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Effect of Calcium and *Bradyrhizobium* Inoculation of the Growth, Yield and Quality of Groundnut *(A. hypogaea L.)*

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Abstract

The study was aimed at determining the effect of fertilizer element calcium and *Bradyrhizobium* inoculation in improving the yield and quality of groundnut seed. The experiment was conducted in 1997-78 and 1998-99 in the clay loam soil. The fertilizing element calcium significantly affected all the yield attributes and quality up to 150kg/ha and then decline. There was also an increasing trend in qualitative characteristics like percentage of oil and protein content of groundnut with the increase in the level of calcium from 0-150 kg/ha. *Bradyrhizobium* fertilization affected the yield significantly but most of the yield attributes was not affected significantly.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important warm-season oilseed crop and is one of the most important oil producing crops in Bangladesh and ranking second position in area and production. Calcium is a soil nutrient most likely to be deficient for groundnut production in Bangladesh. A calcium deficiency results in lower yield and reduces percentage of sound mature kernels. A calcium deficiency results in lower yield and reduces percentage of sound mature kernels. A shortage of calcium has also been shown to decrease seed quality by inhibiting plumule development.[1] Rhizobium inocula tion is a cheaper and usually more effective agronomic practice for ensuring adequate nitrogen supply. Groundnut being a leguminous crop, its yield can be increased by inoculation with the strains of *Rhizobium.*[2] thus the study was undertaken to find out the effect of calcium and *Bradyrhizobium* inoculation on the yield and seed quality of groundnut. The objectives of the study was i. To find out the effect of calcium under different level of *Bradyrhizobium* inoculation on the growth and yield of groundnut. ii. To see the effect of calcium and *Bradyrhizobium* inoculation on seed quality.

Materials and Methods

The study was conducted with the groundnut cultivar 'Jhingabadam' known as ACC-12. It is an erect and early bunch type spreading variety. The life cycle of the crop was about 4-5 months and grown in char lands in *rabi*

(winter) and *kharif* (summer) seasons of Bangladesh. The pod usually contains three seeds and sometimes even more. The yield of the variety ranges from 1700 to 2250 kg/ha. The experimental field was a piece of well-drained high land with moderately even topography. The soil type was clay loam in texture having low organic matter, moderately slow permeability and deficient in nitrogen, phosphorous, potassium and calcium in comparison with the standard nutrition status. The soil was acidic in nature with pH range between 5.9 to 6.1. The crop was grown in *rabi* season. Calcium oxide (contains 60 % calcium) was used for calcium fertilization and BAU-700 was used as inoculant in the study. There were 5 (five) treatments of calcium and 2 (two) treatments of inoculation. The calcium treatments were 0,50,100,150 and 200kg/ha and the inoculation treatments were 0 and 50g/kg of seed. Design of the experiment was Randomized complete block design. The data was analyzed through a statistical computer programme MSTAT-C. The number of replication 3 and plot size was 4m x 2.5m.

Plants were harvested from a 10 square meter of each unit plot. The pods were separated from plants. was cleaned, dried and weighed separately. The pod weight was recorded in kg/ha and adjusted at 12 % moisture content. Five plants were taken from each plot to measure the yield attributes. Plant height was measured with meter scale of each plot from ground level to top of main shoot and mean height was expressed in cm and number of branches was recorded from each plot and mean number was expressed as per unit basis. In order to determine crude protein in seeds Kjeldahl's digestion and distillation procedure was followed to determine total nitrogen in seeds. The percentage of protein in seed was calculated by multiplying the nitrogen percentage with 6.25. Oil contents of the seed was determined by the solvent extraction method using petroleum ether by Soxhlet apparatus.

Results and Discussions

The fertilizer element calcium significantly influenced plant height in 1997-98 and 1998-98 (Table I). In the first year the longest plants were obtained from the treatment 150kg Ca/ha while the shortest plan from the control plot. In the second year similar trend was also showed by calcium. The result might be due to the fact that calcium enhances the growth of groundnut plants. In the first year, plants without inoculation produced longer plants but in the second year, inoculated plants produced longer plants, though the difference between inoculated and non inoculated was found insignificant. The result indicated the inoculation had little effect on the growth of groundnut plants. The result indicated that inoculation had little effect on the growth of groundnut plants. The interaction of calcium and *Bradyrhizobium* fertilization was significant in 1997-98 but insignificant in 1998-99 (Table I). In both the year, the longest plant was produced in the treatment of 50kg Ca/ha with inoculation and the shortest plant was produced in control.

The result revealed that calcium as well as inoculation showed better positive effect on the growth of groundnut.

Calcium fertilization influenced the number of branches per plant significantly in 1997-98 and 1998-99 (Table I). IN 1997-98, the highest number of branches was produced with 150 kg Ca/ha treatment. Other doses of calcium produced identical number of branches with the highest one. Control plot produced significantly poorer number of branches per plant compared to calcium treated plot. In 1998-99 similar trend also showed by the fertilizer elements. The result indicated that inoculation of groundnut with Rhizobium

Table I. Effect of calcium and *Bradyrhizobium* fertilization and their interaction on plant height, number of branches / plant and number of mature pod / plant

Treatment/ Interaction	Plant height (cm)		Number of branches/ plant		Number of mature pod / plant	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Ca dose (kg/ha)						
Ca_0	45.65	42.73	4.75	3.72	12.20	11.40
Ca_{50}	46.23	47.97	5.30	3.92	13.10	12.35
Ca_{100}	49.13	49.77	5.40	4.82	15.23	15.47
Ca_{150}	50.97	51.40	5.70	5.05	17.23	15.80
Ca_{200}	47.63	50.50	5.50	4.27	13.33	14.27
LSD (0.05)	2.273	3.27	0.378	0.410	1.519	0.425
Inoculation (g/kg seed)						
I_0	48.05	47.52	5.26	4.09	13.69	12.59
I_{50}	47.80	49.43	5.40	4.61	14.92	13.53
LSD (0.05)	NS	NS	NS	0.579	2.148	0.603
Calcium x Inoculation						
Ca_0 x I_0	43.77	41.67	4.63	3.53	11.73	11.07
Ca_{50} x I_0	47.53	43.80	4.87	3.90	12.67	11.73
Ca_{100} x I_0	45.13	46.87	5.33	3.43	13.20	12.13
Ca_{150} x I_0	47.33	49.07	5.27	4.40	13.00	12.57
Ca_{200} x I_0	48.33	47.40	5.20	4.53	14.53	15.87
Ca_0 x I_{50}	49.93	52.13	5.60	5.10	15.93	15.07
Ca_{50} x I_{50}	53.47	53.07	5.80	4.87	16.33	16.40
Ca_{100} x I_{50}	48.47	49.73	5.60	5.23	18.13	15.20
Ca_{150} x I_{50}	49.53	48.60	5.33	4.10	12.67	14.47
Ca_{200} x I_{50}	45.73	52.40	5.67	4.43	14.87	14.07
LSD (0.05)	3.214	NS	NS	NS	2.149	NS

species encouraged branching and the variation in number of branching might be due to climatic variation among the years. Deshmukh *et al*. observed similar result.[1] The interaction of calcium and *Bradyrhi-zobium* fertilization was not significant in 1997-98 and 1998-99 (Table I). The result indicated that fertilizer treatments failed to produce distinctly different effects on number of branch per plant.

Calcium had a positive effect on the number of mature pod per plant and affected significantly in 1997-98 and 1998-99 (Table I) The highest number of mature pods/ plant was obtained in the treatment of 150 kg Ca/ha in 1997-98 and the other treatments varied significantly. In 1998-99, the highest number of mature pod/plant was obtained in the treatment of 150 kg Ca/ha that produced identical number with treatment 100 kg Ca/ha and 200 kg Ca/ha. The lowest number of mature pod per plant was obtained in the treatment of 0 kg Ca/ha. The result revealed that calcium had encouraged the number of mature pods. In both the year the effect of inoculation was significant on the number of mature pods per plant (Table I). The number of mature pods/plant interacted significantly by calcium and *Bradyrhizobium* in 1997-98 only (Table I). In 1997-98, the highest number of mature pods was produced with 100 kg Ca/ha with inoculation and the lowest number of matured pods per plant was produced in control. It might be due to better response of calcium was attributed in the presence of *Bradyrhizobium* inoculation.

Calcium had a significant effect on the shelling percentage of groundnut in 1997-98 and 1998-99 (Table II). IN 1997-98, the highest percentage of shelling was obtained

Table II. Effect of calcium and *Bradyrhizobium* fertilization and their interaction on % shelling, harvest index and 100 seed weight

Treatment/ Interaction	% Selling		Harvest index		100 seed weight (g)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Ca dose (kg/ha)						
Ca_0	65.18	60.30	30.91	31.98	26.33	23.20
Ca_{50}	67.59	61.89	31.63	32.53	27.17	24.18
Ca_{100}	70.00	63.39	35.29	36.99	29.75	28.08
Ca_{150}	69.65	64.11	37.68	37.94	30.17	29.45
Ca_{200}	67.43	62.05	35.38	35.59	37.50	26.44
LSD (0.05)	1.306	0.979	1.336	1.387	0.932	1.552
Inoculation (g/kg seed)						
I_0	67.52	62.13	33.87	34.44	27.90	25.98
I_{50}	68.85	62.57	34.49	35.57	28.47	26.56
LSD (0.05)	1.766	NS	NS	1.962	NS	2.195

from the treatment of 100 kg Ca/ha and comparable percentage of shelling was also obtained from 150 kg Ca/ha and other treatments produced significantly lower percentage of shelling in the same year. In 1998-99, the trend was similar and the lowest percentage was produced in control. The result indicated that calcium increased the weight of seed. These results are in full agreement with Das *et al*.[3]

Bradyrhizobium inoculation affected the shelling percentage of groundnut seed significantly in 1997-98 (Table II). The inoculation showed a gradual increase in shelling percentage in both years. The results indicated that inoculation improved the weight of kernel than the shell and are in full agreement with Abu *et al*.[4] The interaction of calcium and *Bradyrhizobium* was not significant in 1997-98 and 1998-99. Harvest index of the crop was affected significantly by calcium in 1997-98 and 1998-99 (Table II). In 1997-98, the highest harvest index was found in the treatment 150 kg Ca/ha and the lowest was obtained in control, which produced identical results with lower doses of calcium (50 kg / ha). In 1998-99, 150 kg Ca/ha produced the highest harvest index that was at par with 100 kg Ca/ha and control. The lower doses of calcium produced similar results that were obtained in 1997-98. It may be concluded from the two years result that calcium has a positive effect on shell of fruits and it increased the weight of kernels. The results are in agreement with Velasquez and Ramirez.[5] There was a positive effect of *Bradyrhizobium* inoculation on the harvest index of groundnut. The interaction of calcium and *Bradyrhizobium* inoculation was not significant in 1997-98 and 1998-99. In both the year the higher harvest index was produced with the treatment 50 kg Ca/ha with inoculation. The lower doses of calcium without inoculation produced poorer harvest index. The result showed that inoculation increased the dry mass of the plants. Pulatova et al. obtained similar result.[6]

100 seed weight of groundnut varied significantly with calcium application (Table II). The heaviest seed in 1979-98 was produced with 150 kg Ca/ha, which produced at per weight with 100 kg Ca/h. Other treatments produced significantly poorer weighed seed and were identical with the control and the lightest seed was obtained in control. In 1998-99, a similar result was also obtained excepting that only 50 kg Ca/ha and control produced identical results. The results indicated that lime enhanced the seed weight are in agreement with Das *et al*.[3] *Bradyrhizoloium* inoculation had a positive effect on 100 seed weight but the difference between inoculation and uninoculated one was not significant. The results are in agreement with Joshi *et al*.[7] The interaction of calcium and *Bradyrhizoloium* inoculation was not significant in 1997-98 and 1998-99.

Calcium had a distinct and significant effect of the yield of groundnut (Table III). In 1997-98, the highest yield was obtained with the treatment 150 kg Ca/ha and other treatments produced significantly poorer yield but 50 kg Ca/ha and control produced identical yield.

Table III. Effect of calcium and *Bradyrhizobium* fertilization and their interaction on pod yield, oil and protein percentage of groundnut

Treatment/ Interaction	Pod yield (t/ha)		% Oil content		% Protein content	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Ca dose (kg/ha)						
Ca_0	1.538	1.533	49.94	50.15	22.14	22.35
Ca_{50}	1.565	1.573	51.01	50.57	22.35	23.79
Ca_{100}	1.688	1.690	51.37	51.35	23.64	24.72
Ca_{150}	1.818	1.735	51.20	51.92	23.91	25.20
Ca_{200}	1.650	1.653	51.28	51.02	23.62	22.99
LSD (0.05)	0.054	0.012	0.568	0.376	0.646	1.180
Inoculation (g/kg seed)						
I_0	1.63	1.62	50.86	50.89	23.03	23.73
I_{50}	1.68	1.66	51.07	51.11	23.24	23.89
LSD (0.05)	0.073	0.017	NS	NS	NS	NS

In 1998-99, similar results were also obtained and the highest yield was obtained with 150 kg Ca/ha and other treatments produced significantly poorer yield and the lowest yield was obtained in control. The results revealed that when calcium was deficient application of calcium gave small seed increase Gajanan *et al.* and Zhang and Zao also obtained similar results.[8,9]

Bradyrhizoboium inoculation showed a significant effect on the yield in 1997-98 and 1998-99 and produced higher yield than the uninoculated one. Abu *et al.* obtained similar results.[4] The interaction of calcium and *Bradyrhizoloium* fertilization was not significant in 1997-98 and 1998-99.

Calcium affected the oil content of the seed significantly in 1997-98 and 1998-99 (Table III). In 1997-98, the highest percentage o oil was obtained with 100 kg Ca/ha, which produced identical percentage of oil with other treatments of calcium. The lowest percentage of oil was obtained in the control. In 1998-99, the highest percentage of oil was obtained in the treatment of 150 g Ca/ha and the lowest in control. The results revealed that calcium increased the oil content of seed gradually with the increasing doses. The results are in agreement with the results obtained by Shahug *et al.*[10] *Bradyrhizobium* inoculation affected the oil content of the seed but inoculation of seed with *Bradyrhizobium* inoculants increased the oil content of the seed in 1997-98 and 1998-99. The results are in partial agreement with Jana *et al.*[11] The interaction of calcium and inoculation was not significant in 1997-98 and 1998-99.

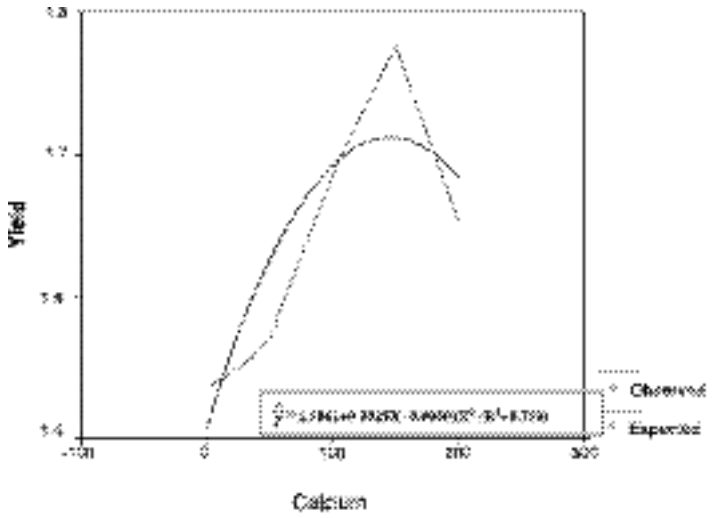

Fig. 1. Polynomial regression of yield (mean of 1997-97 and 1998-99) on calcium

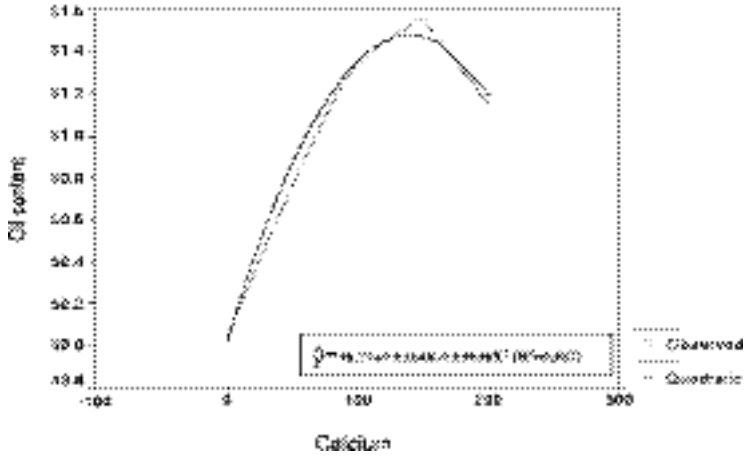

Fig. 2. Polynomial regression of oil content (mean of 1997-97 and 1998-99) on calcium

The level of calcium affected the percentage protein content of seed significantly in 1997-98 and 1998-99 (Table III). In the 1st year the highest percentage of protein was obtained by the treatment 150 kg Ca/ha while in the 2nd year the highest percentage of protein was obtained in the treatment of 200 kg Ca/ha. The lowest percentage of protein was obtained in the control plot. Other treatment produced intermediary results. The results indicated the seed protein content increased with the rate of calcium application. Ursal *et al.* obtained similar result.[12]

Inoculation had a positive effect on the percentage of protein content of groundnut seed and increased the protein percentage of seed in 1997-98 and 1998-99 but the effect was not significant. The results are in partial agreement with Jana *et al.*[11] The interaction of calcium and inoculation were not significant in 1997-98 and 1998-99.

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