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Influence of Calcium and Gibberellic Acid on Growth, Yield and Economics of Summer Groundnut (*Arachis hypogea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

A field experiment was conducted during *Zaid* season (2022) to determine the Influence of calcium and gibberellic acid on growth, yield and economics of summer groundnut (*Arachis hypogea* L.). Experiment was laid out in Randomized Block Design (RBD) with 3 replicates of 10 treatments. The results showed that treatment 9 of [Ca (40kg/ha) + GA_3 (120ppm)] recorded significantly higher plant height (60.4 cm), more dry weight (45.95g), maximum number of nodules/plant (16.4), maximum number of pods/plant (24.60), maximum number of kernels/pod (1.93), higher seed index (37.8 g), higher seed yield (2.02t/ha), higher haulm yield (4.11 t/ha) and higher harvest index (32.83 %). Maximum gross returns (1,25,778.00 INR/ha), maximum net returns (87,853.50 INR/ha) and highest benefit cost ratio (2.32) was also recorded in treatment 9 of Ca (40kg/ha) + GA_3 (120ppm) as compared to other treatments.

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1. INTRODUCTION

The oilseed sector plays an important role in India's agriculture and economy [1]. Nine oil annual seed crops serve as the main source of edible oil [2]. Among soyabeans, peanuts, canola and mustard are the main contributors. Oilseeds are grown mainly on poor soils with a lot of rain. Peanuts are prized for their high oil content and edible seeds. It is the fourth most important source of edible oil and the third most important source. The world's most important vegetable protein source which contain 42-52% oil and 22-30% protein on a dry seed basis, phosphorus, calcium, magnesium and potassium [3]. Peanut are not only a source of income for farmers, but also an excellent source inexpensive source of high-quality dietary protein and oil found in many Ghanaian diets [4].

Peanut are not only an important oilseed crop of India, but also a major agricultural export. Globally, peanuts cover 31.5 million hectares with a production of 53.6 million tons and a productivity of 1701 kg/ha [5]. With annual all-season coverage of 55.71 lakh hectares, globally, India ranks first in Groundnut area under cultivation and is the second largest producer in the world with 102 lakh tonnes with productivity of 1831 kg/ha in 2020-21 [6]. In *Kharif* 2021-22, groundnut production was 82.54 lakh tonnes in an area of 49.14 lakh hectares [6]. Groundnut is cultivated in one or more (*kharif*, *rabi* and summer) seasons, but nearly 90% of acreage and production comes from *kharif* crop (June-October). During 2019-20 total area coverage under groundnut in Uttar Pradesh 93822.00 hectares with a production of 88371 tonnes and the productivity 940kg/ha [6].

Despite the importance of this crop, yields remain below 1.0 t/ha, a long way off. Less than potential yield of 2-3t/ha. This impacted peanut production, income welfare of peanut farmers. It is not entirely clear whether this low-yield problem is due to declining soil fertility or changing climatic conditions. A lack of calcium increases the rate of seed breakage (empty pods or "pops") and improperly packed pods [7]. It also results in broken or shrivelled fruits, including the darkened plumules and production of seedless pods [8]. A sufficient amount of Ca should be present in the soil from early flowering in crop production [9].

Effect of Plant growth regulators in manipulating physiological processes in plant production, germination, vitality, absorption of nutrients from soil, photosynthesis, respiration, degradation of assimilates, growth inhibition, defoliation, post-harvest ripening [10,11].

Gibberellins are large group of plant hormones that stand alongside auxins are one of the main groups of plant regulators [12]. They are all physiologically different activity and structure, and the first gibberellin identified was gibberellic acid (GA_3). Gibberellins widely involved in all stages of plant growth and development, from seed germination to senescence. They promote seed germination; stimulate stem elongation, leaf enlargement, flowering, pollen and seed development, retardation and inhibition of maturation, aging [13]. Given the above facts, the present investigation entitled, "Influence of calcium and gibberellic acid on the growth, yield and economics of summer groundnut (*Arachis hypogaea* L.)"

2. MATERIALS AND METHODS

This experiment was conducted at the Crop Research Farm during 2022 *Zaid* season. Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha), K (240.7 kg/ha) and zinc (2.32 mg/kg). Treatment consists of three calcium stages (20, 30,40kg/ha) and gibberellic acid (40, 80, 120 ppm/ha). The treatment combinations are T1- Ca (20 kg/ha) + GA_3 (40 ppm), T2 - Ca (20 kg/ha) + GA_3 (80 ppm), T3 - Ca (20 kg/ha) + GA_3 (120 ppm), T4 - Ca (30 kg/ha) + GA_3 (40 ppm), T5 - Ca (30 kg/ha) + GA_3 (80 ppm), T6 - Ca (30 kg/ha) + GA_3 (120 ppm), T7 - Ca (40kg/ha) + GA_3 (40 ppm), T8 - Ca (40 kg/ha) + GA_3 (80 ppm), T9- Ca (40 kg/ha) + GA_3 (120 ppm), T10- Control N:P:K (20:60:40 Kg/ha). The growth, yield and economics were recorded at 80 DAS from randomly selected plants in each plot. The data were calculated and analysed by following statistical methods Gomez and Gomez [14].

3. RESULTS AND DISSCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data revealed that significantly higher plant height (60.43 cm) was recorded in treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 1). The significant and higher plant height was observed with the application of calcium (40kg/ha) calcium increases plant nutrient supply, played a important role in photosynthesis, carbohydrate metabolism, protein synthesis and synthesis growth stimulators, consequences of cell division, and cell elongation with would have resulted in increased height. These similar results are agreement with those of Mansingh et al*.* [15]. Additionally, higher plant heights were observed when GA_3 was used (120 ppm) could be due to the application of gibberellic acid *via* leaves, rise the length of the hypocotyl and the length of the two nodes immediately above as a result, it affects the height of the plant. These results are in accordance with Emongor [16].

3.1.2 Number of nodules/plant

The data found that significantly higher number of nodules/plant (16.40 nodules/plant) was recorded in treatment 9 [Ca (40kg/ha) + GA_3 (120 ppm)]. However, treatment 6 [Ca (30kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40kg/ha) + GA_3 (120 ppm)] (Table 1). Significantly higher number of nodules/plant was observed with the application of GA_3 (120ppm), which might be due to foliar application of GA_3 increases plant vitality and strengthens stems. Current results are close proximity to Senthil et al*.* [17].

3.1.3 Plant dry weight (g)

Results revealed that significantly higher plant dry weight (45.71 g) was recorded in treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 1). Significant and greatest plant dry weight was observed with calcium application (40 kg/ha), possibly due to the application of calcium sources, which increased the total dry weight and yield of peanuts due to a reduction in percentage of unfilled seeds. There were similar reports as agreed by Kamara et al*.* [18]. Further, higher plant dry weight was observed with the application of GA_3 (120 ppm), this may be because GA_3 is one of these growth regulators it as a positive effect on plant as it promotes vegetative growth and ultimately increased plant dry weight. Similar findings were confirmed by Islam et al*.* [19].

3.1.4 Crop growth rate (g/m^2/day)

The data recorded that during 60-80 DAS, there was no significant difference between the treatments. However, highest crop growth rate (17.85 g/m^2/day) was recorded in treatment 4 Ca (30 kg/ha) + GA_3 (40 ppm) (Table 1).

3.1.5 Relative growth rate (g/g/day)

The data revealed that during 60 – 80 DAS, there was no significant difference between the treatments. However, highest relative growth rate (0.0183 g/g/day) was recorded in treatment 10 [control (RDF)] (Table 1).

3.2 Yield Attributes

3.2.1 Number of pods/plant

The data found that significantly higher number of pods/plant (24.60) was recorded in the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, the treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 2). more pods/plant was observed with calcium application (40 kg/ha), this might be due to soils that have been amended with gypsum as a calcium source. Contributed to better development of peanut pods and kernels, leading to higher number of pods/plant. Similar findings were earlier reported by Kabier et al*.* [20]

3.2.2 Number of kernels/pod

The data showed that significantly higher kernels/Pod (1.93) were recorded in the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, the treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 2). Significant and higher kernels/pod was observed with the application of calcium (40 kg/ha), this might be due to calcium maintaining cell integrity, membrane permeability activates and participates in a number of enzymes involved in cell division, protein synthesis and carbohydrate transfer, resulted in development of kernels/pod in plant. Similar results were also noticed by Rajanarasimha et al*.* [21]. Further higher kernels/pod was observed with application of GA_3 (120 ppm), which might be due to the plant growth regulators such as gibberellic acid may be involved in formation of seeds in pods and their optimum nutrition resulted in fewer number of aborted seeds and thus maximizes fertile seeds/pods survival for oilseed rape and mustard. This result corroborates the one reported by Akter et al. [22].

3.2.3 Seed index (g)

The data inferred that significantly higher seed index (37.80 g) was recorded in the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 2). Significant and higher seed index was observed using calcium (40kg/ha), this may be because peanuts are a calcium-loving crop and Ca above 90% in peanut pods is absorbed during the pod formation stage, resulting in calcium absorption from the soil important for peanut embryo and pod development. Similar results were also supported by Yang et al. [23]. Further the higher seed index was observed with application of GA_3 (120 ppm), this might be due to GA_3 prolonging the grain filling time as a result, it ensures long-term transport of photo-assimilates into grains, increases the 100 seed weight. This is in accordance with previous findings by Wang et al. [24].

3.2.4 Seed yield (t/ha)

The data stated that significant and higher seed yield (2.02 kg/ha) was recorded in the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, the treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 2). Significant and higher seed yield was observed with application of calcium (40kg/ha) might be due to the fact that calcium plays an important role in reproduction development of peanut crops with increased seed yield. Similar findings were in accordance with Sagar et al. [25]. Further the higher seed yield was observed with application of GA_3 (120 ppm), which may be due to the positive effect of GA_3 on improving yield by transferring more photo-assimilates to seeds. This is in agreement with the results of Varshitha et al. [26].

3.2.5 Stover yield (t/ha)

The data reported that significant and higher haulm yield (4.11 t/ha) was recorded with the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)]. However, the treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] which was found to be statistically at par to the treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm)] (Table 2). Significant and higher haulm yield was observed with the application of calcium (40kg/ha), which may be attributed to increased pod yield and haulm and higher Ca concentrations with increased gypsum content as a source of calcium, as a result the uptake of this nutrient by pod and haulm is increased, ultimately resulting in recording. Similar results were supported by Patro et al. [27]. Further the higher haulm yield was observed with the use of GA_3 (120 ppm). Gibberellic acid leads to increased plant height and branch numbers which also translated into higher number of leaves which invariably made up the haulm. These results were in conformity with those of Harb [28].

3.2.6 Harvest index (%)

Significant and higher harvest index (32.83 %) was recorded in the treatment 9 (Ca (40 kg/ha) + GA_3 (120 ppm)] [29]. However, the treatments 3 [Ca (20kg/ha) + GA_3 (120ppm) and treatment 5 [Ca (30 kg/ha) + GA_3 (80 ppm)] and treatment 6 [Ca (30 kg/ha) + GA_3 (120 ppm)] and treatment 7 [Ca (40kg/ha) + GA_3 (40 ppm)] and treatment 8 [Ca (40 kg/ha) + GA_3 (80 ppm)] was found statistically at par with treatment 9 [Ca (40 kg/ha) + GA_3 (120 ppm) (Table 1). Significant and higher harvest index was observed with the application of GA_3 (120ppm), which might be due to the higher harvest index indicating GA_3 application acceleration of anabolic feed to the sink. Similar findings have also been reported earlier by Akter et al. [22].

3.2.7 Economics

The results stated that maximum gross return (1,25,778.00 INR/ha), higher net return (87,853.50 INR/ha) and higher benefit cost ratio (2.32) was recorded in treatment 9 [Ca (40kg/ha) + GA_3 (120ppm)] as compared to other treatments (Table 3). Significant and maximum B:C ratio was observed with the application of Calcium (40kg/ha), which might be due to the application of gypsum as a source of Ca increase net returns and B:C ratio of harvesting peanuts with optimal nutrient utilization by gypsum during harvest leads to better growth and development of pods. Similar results were found by Sagar et al. [25].

Table 1. Influence of calcium and gibberellic acid on growth parameters of groundnut

S. No	Treatments	Plant height (cm)	Number of nodules/plant	Plant dry weight (g)	CGR (g/m^2/day)	RGR (g/g/day)
1	Ca 20 kg/ha + GA_3 40 ppm	56.60	13.73	41.90	17.23	0.0143
2	Ca 20 kg/ha + GA_3 80 ppm	58.23	14.70	43.15	17.39	0.0140
3	Ca 20 kg/ha + $GA_3$120 ppm	58.90	15.03	43.65	17.47	0.0140
4	Ca 30 kg/ ha + GA_3 40 ppm	57.13	14.06	42.44	17.85	0.0147
5	Ca 30 kg/ha + GA_3 80 ppm	59.26	15.53	43.95	16.84	0.0130
6	Ca 30 kg/ha + $GA_3$120 ppm	60.10	16.16	45.95	17.57	0.0130
7	Ca 40 kg/ ha + GA_3 40 ppm	58.03	14.23	42.73	17.77	0.0140
8	Ca 40 kg/ha + GA_3 80 ppm	59.53	15.86	44.84	17.79	0.0137
9	Ca 40 kg/ha + GA_3 120 ppm	60.43	16.40	45.71	17.46	0.0130
10	Control (RDF)	55.23	13.16	41.06	16.49	0.0183
	F-test	S	S	S	NS	NS
	SEm (±)	0.13	0.07	0.15	0.24	0.0002
	CD at 5%	0.41	0.23	0.45	0.72	0.0007

Table 2. Influence of calcium and gibberellic acid on yield and yield attributes of groundnut

S. No	Treatments	Number of pods/plant	Number of kernels/pod	Seed index (g)	seed yield (t/ha)	Haulm yield (t/ha)	Harvest index (%)
1	Ca 20 kg/ha + GA_3 40 ppm	20.15	1.27	31.26	1.62	3.54	31.47
2	Ca 20 kg/ha + GA_3 80 ppm	22.45	1.48	33.63	1.78	3.75	32.17
3	Ca 20 kg/ha + $GA_3$120 ppm	23.08	1.59	35.20	1.82	3.82	32.31
4	Ca 30 kg/ ha + GA_3 40 ppm	21.23	1.33	31.83	1.66	3.59	31.63
5	Ca 30 kg/ha + GA_3 80 ppm	23.55	1.66	35.90	1.85	3.88	32.28
6	Ca 30 kg/ha + $GA_3$120 ppm	24.05	1.87	37.66	1.96	4.10	32.33
7	Ca 40 kg/ ha + GA_3 40 ppm	21.57	1.41	33.03	1.73	3.63	32.31
8	Ca 40 kg/ha + GA_3 80 ppm	23.87	1.77	36.43	1.89	3.93	32.56
9	Ca 40 kg/ha + GA_3 120 ppm	24.60	1.93	37.80	2.01	4.11	32.83
10	Control (RDF)	18.63	1.20	31.13	1.58	3.46	31.35
	F-test	S	S	S	S	S	S
	SEm (±)	0.19	0.02	0.16	18.19	24.75	0.19
	CD at 5%	0.57	0.07	0.50	0.05	0.07	0.58

Table 3. Influence of calcium and gibberellic acid on the economics of groundnut

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1	Ca 20 kg/ha + GA_3 40 ppm	32,515.80	93,504.00	60,988.20	1.88
2	Ca 20 kg/ha + GA_3 80 ppm	34,915.80	1,02,748.00	67,832.20	1.94
3	Ca 20 kg/ha + GA_3 120 ppm	37,315.80	1,05,284.00	67,968.20	1.82
4	Ca 30 kg/ ha + GA_3 40 ppm	32,820.16	95,920.00	63,099.80	1.92
5	Ca 30 kg/ha + GA_3 80 ppm	36,220.16	1,06,754.00	70,533.80	1.95
6	Ca 30 kg/ha + GA_3 120 ppm	37,620.16	1,13,044.00	75,423.80	2.00
7	Ca 40 kg/ ha + GA_3 40 ppm	33,124.52	99,866.00	66,741.50	2.01
8	Ca 40 kg/ha + GA_3 80 ppm	35,524.52	1,09,062.00	73,537.50	2.07
9	Ca 40 kg/ha + GA_3 120 ppm	37,924.52	1,25,778.00	87,853.50	2.32
10	Control (RDF)	29,507.20	74,552.00	45,044.80	1.53

4. CONCLUSION

Based on above findings it can be concluded that application of calcium at 40 kg/ha along with foliar application of Gibberellic acid 120 ppm (Treatment 9), has performed better in growth, yield and benefit cost ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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