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Influence of different levels of calcium and phosphorus fertilization on growth and yield attributes of groundnut (*Arachis hypogaea* L.)

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Abstract: A field experiment was conducted at crop research farm, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom Institute of Agricultural, Technology & Sciences, Allahabad (U. P) near the Yamuna river to study the effect of different levels of calcium and phosphorus on growth and yield attribute of groundnut (*Arachis hypogaea* L.) during *Kharif* season, 2014. It was consisting of combination of four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) and four levels of calcium (0, 50, 100 and 150 kg Ca ha^{-1}). The field experiment was laid out in randomized block design with three replications. The results showed that application of calcium fertilizer (150 kg ha^1) had a significantly maximum growth and yield attributes *viz.,* plant height (9.17, 22.36 and 36.38 cm, at 30, 60, 90 DAS), plant dry weight (2.33, 4.55, 5.93 and 14.66 g at 15, 30, 45 and 60 DAS), CGR (g m^{-2} day^{-1}) (1.92, 1.77, 2.10 and 6.98 g at 0-15, 15-30, 30-45, and 45-60 DAS), number of nodule $plant^{-1}$, seed yield (2.065 t ha^{-1}), pod yield (2.70.85 t ha^{-1}), number of filled pods $plant^{-1}$ (38.00), shelling percentage (76.41 %) respectively than other application of fertilizers application levels treatments.
Key words: Groundnut (*Arachis hypogaea* L.), phosphorus levels and calcium levels

Introduction

Groundnut is the most important food legume in India in terms of consumption and area under production. Its high content of oil and protein makes it an important commodity for both human use and livestock feed. Moreover, its shells are sometimes used as fuel, for the generation of electricity. Groundnut (*Arachis hypogaea* L.) belongs to genus *Arachis* of family *Leguminosae* is the "King of oilseed" in our country is an important crop both for oil and food. About 2/3 of the crop produce in the world is crushed to extract oil and 1/3 is used to make other edible products. (Kamdi *et al.,*2014). It is an annual legume native to South America. It is now grown in most tropical, sub-tropical and warm temperate regions of the World between 40° N and 40° S latitudes (Kumar *et al.*, 2014). Although, excessive use of fertilizers negatively affects soil environment and reduces profit margins in farmers gain, it occurs to boost crop production to meet the increasing demands of consumers. Optimization of mineral fertilization is the key for optimizing groundnut production, as it has very high nutrient requirements. Contrarily, severe mineral nutrient deficiencies due to inadequate and imbalanced use of nutrients are one of the major factors responsible for low yield (Kabir *et al.*, 2013).

Calcium is a soil nutrient, deficient in Allahabad soils. Calcium deficiency leads to high percentage of aborted seeds (empty pods or "pops") and improperly filled pods. To get good yields of quality groundnut pods, an adequate amount of Ca should be present in the soil from early flowering of crop production onwards. Phosphorus, an essential nutrient for crop growth and yield with good quality is deficient in most Allahabad soils. Although legumes can fix their own nitrogen, they often need phosphorus and potassium for good seed formation (Asiedu *et al*., 2000). Phosphorus also promotes root growth, enhances nutrient and water use efficiency and increases yield.The requirement of phosphorus in nodulating legumes is higher compared to non-nodulating crops. Hence, appropriate Ca combination with P fertilization may reveal the causes of empty pods, low yields and seed quality of groundnut. The main objective of this study was to determine the effect of Ca and P fertilization on the growth and yield (pod and seed) of groundnut. Abelson (1999) projected the likelihood of a potential phosphate crisis for agriculture in the 21st century. To counteract the anticipated P shortfall, acquisition of soil P by plant root systems is a subject of considerable interest in agriculture and ecology, as well as a complex and challenging problem in basic plant biology. Unfortunately, this problem has received less attention, despite its probable importance in agriculture. Thus, sustainable P management requires development of crops with enhanced P efficiency (Vance, 2001). Plant responses to P stress condition involve changes in root morphology and architecture (Liao *et al.,* 2001; Lynch and Brown, 2001) as well as changes in shoot and flower development (Bucciarelli *et al.,* 2006; Kumar *et al.,*2014).

Materials and Methods

This experiment was conducted in the year 2014 during rainy *Kharif* season at crop research farm (CRF) Department of Agronomy, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. The geographical co-ordinates of

Allahabad are $25^0 57^0$ N latitude and 87^0 19^0 E longitude and an altitude of 98m above mean sea level. The area is situated on the south of the Allahabad (U.P.) on the side of the Yamuna River at Rewa road at a distance of about 5.0 km away from Allahabad city. All the facilities required for crop cultivation were available. The total rainfall received during the crop growing period of 709.3 mm. The mean maximum temperature varied between 34.07^0 and the minimum temperature varied between 25.5^0 C during the *Kharif* season of 2014, as against the normal mean weekly relative humidity which was ranged from 43.43 to 91.32 per cent received during the crop growing season.

The soil of experimental plot was sandy loam in texture having pH of 7.60 with low level of organic carbon 0.51 %, available N (201.23kg/ha) by alkaline permanganate method (Subbaiah and Asija, 1956) but medium level of P (17.45 kg/ha) and K (231 kg/ha) by NH4OAC- Leaching method (Jackson, 1973). Ca and P_2O_5 was applied through Calcium and DAP, respectively. The experiment was carried out in randomized block design, comprising of sixteen treatment combinations each replicated thrice.

The treatments consisted of four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) and four levels of calcium (0, 50, 100 and 150 kg Ca ha^{-1}). Total sixteen treatment combinations *viz.,* T_1 Ca 0 kg ha^{-1} + P 0 kg ha^{-1},T_2 Ca 0 kg ha^{-1} + P 25 kg ha^{-1} ,T_3 Ca 0 kg ha^{-1} + P 50 kg ha^{-1},T_4 Ca 0 kg ha^{-1} + P 75 kg ha^{-1},T_5 Ca 50 kg ha^{-1} + P 0 kg ha^{-1},T_6 Ca 50 kg ha^{-1} + P 25 kg ha^{-1} ,T_7 Ca 50 kg ha^{-1} + P 50 kg ha^{-1} ,T_8 Ca 50 kg ha^{-1} + P 75 kg ha^{-1} , T_9 Ca 100 kg ha^{-1} + P 0 kg ha^{-1} , T_{10} Ca 100 kg ha^{-1} + P 25 kg ha^{-1} , T_{11} Ca 100 kg ha^{-1} + P 50 kg ha^{-1} , T_{12} Ca 100 kg ha^{-1} + P 75 kg ha^{-1} , T_{13} Ca 150 kg ha^{-1} + P 0 kg ha^{-1} , T_{14} Ca 150 kg ha^{-1} + P 25 kg ha^{-1} , T_{15} Ca 150 kg ha^{-1} + P 50 kg ha^{-1} and T_{16} Ca 150 kg ha^{-1} + P 75 kg ha^{-1} .

Emerged seedlings were counted two weeks after planting. Five plants were taken from each plot to measure the yield attributes. Plant height was measured with a meter rule and means expressed in centimeter, number of leaves and number of branches were recorded from each plot and mean number expressed as per unit basis. At harvest, five plants in the middle rows were taken randomly to determine the yield components as follows:

Crop growth rate (CGR) (g m^{-2} day^{-1}): It represents dry weight gained by unit area of a crop in a unit time, expressed as g m^{-2}day^{-1}. The crop growth rate was computed with the help of dry matter production recorded for each treatment at 0-15, 15-30, 30-45, and 45-60 DAS intervals. It was calculated with the help of following formula.

Crop growth rate (CGR) = W_2-W_1 / t_2-t_1

Where: W_1 = dry weight production per unit area at time t_1; W_2 = dry weight production per unit area at time t_2

Pod yield (kg ha^{-1}) and seed yield (kg ha^{-1}): Number of empty pod, number of filled pods and 100 seed weight. Plants from the two middle rows were used to calculate the pod and seed yield using the formula:

Pod yield (kg ha^{-1}) =Pod yield (kg) X 10000 m^2 / Harvested area (m^2)

Seed yield (kg ha^{-1}) = Seed yield (kg) X 10000 m^2 / Harvested area (m^2)

Statistical analysis: The value of table 'F at 5% level significance, where the treatment difference between were found significant among the treatments. The value of CD and CV % were also worked out to compare the treatment mean (Snedecor and Cochran, 1967). At initial stage five plants were selected randomly from net plot area for further recording observations.

Results and Discussion

Effect of growth parameter on groundnut: Data presented in (Table-1) plant height at 30 and 60 DAS, though the significantly higher value recorded was 9.17 and 22.36 cm in treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1}. However, the significantly the highest plant height (36.38 cm) found was it treatment. The plant dry weight at 15 DAS, observed plant dry weight (2.33 g) showed statistically non significant difference among treatments. However, treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1} recorded the significantly higher dry weight 4.55, 5.93 and 14.66 g at 30, 45 and 60 DAS respectively. It might be due to sole application of chemical fertilizer at recommended dose recorded lowest values of dry matter accumulation in almost all sampling. The higher vegetative growth might be achieved by greater amount of available phosphorus in soil at important stages of growth, which probably enabled the plant to grab higher amount of nutrient from the soil with greater root rhizosphere. Das *et al.* (2015)

The treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1} observed that non significantly the highest crop growth rate (CGR) (1.92, 1.77 and 2.10, g m^{-2} day^{-1} at 0 to15, 15-30 and 30.45 DAS intervals. However, significantly the highest CGR (6.98 g m^{-2} day^{-1} at 45-60 DAS). It might be due to maximum branching and vegetative growth facilitated by proper nutrient supply and also could be positive effect of P, Ca and P requirement of crop is fairly high and seldom met from normal soil and additional P application could increase the plant growth. The result of this experiment is in agreement with these findings. Ca is important for vascular bundle development which could indirectly affect on plant growth. Second reason it might be due to the increase in availability of phosphorus attributed to accelerated rate of organic matter decomposition due to increased biological activity of soil (Haynes, 1992). The significantly the higher number of nodule plant^{-1} recorded (30.13, 53.10 and 100.66 at 30, 45 and 60 DAS) respectively. The increases in plant growth and total dry weight due to P application may be attributable to the fact that P is known to help in the development of more extensive root system and nodulation, and thus enables plants to absorb more water and nutrients from depth of the soil (Sharma *et al.,*1997; Gobarah *et al.,* 2007). This in turn could enhance the plant's ability to produce more assimilates which were reflected in the high dry weight. Similar results have been reported by El- Habbasha *et al.* (2005) and Gobarah *et al.* (2006).

Yields attributes and yield of groundnut: The results indicated that treatment (Table-2) the effect of fertilizer levels on grain yield (2.068 t ha^{-1}) of groundnut and pod yield (2.70 t ha^{-1}) were recorded significantly higher under the treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1} Whereas, significantly lower grain yield (0.81 t ha^{-1}) and significantly lower pod yield (1.243 t ha-1) were observed under (T_1) Ca 0 kg ha^{-1} + P 0 kg ha^{-1} (control). The yield and most of the yield attributing characters were increased with increasing fertilizer level. The increase in yield due to P fertilizer may be attributed to

Table-1: Effect of calcium and phosphorus on the growth parameters of groundnut (*Arachis hypogaea* L.)

Treat-ments	Plant height (cm)			Dry weight (g) plant^{-1}				Crop growth rate (g/m^2/day)				No. of nodule plant^{-1}		
	30 DAS	60 DAS	90 DAS	15 DAS	30 DAS	45 DAS	60 DAS	0-15 DAS	15-30 DAS	30-45 DAS	45-60 DAS	30 DAS	45 DAS	60 DAS
T_1	8.14	18.06	23.48	2.26	3.22	4.06	8.43	1.49	0.76	1.66	3.15	22.78	42.86	60.06
T_2	8.46	19.42	26.08	2.53	3.53	4.46	9.60	1.73	0.80	1.74	4.00	25.57	45.88	72.06
T_3	8.69	20.07	28.64	2.43	3.76	4.86	10.96	1.81	1.06	1.87	4.88	25.66	46.58	73.26
T_4	8.88	20.72	31.07	2.43	4.43	5.46	13.66	1.86	1.60	1.82	6.52	28.94	44.91	80.73
T_5	8.30	19.20	24.98	2.33	3.36	4.36	8.96	1.62	0.82	1.79	3.68	24.32	44.05	67.73
T_6	8.62	19.56	26.48	2.16	3.70	4.60	9.60	1.73	1.22	1.72	4.11	25.46	44.82	72.16
T_7	8.78	20.45	28.70	2.33	4.20	4.93	11.66	1.81	1.49	1.58	5.38	25.72	44.60	73.60
T_8	9.04	20.82	32.77	2.13	4.46	5.60	13.75	1.94	1.86	1.90	6.56	29.05	48.70	87.60
T_9	8.42	19.24	25.06	1.86	3.43	4.43	9.40	1.68	1.25	1.79	3.73	25.59	44.65	68.60
T_{10}	8.65	19.58	26.96	2.26	3.60	4.66	9.80	1.76	1.06	1.84	4.11	24.60	47.53	72.40
T_{11}	8.00	20.56	29.18	2.16	4.23	5.03	12.00	1.86	1.65	1.63	5.57	25.13	45.40	78.86
T_{12}	8.08	21.60	35.43	2.10	4.50	5.63	14.16	1.94	1.92	1.90	6.82	29.44	51.79	98.86
T_{13}	8.45	19.26	25.82	2.03	3.46	4.46	9.13	1.70	1.14	1.80	3.97	24.38	46.32	69.16
T_{14}	8.66	19.81	28.15	2.20	3.76	4.73	10.66	1.78	1.24	1.77	4.74	25.95	43.62	73.00
T_{15}	8.60	20.69	30.56	2.23	4.13	5.36	12.66	1.86	1.51	1.98	5.84	26.46	46.39	79.20
T_{16}	9.17	22.36	36.38	2.33	4.55	5.93	14.66	1.92	1.77	2.10	6.98	30.13	53.10	100.66
F test	S	S	S	NS	S	S	S	NS	NS	NS	S	S	S	S
SEd(_+)	0.263	1.028	1.587	-	0.230	0.263	0.655	-	-	-	0.136	1.46	2.45	7.62
CD (P=0.05)	0.561	2.192	3.270	-	0.476	0.539	1.335	-	-	-	0.246	3.11	5.23	16.24

Table-2: Effect of calcium and phosphorus on the yield and yield attributes of groundnut (*Arachis hypogaea* L.)

Treat-ments	Seed/ Kernel yield (t ha^{-1})	Pod yield (t ha^{-1})	No. of filled pods plant^{-1}	No. of pops (empty pods) plant^{-1}	Shelling %
T_1	0.816	1.243	15.40	8.73	65.33
T_2	1.060	1.566	21.73	8.40	68.00
T_3	1.478	2.133	30.46	8.00	69.33
T_4	1.614	2.317	37.46	7.80	69.66
T_5	1.164	1.633	16.46	7.06	71.33
T_6	1.385	1.933	22.73	6.73	71.66
T_7	1.561	2.166	33.00	6.60	72.08
T_8	1.808	2.466	37.66	5.86	73.33
T_9	1.406	1.900	19.20	4.80	74.00
T_{10}	1.528	2.066	24.13	4.33	74.00
T_{11}	1.635	2.200	33.06	4.20	74.33
T_{12}	1.841	2.466	37.86	3.80	74.66
T_{13}	1.490	1.966	19.26	3.20	75.83
T_{14}	1.695	2.233	24.86	3.13	75.91
T_{15}	1.998	2.633	33.53	2.73	75.91
T_{16}	2.068	2.707	38.00	2.33	76.41
F test	S	S	S	S	S
SEd(_+)	2.229	1.460	0.929	0.163	0.554
CD (P=0.05)	0.004	0.009	1.890	0.338	1.132

Treatment combinations in both tables: T_1: Ca 0 kg ha^{-1} + P0 kg ha^{-1} (control); T_2 : Ca 0 kg ha^{-1} + P 25 kg ha^{-1}; T_3 : Ca 0 kg ha^{-1} + P 50 kg ha^{-1}; T_4 : Ca 0 kg ha^{-1} + P 75 kg ha^{-1}; T_5 : Ca 50 kg ha^{-1} + P 0 kg ha^{-1}; T_6 : Ca 50 kg ha^{-1} + P 25 kg ha^{-1}; T_7 : Ca 50 kg ha^{-1} + P 50 kg ha^{-1}; T_8 : Ca 50 kg ha^{-1} + P 75 kg ha^{-1}; T_9 : Ca 100 kg ha^{-1} + P 0 kg ha^{-1}; T_{10} :Ca 100 kg ha^{-1} + P 25 kg ha^{-1}; T_{11} : Ca 100 kg ha^{-1} + P 50 kg ha^{-1}; T_{12} : Ca 100 kg ha^{-1} + P 75 kg ha^{-1}; T_{13} : Ca 150 kg ha^{-1} + P 0 kg ha^{-1}; T_{14} : Ca 150 kg ha^{-1} + P 25 kg ha^{-1}; T_{15} : Ca 150 kg ha^{-1} + P 50 kg ha^{-1}; T_{16} : Ca 150 kg ha^{-1} + P 75 kg ha^{-1}

the activation of metabolic processes, where its role in building phospholipids and nucleic acid is known.

Moreover P is an important nutrient for all the crops in general and legumes in particular, it is a key constituent of ATP and plays significant role in energy transformation in plant and also roles in seed formation. Application of P, and Ca fertilizers increased nutrients availability to the crop during the growing season which leads to greater utilization of assimilates into the pods and ultimately increased number of filled pods and shelling percentage. Among the number of filled pods plant^{-1} (38.00) was recorded significantly higher under the treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1}.

The probable reason might be due to increased application of phosphorus might have resulted in increased P uptake with simultaneous increase in the uptake of nitrogen, potassium and other nutrients resulting in higher yield. The increase in the pod yield of groundnut with increased P application was also due to the low available P status of soils and the results are comparable with those obtained by Nakagawa *et al.* (1993) and Ranjit *et al.* (2007).The significantly higher number of pops (empty pods) 8.73 plant^{-1}) was under the treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1} respectively. In case of selling percentage (76.41%) significantly higher under the treatment (T_{16}) Ca 150 kg ha^{-1} + P 75 kg ha^{-1}.

From the above findings it is concluded that among all the treatment an application of calcium at 150 kg ha^{-1} applied in combination with phosphorus at 75 kg ha^{-1} was found to be the best for obtaining highest growth and yield of groundnut. The study findings also have brought an expectation that further investigation on different levels of fertilizers in growing seasons and soil types can be a step forward to identify more realistic effect of different fertilizers on the growth and yield of groundnut. Finally these findings will help our farmers to apply balanced fertilizer dose, which will be synchronized with crop demand and also will reduce the cost of production.

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