Original Research Article

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

ABSTRACT

A field experiment was conducted during*Zaid* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) to determine the Influence of calcium and gibberellicacid on growth, yield and economics of summer groundnut (*Arachis hypogea* L.). The results showed that treatment 9 [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 seedindex (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[Ca (40kg/ha) + GA_3 (120ppm)] as compared to other treatments.

Keywords: Groundnut, Calcium, Gibberellic acid, Growth, Yield and Economic

1. Introduction

The oilseed sector plays an important role in India's agriculture and economy. Nine oil annual seed crops serve as the main source of edible oil(Reference). Among soyabeans, peanuts, canola and mustard are the main culprits.(change word) 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 (Reference). The world's most important vegetable protein source. (pleasecorrect grammar and line construction)Contains 42-52% oil and 22-30% protein on a dry seed basis, phosphorus, calcium, magnesium and potassium(Reference). 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**(Asibuo*etal*., 2008).**(Reference of Ghana suddenly while talking about Indian productivity does not make sense, if you must, also give reference of other places around the world)

Groundnut is not only an important oilseed crop of India but also an important agricultural export commodity. Globally, Groundnut covers 315 lakh hectares with the production of 536 lakh tonnes with the productivity of 1701 kg/ha **(FAOSTAT, 2020).(PLAGIARISED)**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(Reference). In *Kharif* 2021-22(mention in English the months), groundnut production was 82.54 lakh tonnes in an area of 49.14 lakh hectares(Reference). Groundnut is cultivated in one or more (*kharif*, *rabi* and summer) seasons (name the seasons in English), but nearly 90% of acreage(??) and production comes from *kharif* crop (June-October).**(PLAGIARISED)**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 **(DAC,2020).**(please correct grammar and line construction)

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 very clear whether this problem of low yields is as a result of declining soil fertility or changes in climatic condition. Calcium is a soil nutrient deficient in Ghanaian soils.**(PLAGIARISED)**(Reference of Ghana suddenly while talking about Indian productivity does not make sense, if you must, also give reference of other places around the world). A lack of calcium increases the rate of seed breakage (empty pods or “pops”) and improperly packed pods **(Ntare*etal.*, 2008)**. It also leads to aborted or shrivelled fruit, including darkened plumules and production of pods without seed **(Singh and Oswalt, 1995)**.**(PLAGIARISED)**A sufficient amount of about it(??) should be present in the soil from early flowering in crop production **(Kamara, *et al.*, 2011).**

Effect of PGRs (please write in full and not acronyms when mentioning for the first time) 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 **[(Rahman and Nath (1993),Hossain*et al.* (2015)].**

Gibberellins are large group of plant hormones that stand alongside auxins are one of the main groups of plant regulators **(Bethke, 1998)**. They are all physiologically different activity and structure, and the firstgibberellin identified was gibberellic acid

(GA_3) (Reference). 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, pollenand seed development, retardation and inhibition of maturation, aging**(Mshelmbula,*et al.*, 2021)**. Given the above facts, the present investigation entitled, "Influence of calcium and gibberellic acid on the growth, yield and economics of summer groundnut (*Arachishypogaea*L.)"

2. MATERIALS AND METHODS:

This experiment was conducted at the Crop Research Farm during 2022*zaid*season(mention in English the months). 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)andgibberellic acid (40, 80, 120ppm/ha). Experiment was laid out in Randomized Block Design (RBD) with 3 repeats of 10 treatments. The treatment combinations are T1- Ca (20kg/ha) + GA_3 (40ppm), T2- Ca (20kg/ha) + GA_3 (80ppm), T3- Ca (20kg/ha) + GA_3 (120ppm), T4- Ca (30kg/ha) + GA_3 (40ppm), T5- Ca (30kg/ha) + GA_3 (80ppm), T6 - Ca (30kg/ha) + GA_3 (120ppm), T7- Ca (40kg/ha) + GA_3 (40ppm), T8- Ca (40kg/ha) + GA_3(80ppm), T9- Ca (40kg/ha) + GA_3 (120ppm), T10- Control N:P:K (20:60:40 Kg/ha). The growth, yieldandeconomicswas recorded at 80 DAS from randomly selected plants in each plot. The data were calculated and analysed by following statistical methods.**Gomez and Gomez (1984).**

3. RESULT AND DISSCUSSION

Growth parameters

Plant height (cm)

The data revealed thatsignificantly 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 statisticallyat parwith 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 increasesplant nutrient supply, played a important role in photosynthesis,carbohydrate metabolism, protein synthesis and synthesisgrowth stimulators, consequences of cell division, and cell elongation with would have resulted in increased height. These similar results areaggrement with those of**Mansingh*et al.* (2018).** 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 **Emongor (2007).**(please correct grammar and line construction)

Number of nodules/plant

The data found thatsignificantly 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 (120ppm)] 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 when applying calcium (40kg/ha), may be due to this using 25, 50, 75 and 100% gypsum as a Ca source. Peanut root weight, shoot weight and nodule number should be increased. Increased nitrogen in seed and haulm.(Line does not make any sense)These findings were in consistent with the reports of researchers **Ullah*et al.* (2019).** Additionally,highernumber 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.* (2004).**

Plant dry weight (g)

Results revealed thatsignificantly higher plant dry weight (45.71 g) 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).Significant and greatest plant dry weight was observed with calcium application (40kg/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 reportsas agreed by **Kamara*et al.* (2011).** Further, higher plant dry weight was observed with the application of GA_3 (120ppm), 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.* (2021).**

Crop Growth Rate (g/m^2/day)

The data recorded that during 60-80 DAS, significantly higher crop growth rate (17.85 g/m^2/day) was recorded intreatment 4 [Ca (30kg/ha) + GA_3(40ppm),and were not statistically equivalent value found.

Relative Growth Rate (g/g/day)

The data revealed that during 60 – 80 DAS, significantly highest relative growth rate (0.0183 g/g/day) was recorded intreatment 10[control (RDF)], and were not statistically equivalent value found.(?? Grammatical error)

Yield Attributes:

Number of pods/plant

The data found that significantly highernumber of pods/plant (24.60) was recorded in the treatment 9 [Ca (40kg/ha) + GA_3(120 ppm)] among all the treatments (Table 2). more pods/plant was observed withcalcium application (40kg/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.* (2013**

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 (40kg/ha), this might be due to calcium maintaining cell integrity, membrane permeability activatesand 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.* (2021).** Further higher kernels/pod was observed with application of GA_3 (120ppm), which might be due to the plant growth regulators such asgibberellic 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.* (2007).**

Seed index (g):

The data inferred that significantly higherseed 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 forpeanut embryo and pod development. Similar results were also supported by **Yang *et al.* (2017).** Further the higher seed index was observed with application of GA_3 (120ppm), this might be due to GA_3 prolonging the grain filling time as a result, it ensures long-term transport of photo-assimilates intograins,increases the 100 seed weight. This is in accordance with previous findings by**Wang *et al.* (2006).**

Seed yield (t/ha):

The data stated that significant and higherseed 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 agreed(Grammatical error) with**Sagar*et al.* (2020).** Further the higher seed yield was observed with application of GA_3 (120ppm), 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.* (2022).**

Stover yield (t/ha)

The data reported that significant andhigher 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.* (2016).** Further the higher haulm yield was observed with the use of GA_3 (120ppm). 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 (1992).**

Harvest index (%)

Significant and higher harvest index (32.83 %) was recorded in the treatment 9 (Ca(40 kg/ha) +GA_3(120ppm)]. However, the treatments 3 [Ca (20kg/ha)+ GA_3 (120ppm) andtreatment 5[Ca (30 kg/ha) + GA_3(80ppm)] and treatment 6 [Ca (30kg/ha) + GA_3 (120 ppm)] and treatment 7 [Ca (40kg/ha) + GA_3 (40 ppm)] and treatment 8 [Ca (40kg/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.*** (2007).

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.* (2020).**

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	23.95	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	Ca30 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

CONCLUSION (Conclusion should include a few more lines)

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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