post-harvest observations were recorded. Haulm was sun dried before recording the dry weight.

The experimental data was analyzed using the analysis of variance (ANOVA) technique (Cochran and Cox, 1967). The significance and non-significance of the treatment effect was judged with the help of "F" (variance ratio) table. The significant differences between the means have tested at 5% probability level.

Results and Discussion

Effect of boron as foliar spray

Growth parameters of groundnut were significantly influenced by application of boron as foliar spray at flowering and pod formation stages in both years. Growth parameters, i.e. plant height, number of branches, nodules and dry weight of groundnut plants increased with foliar application of boron up to 2 ppm compared to non application (control). But increasing the concentration to 3 ppm resulted in considerable decrease in growth compared to other B levels and also control. Maximum plant height (33.88 cm, 35.32 cm), no. of branches/plant (15.89, 17.95), plant dry weight (38.05 g, 38.37 g) were recorded from the plants which received 2 ppm B as foliar spray at flowering and pod development stages in 2009 and 2010, respectively (Table 1). The increment in plant height and number of branches might have occurred because of boron's vital role in development and differentiation of tissues particularly growing tips, phloem and xylem. As boron generally influences cell division and nitrogen absorption from the soil might enhanced plant growth which reflects in terms of plant dry weight. These findings are in harmony with those obtained by Kumar *et al.* (1996) and Elayaraja and Singaravel (2010). Decrease in growth with 3 ppm boron spray may be attributed due to boron toxicity.

Table 1 : Effect of boron application as foliar spray at flowering and pod formation stage on growth of groundnut

Boron	Plant height (cm)		Branches/plant (No.)		Plant dry weight (g)	
	2009	2010	2009	2010	2009	2010
0.0 ppm	29.07	31.51	13.05	14.62	31.64	32.28
0.5 ppm	31.06	32.22	14.12	15.45	32.49	32.02
1.0 ppm	32.45	34.05	15.23	16.89	37.40	36.74
2.0 ppm	33.88	35.32	15.89	17.95	38.05	38.37
3.0 ppm	28.93	29.87	13.78	14.23	29.68	29.69
SEm±	0.19	0.18	0.24	0.30	0.19	0.31
CD (P=0.05)	0.43	0.42	0.54	0.68	0.43	0.70

Effect of rhizobium on nodulation

Observations recorded on nodulation indicated that use of rhizobium culture stimulated nodulation significantly during both the years. Higher number of nodules were found with the seed inoculation of *Rhizobium* which is in confirmation with the results reported by Basu *et al.* (2003) and Elkan *et al.* (1980).

Table 2 : Effect of rhizobium inoculation on plant dry weight

Inoculation	Plant dry weight (g)	
	2009	2010
I_0: Un-Inoculation	30.56	30.63
I_1: Rhizobium	37.15	36.99
SEm±	0.07	0.12
CD (P=0.05)	0.17	0.28

Plant dry weight was recorded as 37.15 g and 36.99 g with rhizobium inoculation, and 30.56 g and 30.63 g without inoculation in 2009, 2010, respectively (Table 2). Explicit role of rhizobium in furnishing better rizosphere for plant growth and supply of nitrogen might be the reason for the observed increase in dry-weight of the groundnut plants which were inoculated with rhizobium strain.

Yield parameters

Effect of boron as foliar application

Foliar feeding of boron at two growth stages of groundnut resulted in remarkable difference in yield attributes and yield of groundnut. Yield attributes i.e number of pods/plant, 100 pod weight, seed index and pod yield of groundnut are presented in Table 3. Foliar feeding of groundnut with different levels of boron at flowering and pod formation stages significantly increased all the above mentioned attributes in both the years of experiment compared to control. Affirmative effect of boron foliar feeding on groundnut yield attributes and yield is in agreement with the findings of Noor *et al.* (1997) and Venkatesh *et al.* (2006) who observed increment in pod weight, seed index and pod yield of groundnut with foliar application of Boron. The positive effect of boron may be due to key role in plant metabolism and in the synthesis of nucleic acid (Humdt *et al.*, 1970).

An average increase of 38.14% in pods/plant, 17.77% in 100 pod weight, 16.72% in seed index, finally 20.38% in pod yield were observed from both the years of experiment in 2009 and 2010 with 2 ppm foliar application of Boron at flowering and pod development stages when compared with control which received only basal application of recommended fertilizer (Table 3). However, increasing the boron level from 2 ppm to 3 ppm was toxic and resulted in decrease of above mentioned parameters. Gopal *et al.* (1969) noticed that foliar aplication of boron was inhibited the growth of groundnut plants with increasing amounts of boron in the hypocotyl, leaves (which

Table 3 : Effect of boron application as foliar spray at flowering and pod formation stage on yield and yield attributes of groundnut

Boron	Number of pods/plant		100 pod weight (g)		Seed index (g)		Pod yield (q/ha)	
	2009	2010	2009	2010	2009	2010	2009	2010
0.0 ppm	18.83	15.66	77.73	74.76	34.96	39.55	21.68	23.26
0.5 ppm	21.83	18.50	79.95	78.40	40.08	42.28	22.68	23.00
1.0 ppm	23.16	22.00	89.33	84.88	40.81	41.75	24.90	25.71
2.0 ppm	25.50	22.16	91.63	87.96	43.55	43.41	26.13	27.96
3.0 ppm	18.00	16.00	73.13	73.77	37.88	38.75	19.83	23.83
SEm±	0.44	0.62	0.47	0.69	0.76	0.56	0.34	0.32
CD (P=0.05)	1.013	1.41	1.07	1.57	1.72	1.28	0.78	0.73

were severly chlorotic) which led to deleterious effect on the total growth of grountnut plants. Khalifa (2005) also found that highest level of boron led to non- significant increase in number of pods/plant as compared to control.

Highest pod yield was noticed with treatment which received 2 ppm boron as foliar spray at flowering and pod formation stages and the values were recorded as 26.13 and 27.96 q/ha in 2009 and 2010, respectively whereas control plot only produced 21.68 and 23.26 q/ha in 2009 and 2010, respectively. Increment in pod yield per ha due to boron application might be due to its vital role in promotion of photosynthetates transportation from vegetative organs to reproductive organs, thus resulting in significant improvement in groundnut yield (Du Ying Qiong *et al.,* 2002).

Effect of rhizobium inoculation alone or in combination with boron foliar spray

Bacterial biofertilizer can play an important role in improving soil fertility, plant production and its quality, decrease production costs and environmental pollution. Table 3 indicates that seed inoculation with *rhizobium* strain significantly influenced all the parameters of groundnut as compared to control. Combined effect of foliar application

Table 4 : Effect of foliar spray with different levels of boron sole and/or in combination with rhizobium inoculation on yield and yield attributes of groundnut for 2009 and 2010

Tr. No	Treatments		Yield attributes						Pod yield (q/ha)	
	*In.	Boron (ppm)	Number of pods/ plant		100 pod weight (g)		Seed index (g)		2009	2010
			2009	2010	2009	2010	2009	2010		
1	-	-	15.00	14.00	65.50	66.03	32.93	38.60	17.46	19.63
2	#RI	0	22.66	17.33	89.96	83.50	37.00	40.50	25.90	26.90
3	-	0.5	17.66	14.00	68.86	68.33	34.56	40.16	18.46	20.33
4	RI	0.5	26.00	23.00	91.03	88.48	45.60	44.40	26.90	25.66
5	-	1.0	19.66	18.66	85.36	78.33	35.90	38.33	21.96	23.50
6	RI	1.0	26.66	25.33	93.30	91.43	45.73	45.16	27.83	27.93
7	-	2.0	24.00	16.66	88.83	80.72	39.63	40.13	24.10	25.16
8	RI	2.0	27.00	27.66	94.43	95.21	47.46	46.70	28.26	30.76
9	-	3.0	17.33	15.66	71.90	71.32	38.93	40.00	19.44	25.13
10	RI	3.0	18.66	16.33	74.36	76.22	36.83	37.50	20.23	22.53
		SEm±	0.89	1.25	0.94	1.38	1.52	1.138	0.69	0.64
		CD (P=0.05)	2.02	2.83	2.14	3.14	3.44	2.57	1.57	1.46

*In.- Inoculation #RI- Rhizobium inoculation

of boron and *rhizobium* inoculation had positive effect on number of pods/plant, 100 pod weight, seed index and finally pod yield of groundnut. There was 88.48% increase in mean of (2009 and 2010) number of pods/plant with treatment T8 (Seed inoculation with *rhizobium* strain and 2 ppm foliar spray of boron at flowering and pod formation stages) whereas only *rhizobium* inoculation showed 37.93% increase over control (Table 4). Similar trend was observed in other yield attributes also where, 44.19% in 100 pod weight, 31.65% in seed index, 59.08% in pod yield was noticed. The obtained results were in line the findings of Shukla and Dixit (1996).

The increase in number of pods/plant with inoculation of *rhizobium* strain might be due to favorable effect of rhizobium on improvement of nodulation which increased the supply of nitrogen and proper vegetative growth which later converted to reproductive phase resulting to more number of pods/ plant and viable seed. The findings obtained with inoculation along with boron application in terms of seed index and pod yield can possibly be explained in terms of better growth and better mobilization of reserve food materials to developing seeds which act as sink for carbohydrates and nitrogenous compounds (Bhat *et al.,* 2010).

Conclusions

Application of boron in foliar form at flowering and pod formation stage can have a positive effect on groundnut crop yields under sub-tropical and semi-arid climatic conditions of Northeastern parts of Uttar Pradesh.

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