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Effect of Cobalt, *Rhizobium* and Phosphobacterium Inoculations on Growth, Yield, Quality and Nutrient Uptake of Summer Groundnut (*Arachis hypogaea*)

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ABSTRACT

A field experiment was carried out on the neutral soil of Student's Instructional Farm, Barajaguli, B. C. K. V., Nadia, West Bengal with groundnut during pre-kharif season (Feb-June) of 2001, 2002 and 2003. It revealed that in increasing plant height (cm), no. of branches per plant, leaf area index (LAI), dry matter accumulation (gm per m^2) and no. and dry weight (gm) of nodules per plant at different dates of observation, *Rhizobium* was more effective than phosphobacterium. Again it was found that *Rhizobium* was more effective than phosphobacterium for higher pod yield, shelling percent, oil and protein content. Regarding nutrient concentration *Rhizobium* had better performance in N and K concentration but phosphobacterium gave better result in P concentration though the uptake of all the three nutrients was higher in *Rhizobium* inoculation. Cobalt @ 0.21 kg per ha gave best result in all the above-mentioned parameters.

Keywords: Arachis hypogaea, Rhizobium, Phosphobacterium, Cobalt.

1. INTRODUCTION

Among all oilseed crops groundnut (*Arachis hypogaea* L.) has first place in India. Groundnut is also known as peanut, earthnut, monkeynut, goober, pinda and Manillanut. Groundnut produced in India is used for seed, for edible purpose and for oil extraction. The kernel contains 47-53% oil. Being a leguminous plant, groundnut enriches the soil with nitrogen and is, therefore, valuable in crop rotation and soil management. Nodules formed by the native strains may not fix nitrogen or their fixation rate may often be inadequate. It has been suggested that the lack of response to nodulation and low yield in groundnut are probably due to competition from strains in the soil which are ineffective with this host. But recent studies showed that inoculation with an effective *Rhizobium* strain increased the yield as well as oil content of groundnut cultivar. Thus inoculation helps to meet the additional nitrogen demand of plant, by increasing nodulation, so enable to realize the yield potential of the plant. Phosphorus has a role in nodulation of legume crops. Considerable amount of phosphorus which is present in the soil or applied to the soil become easily unavailable, phosphobacterium can make this unavailable phosphorus available-to-plant and thus indirectly influences nodulation, growth and yield of groundnut. It has now been established that *Rhizobium* and other nitrogen-fixing microorganisms have an absolute cobalt requirement. Three specific cobalamine dependent enzyme systems in *Rhizobium* which may account for

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the influence of cobalt on nodulation and nitrogen fixation are: Methionine synthase**,** Ribonucleotide reductase and Methylmalonyl co-enzyme A mutase. Many workers have obtained higher yield of groundnut by applying cobalt to soil (Jana *et al*, 1994 and Raj, 1997, Basu et al., 2003, 2006a, b, Basu and Bhadoria, 2008). Keeping these in view the present experiment has been carried out.

2. MATERIALS AND METHODS

The present experiment was carried out at Student's Instructional Farm, Barajaguli, B.C.K.V., Nadia, West Bengal, India in Gangetic alluvium soil (Entisol) of Bidhan Chandra Krishi Viswavidyalaya during pre-kharif season (Feb-June) for consecutive three years (2001-2003). The sandy clay loam soil of the experimental plot had well drainage facility with medium fertility (organic carbon 0.66%, total nitrogen 0.05%, available phosphorus 25.01 kg per ha, available potassium 184.67 kg per ha) and neutral pH (7.2). The cobalt status was low with 0.03 ppm available cobalt. The design of the experiment was split plot having two factors, i. e., levels inoculations and doses of cobalt. There were three levels of inoculations viz. inoculation with either *Rhizobium* (I_1) and phosphobacterium (I_2) or uninoculation (I_0) and three levels of cobalt viz., no cobalt (C_0), 0.21 kg ($C_{.21}$) and 0.42 kg cobalt per ha ($C_{.42}$) in the form of cobalt sulphate ($CoSO_4$, $7H_2O$). Inoculations were allotted to main plots and levels of cobalt to the sub plots under each main plot. There were 9 treatment combinations with three replications. 20 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} through urea, single super phosphate and muriate of potash respectively as basal were applied to each plot. During the last week of February groundnut (cv. JL-24) was sown with row spacing of 30 cm-15 cm. The crop was harvested at 120 days after sowing (DAS). After harvesting of the crop data on yield components, yield, oil and protein content and N, P & K uptake by the kernel was recorded.

3. RESULTS AND DISCUSSION

The shoot length (cm), number of branches per plant, leaf area index (LAI), dry matter accumulation (gm^{-2}), number and dry weight of nodules per plant of groundnut was significantly influenced by levels of inoculation at different days of sampling (Table 1).

Table 1: Effect of inoculations growth attributes of groundnut at different dates of observation (Pooled mean of three years)

Levels of Inoculation	Shoot Length (cm)	No. of branches plant^{-1}	Leaf Area Index (LAI)	Dry matter accumulation (gm^{-2})	No. of nodules plant^{-1}	Dry weight of nodules plant^{-1} (gm)
			25 DAS			
I_0	12.3	-	0.17	32.2	84.0	0.092
I_1	16.1	-	0.21	39.6	101.3	0.121
I_2	14.3	-	0.18	36.6	90.4	0.105
CD at 5% level	1.51	-	0.007	2.02	4.97	0.0071
			50 DAS			
I_0	40.3	6.2	1.90	188.8	139.6	0.221
I_1	46.8	9.4	3.04	211.2	178.5	0.264
I_2	43.1	6.7	2.55	201.9	153.3	0.239
CD at 5% level	2.44	0.18	0.035	7.66	11.69	0.0081
			75 DAS			
I_0	62.9	9.6	3.04	368.5	152.8	0.821
I_1	69.5	14.4	3.98	396.2	192.0	0.990
I_2	65.7	11.6	3.35	380.1	167.1	0.849
CD at 5% level	1.63	1.12	0.039	8.49	12.60	0.0091
			100 DAS			
I_0	90.0	10.4	-	564.6	-	-
I_1	97.4	15.7	-	596.2	-	-
I_2	93.7	12.7	-	575.6	-	-
CD at 5% level	2.44	1.48	-	8.80	-	-

Note: I_0 = No inoculation, I_1 = Inoculation with *Rhizobium*, I_2 = Inoculation with phosphobacterium.

The highest values were obtained from I_1 (inoculation with *Rhizobium* culture) followed by I_2 (phosphobacterium inoculation). The lowest values were received at I_0 (control treatment). All the above-mentioned parameters of the crop were gradually increased from lowest to highest sampling dates. Shaheen and Rahmatullah (1994) and Basu et al. (2003, 2006b) also observed the positive effect of *Rhizobium* inoculation on the shoot length, no of branches per plant, LAI and DM accumulation of groundnut plant. Different levels of cobalt also significantly influenced these parameters at all dates of observation (Table 2). The highest values were found at $C_{0.21}$ followed by $C_{0.42}$ at all dates of observation .C_0 produced the lowest values. There was significant difference among them. Beneficial effect of cobalt on growth attributes of groundnut was also found by Naidu (2000) and Basu et al. (2006a, b).

Table 2: Effect of cobalt on growth attributes of groundnut at different dates of observation (Pooled mean of three years)

Levels of Cobalt	Shoot Length (cm)	No. of branches plant^{-1}	Leaf Area Index (LAI)	Dry matter accumulation (gm^{-2})	No. of nodules plant^{-1}	Dry weight of nodules plant^{-1} (gm)
			25 DAS			
C_0	12.6	-	0.14	33.9	88.2	0.099
$C_{0.21}$	15.7	-	0.19	37.8	96.8	0.113
$C_{0.42}$	14.5	-	0.15	35.9	90.8	0.106
CD at 5% level	0.31	-	0.007	0.81	1.82	0.0021
			50 DAS			
C_0	40.6	6.4	2.06	195.8	151.2	0.229
$C_{0.21}$	45.2	8.6	2.70	205.8	162.3	0.240
$C_{0.42}$	43.3	7.3	2.32	200.0	157.9	0.235
CD at 5% level	0.49	0.46	0.034	3.13	2.90	0.0033
			75 DAS			
C_0	64.2	10.8	3.28	378.3	164.7	0.861
$C_{0.21}$	68.2	13.2	3.62	393.2	175.9	0.921
$C_{0.42}$	65.7	11.6	3.45	385.2	171.2	0.868
CD at 5% level	0.39	0.21	0.065		2.37	0.0021
			100 DAS			
C_0	92.0	11.9	-	561.3	-	-
$C_{0.21}$	96.4	14.2	-	583.1	-	-
$C_{0.42}$	93.7	12.6	-	569.0	-	-
CD at 5% level	0.43	0.39	-	5.73	-	-

Note: $C_{0,}$ $C_{\cdot 21,}$ C_{042} = zero dose, 0.21 kg cobalt ha^{-1} and 0.42 kg cobalt ha^{-1}respectively.

Levels of inoculation and levels of cobalt significantly influenced the percent nitrogen, phosphorus and potassium content of groundnut seed and also their uptake (kg/ha) at harvest (Table 3). Regarding percent nitrogen and potassium content of seed and their uptake, highest value was obtained at *Rhizobium* inoculation, which was followed by phosphobacterium inoculation. Uninoculation gave the lowest value. Percent phosphorus content (Fig. 1) was the highest at phosphobacterium inoculation followed by *Rhizobium* inoculation, but the highest uptake value was recorded at *Rhizobium* inoculation followed by phosphobacterium inoculation. Higher uptake of P was mainly due to higher yield obtained in *Rhizobium* inoculation than phosphobacterium inoculation. Shasidhara and Sreenivasa (1994) obtained higher N, P and K content in groundnut plant by using *Rhizobium* + VAM fungi along with 100% recommended dose of N, P and K. Mane and Rout (1993) reported higher P uptake in groundnut plant in *Rhizobium* inoculation. Different levels of cobalt significantly influenced the percent N, P and K content of groundnut seed as well as their uptake. Highest values were obtained at $C_{.21}$ dose fallowed by $C_{.42}$ treatment. C_0 recorded the lowest values. Similar observation was reported by Jana *et al* (1994) and Basu and Bhadoria (2008).

Table 3: Effect of inoculations and cobalt on nutrient concentration and uptake by kernel of groundnut (Pooled mean of two years)

Levels of inoculation	Content (%)			Uptake (kg ha^{-1})		
	N	P	K	N	P	K
I_0	4.3	0.48	0.48	51.4	5.7	5.8
I_1	5.5	0.55	0.61	76.6	7.7	8.4
I_2	4.9	0.58	0.54	61.7	7.3	6.8
CD at 5% level	0.43	0.026	0.054	8.62	0.62	1.03
Levels of cobalt	**N**	**P**	**K**	**N**	**P**	**K**
C_0	4.8	0.51	0.52	58.6	6.3	6.3
$C_{.21}$	5.0	0.56	0.56	67.1	7.6	7.6
$C_{.42}$	4.9	0.54	0.54	62.9	6.9	6.9
CD at 5% level	0.09	0.018	0.016	3.51	0.471	0.43

Note: I_0 = No inoculation, I_1 = Inoculation with *Rhizobium*, I_2 = Inoculation with phosphobacterium.
C_0, $C_{.21}$, C_{042} = zero dose, 0.21 kg cobalt ha^{-1} and 0.42 kg cobalt ha^{-1}respectively.

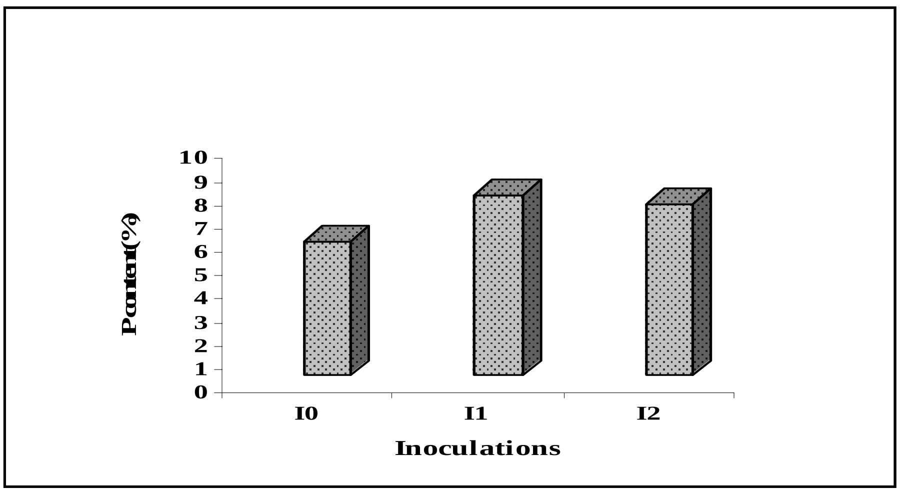

Fig. 1: Effect of different inoculations on P content (%) of kernel of groundnut (Pooled mean of three years) (Note: I_0 = No inoculation, I_1 = Inoculation with *Rhizobium*, I_2 = Inoculation with phosphobacterium.)

Levels of inoculation and levels of cobalt significantly influenced the number of pods per plant, number seeds per pod, pod yield, shelling percent, oil (Fig. 2) and protein content of groundnut (Table 4). The highest values of all these parameters were received at *Rhizobium* inoculation which was significantly higher over control (no inoculation) and phosphobacterium inoculation. There was also significant difference between control (no inoculation) and phosphobacterium inoculation, control (no inoculation) treatment producing the lowest value. There was no significant effect of treatments of inoculation on test weight (g) of seeds. Subramaniyan et al. (2000) and Basu et al. (2006b) reported the beneficial effect of *Rhizobium* inoculation on shelling percent. The favorable effect of *Rhizobium* inoculation on higher oil percent was also supported by Jana et al. (1994) and Basu et al. (2006a). Oil percent was higher due to the fact that higher N absorption had enhanced more Acetyl Co-A formation, which was directly related with oil formation. Among all the doses of cobalt, $C_{.21}$ gave the highest number of pods per plant and the highest number of seeds per pod. Pod yield, oil and protein content and oil yield of groundnut at $C_{.21}$ were also significantly higher over C_0 and $C_{.42}$. $C_{.42}$ gave significantly higher number of pods per plant over C_0, but in case of number of seeds per pod, C_0 and $C_{.42}$ were statistically at par. Different levels of cobalt had no significant influence on the test weight of groundnut seed. Similar response of groundnut crop to cobalt levels in respect of yield was also supported by Raj et al. (1996) and Basu and Bhadoria (2008). Higher oil and protein percent due to cobalt application had been observed by Jana et al. (1994) and Basu and Bhadoria (2008).

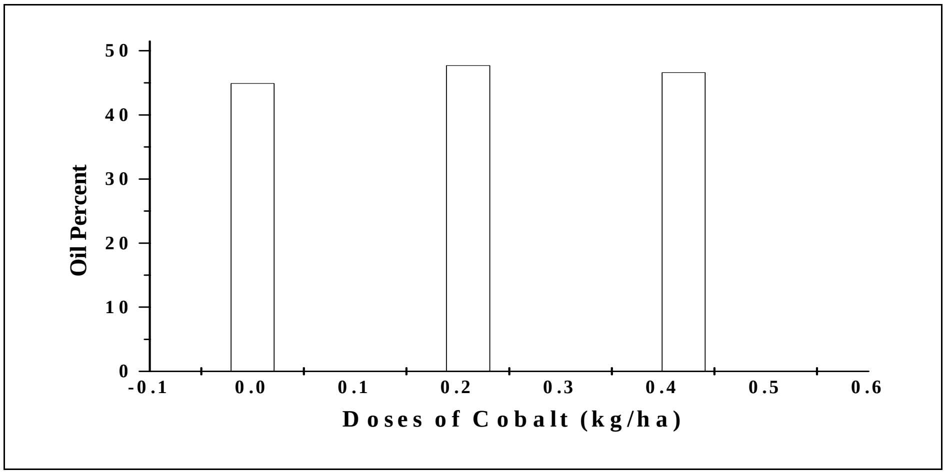

Fig. 2: Effect of different doses of cobalt on oil percent of groundnut (Pooled mean of three years)

Table 4: Effect of inoculations and cobalt on pod yield (kg ha^{-1}), shelling percent, oil and protein content of groundnut (Pooled mean of three years)

Treatments	No. of pods/ plant	No. of seeds/ pod	Test weight (g)	Pod yield (kg ha^{-1})	Shelling percent	Protein %	Oil %	Oil yield (kg ha^{-1})
				Levels of Inoculation				
I_0	20.9	1.66	348.0	1737.7	68.8	26.9	45.1	540.6
I_1	28.5	1.96	348.1	1929.9	72.2	34.4	47.6	663.5
I_2	24.3	1.80	348.0	1803.0	69.8	30.8	46.4	585.4
CD at 5% level	2.56	0.112	NS	48.26	0.97	3.26	0.85	41.97
				Levels of Cobalt				
C_0	22.3	1.69	348.0	1767.7	69.0	30.0	44.9	549.0
$C_{.21}$	26.8	1.93	348.0	1880.0	71.4	31.3	47.7	641.3
$C_{.42}$	24.6	1.79	348.1	1822.7	70.4	30.8	46.6	599.2
CD at 5% level	1.76	0.105	NS	48.26	0.97	0.63	0.83	36.13

Note: I_0 = No inoculation, I_1 = Inoculation with *Rhizobium,*, I_2 = Inoculation with phosphobacterium.
C_0, $C_{.21}$, C_{042} = zero dose, 0.21 kg cobalt ha^{-1} and 0.42 kg cobalt ha^{-1}respectively.

4. CONCLUSION

It can be concluded from the above discussion that Rhizobium inoculation was more effective for increased the growth attributes, yield and oil content of groundnut as compared to phosphobacterium inoculation. Regarding nutrient concentration *Rhizobium* had better performance in N and K concentration but phosphobacterium gave better result in P concentration though the uptake of all the three nutrients was higher in *Rhizobium* inoculation. Cobalt @ 0.21 kg per ha gave best result in all the above-mentioned parameters.

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