Original Research Article

Growth of groundnut(*Arachis hypogaea* L.) as influenced by genotypes and sulphur levels

ABSTRACT

Groundnut is an important oilseed crop and belongs to the family Leguminosae. However, the productivity of groundnut in India is less as compared to average productivity of the world. The main cause of low groundnut production is an unbalanced and insufficient usage of nutrients. Because groundnut is a legume-oilseed crop, it has a high phosphorus, calcium, and Sulphur demand. Therefore, this field experiment was conducted during the *Kharif* season of 2023 at crop physiology field lab, Department of Agronomy, CCS Haryana Agricultural University, Hisar.The experiment was laid out in split plot design with four genotypes (G_1-MH 4, G_2-HNG 10, G_3-HNG 69, G_4- GNH 804) in main plots and four sulphur levels (S_1-Control, S_2-20 kg/ha, S_3-40 kg/ha, S_4-60 kg S/ha) in sub-plots with three replications.The findings demonstrate that genotypes and sulphur fertilizer yielded significant improvements in various aspects of groundnut growth parameters.These improvements encompassed increased plant height, root length, improved root-to-shoot ratio on a length and weight basis, greater numbers of root nodules per plant and dry weight of root nodules per plant.

Key words: Genotypes,groundnut, growth, nodules, sulphur

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the best-known oilseed crops and belongs to the family Leguminosae and sub-family Papilionaceae. It is believed that it originated in South America (Kamal *et al.,* 2023a; Hussainy*et al.,* 2023).Groundnut covers an area of 44.3 lakh ha with production of 86.5 lakh tonnes and productivity of 1953 kg ha^{-1} in India during 2023-24. The major groundnut producing states in India are Gujrat, Rajasthan and Tamil Nadu. Groundnut accounts for 31.7% of India total oilseed production and about 28.3 % of the cultivated area of total oilseeds (Kamal *et al.,* 2024b; Ali*et al.,* 2021).In India groundnut is grown in both the seasons i.e., *Kharif* and *Rabi*. But in Haryana groundnut is grown only in *Kharif* season over an area of 0.07 lakh ha with production and productivity of 0.08 lakh tonnes and 1080 kg ha^{-1}, respectively during 2023-24 (Anonymous, 2024).

There is less productivity of groundnut in India as compared to average productivity of world due to uncertainty in monsoon rainfall as well as different bio-stresses such as diseases, insect pests and weeds. The main cause of low groundnut production is an unbalanced and insufficient usage of nutrients. Because groundnut is a legume-oilseed crop, it has a high phosphorus, calcium, and sulphur demand (Kamal *et al.*, 2023b).Variety and sulphur are crucial for the physiological growth and yield of crops like groundnut. Selecting the appropriate variety is crucial for groundnut production. The adoption of high-yielding varieties has surged in recent years, bringing the country close to self-sufficiency in groundnut. Varieties suited to early *Kharif* differ significantly in growth habits compared to those suited for other seasons. Maintaining the optimum plant population per hectare for a given variety in a specific situation not only reduces cultivation costs but also maximizes the yield potential of the cultivar (Dileep *et al.*, 2021). Certain groundnut varieties have demonstrated that a poor source-to-sink relationship leads to the formation of more unfilled pods and a lower seed yield (Chandrasekaran *et al*., 2007). Variety isa key factor that affects the development, productivity, and quality of peanuts.

Sulphur plays a crucial role in several metabolic enzyme processes in plants, it affects productivity both quantitatively and qualitatively (Sheoran *et al.*, 2013). Sulphur is essential in the process of synthesis of amino acids that contain sulphur, such as methionine and cysteine and it plays an important role in the synthesis of proteins, chlorophyll and oil (Kamal *et al*., 2024a). The Sulphur containing enzyme is also responsible for the synthesis of vitamins (biotin and thiamine), as well as co-enzyme A and metabolism of carbohydrates, proteins and fats. Biomass partitioning is the most influential physiological factor in yield determination of groundnut.The high yield is associated with rapid increase in pod number and near cessation of vegetative growth during pod filling.Keeping in mind the aforementioned facts, the present study was undertaken to know the impact of different genotypes and sulphur levels on growth parameters of groundnut.

MATERIALS AND METHODS

The field experiment was conducted during the *Kharif* season of 2023 at crop physiology field lab, Department of Agronomy, CCS Haryana Agricultural University, Hisar.

Geographically, Hisar is situated at 29°10' N latitude and 75°46' E longitude at an elevation of 215 m above mean sea level. The total rainfall received during the crop growing period was 176.1 mm. Weekly maximum and minimum temperatures remained under a suitable range for different crop growth stages. Average temperature on sowing date for crop season was 35.2°C, while average temperature at harvesting was 24.9°C.On the other hand, mean weekly maximum and minimum temperatures ranged between 30.5-39.1°C and 15.6-28.3°C, respectively during crop season. The experiment was laid out in split plot design with four genotypes (G_1-MH 4, G_2-HNG 10, G_3-HNG 69, G_4- GNH 804) in main plots and four sulphurlevels (S_1-Control, S_2-20 kg/ha, 10, S_3-40 kg/ha, S_4-60 kg S/ha) in sub-plots with three replications.The soil of the field was sandy in texture, slightly alkaline in pH (8.1), EC (0.15 ds/m), low in organic carbon (0.12%), low in available N (130.8 kg/ha), medium in available P (17.9 kg/ha), medium in available K (138.8 kg/ha) and low in available S (21.4 kg/ha). Standard cultural practices were followed for all treatments which was recommended in groundnut crop.Plant height and root length were recorded at 30, 60, 90 DAS and at maturity. Three plants in each plot were selected randomly as true representative of the whole plot and were labeled. The height of the main shoot was measured from ground level to top of the shoot of the plant with the help of meter rod (cm) to determine plant height. Three plants from each replication were taken out with roots after thorough washing of the sand by gentle water jet. The root length of three plants was measured (cm) with metre rod and their average was determined for each treatment and expressed in cm. After that nodules of all the three plants were counted. Average of three plants was worked out and expressed as nodules per plant. After counting the nodules, they were removed from the roots and after sun drying, nodules were oven dried at 80 ºC for 72 hours and their dry weight was recorded. The average dry weight of the nodules per plant was worked out and expressed in mg per plant. The Root Shoot ratio was calculated at 30, 60, 90 DAS and at maturity. Root shoot ratio on length basis is calculated by dividing root length to shoot length. Root shoot ratio on weight basis is calculated by dividing dry weight of below ground plant parts (root, nodule) to dry weight of above ground plant parts (stem, leaves, pods).All the data recorded were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) for split plot design. At a 5% level of significance, the effect of treatments was examined using the least significant test.

RESULTS AND DISCUSSION

Plant height, root length, number of root nodules, dry weight of root nodules, root: shoot on length and weight basis, at 30, 60, 90DAS and at maturity as influenced by

(I) Genotypes:

The data pertaining to plant height of groundnut crop at different stages of crop growth are summarized in Table 1.A perusal of data in Table 1 depicted that irrespective of genotypes and sulphur levels plant height was continuously increased up to maturity but maximum increase was recorded between 30-60 DAS stage followed by marginal increase between 60 DAS to maturity.Plant height was significantly affected by genotypes at all the stages of observations. Among genotypes significant increase in plant height was recorded at all the stages of observations. Among genotypes significantly higher plant height at 30 DAS (14.06 cm), 60 DAS (37.06 cm), 90 DAS (51.90 cm) and maturity (53.70 cm) was recorded with GNH 804, which were 49.57, 23.94, 10.56 and 14.08 percent higher over MH 4, respectively.A delve to data given in Table 2 presented that root length increased rhythmically from sowing to 90 DAS and decreased thereafter up to maturity. Among genotypes the maximum root length was obtained with the GNH 804 which was significantly higher over MH 4 and was at par with HNG 69 and HNG 10 at 30 and 60 DAS. At maturity no significant increase in root length was observed. Root length of the GNH 804 was 15.09, 10.98, 9.70 and 4.81 per cent higher over MH 4 at 30, 60, 90 DAS and maturity, respectively.A disquisition to data given in Table 3 exhibited that irrespective of genotypes and sulphur levels number of root nodules per plant were continuously increased up to 90 DAS and then reduced at maturity but maximum increase was recorded between 30-60 DAS stage followed by marginal increase between 60 DAS to 90 DAS and then reduced at maturity. Number of root nodules per plant were significantly affected by genotypes at all the stages of observations. Among genotypes significant increase in number of root nodules per plant was recorded at all the stages of observations. Non-significant variation regarding number of root nodules per plant were observed between GNH 804 and HNG 69. Among genotypes significantly higher number of root nodules per plant at 30 DAS (13.75), 60 DAS (60.83), 90 DAS (80.25) and maturity (58.08) were recorded with GNH 804, which was 28.98,32.72, 17.58 and 14.44 percent higher over MH 4, respectively.

A delve to data exhibited in Table 4 revealed that irrespective of genotypes and sulphur levels dry weight of root nodules per plant was continuously increased up to 90 DAS and then reduced at maturity but maximum increase was recorded between 30-60 DAS stage followed by marginal increase between 60 DAS to 90 DAS and then reduced at maturity. Weight of root nodules per plant was significantly affected by genotypes at all the stages of observations. Among genotypes significant increase in dry weight of root nodules per plant was recorded at all the stages of observations. Non-significant variation regarding dry weight of root nodules per plant were observed between GNH 804 and HNG 69 at 90 DAS and at maturity and at 30 DAS non-significant variation was recorded among HNG 10, HNG 69 and GNH 804. Among genotypes significantly higher weight of root nodules per plant at 30 DAS (38.33 mg), 60 DAS (202.75 mg), 90 DAS (209.50 mg) and maturity (178.35 mg) was recorded in GNH 804 which was 13.67, 9.26, 9.54 and 9.71 percent higher over MH 4, respectively.A critical examination of data on root: shoot (length basis) of groundnut (Table 5) as influenced by different genotypes and sulphur levels indicated that the root: shoot (length basis) was maximum at 30 DAS which decreased with the advancement of crop growth up to maturity of crop. No marked differences in root: shoot (length basis) was observed at 30, 60 and 90 DAS between different genotypes. Root: shoot (length basis) was recorded significantly higher in MH 4 as compared to other genotypes, where it gave at par results with the genotype HNG 69. The lower root: shoot (length basis) at all stages was recorded in the groundnut GNH 804 genotype crop. The higher root: shoot (length basis) at maturity in order of 7.6, 8.5, 8.8 percent was recorded, in MH 4 compared to HNG 10, HNG 69, GNH 804 genotypes, respectively.A perusal of data in Table 6 depicted that no marked differences in root: shoot (weight basis) were observed at 30 and 60 DAS between different genotypes. Root: shoot (weight basis) of groundnut was maximum at 30 DAS which decreased with the advancement of crop growth up to the maturity. The preponderant effect of genotypic variation on various growth parameters (plant height, root length and number of root nodules) of groundnut due to increased utilization of carbohydrates for protein synthesis and physiological capacity to translocate them to organ of vegetative growth, resulting in increased plant growth and growth characteristics. Similar results have been reported by (Kalaiyarasan*et al*. 2019; Nurezannat*et al*. 2019).

(II) Sulphur levels:

An inquisition to data showed in Table1 strutted that sulphur levels have also affected plant height significantly at all the stages of observations. Plant height was significantly increased with increasing levels of sulphur from 0 to 60 kg/haat all the stages of observations but non-significant variation was observed between 40 and 60 kg/ha sulphur levels. Sulphur level of 60 kg/ha recorded significantly higher plant height at 30 DAS (13.62 cm), 60 DAS (35.41 cm), 90 DAS (51.35 cm) and maturity (52.91 cm) which were 28.24, 7.20, 6.93, 7.49 percent higher over control, respectively.The data pertaining to Table 2 showed that with the increasing levels of sulphur root length increased at all stages and the maximum root length i.e. 57.00 cm, 81.25 cm, 93.33 cm and 73.58 cm at 30, 60, 90 DAS and maturity, respectively were observed in the plot receiving treatment of 60 kg S/ha closely followed by 40 kg S/ha.A probe to data presented in Table 3 unveiled that sulphur levels also affected number of root nodules per plant significantly at all the stages of observations. Number of root nodules per plant were significantly increased with increasing levels of sulphur from 0 to 60 kg/ha at all the stages of observations but non-significant variation was observed between 40 and 60 kg/ha sulphur levels and at 30 DAS non-significant variation was recorded between 20-40 kg/ha also. Sulphur level of 60 kg/ha recorded significantly higher number of root nodules per plant at 30 DAS (12.91), 60 DAS (57.75), 90 DAS (78.25) and maturity (57.33) which were 9.87, 14.92, 11.13, 10.6 percent higher over control, respectively.An inquisition to data showed in Table 4 strutted that sulphur levels also affected dry weight of root nodules per plant significantly at all the stages of observations. Dry weight of root nodules per plant were significantly increased with increasing levels of sulphur from 0 to 60 kg/ha at all the stages of observations but non-significant variation was observed between 20-40 kg/ha and 40-60 kg/ha sulphur levels at 90 DAS and at maturity. Non-significant variation was recorded among all the sulphur levels at 30 DAS. Sulphur level of 60 kg/ha recorded significantly higher number of root nodules per plant at 60 DAS (200.00 mg), 90 DAS (205.25 mg) and maturity (175.68 mg), which were 6.09, 4.26 and 5.09 Percent higher over control, respectively.A delve to data exhibited in Table 5 unveiled that significant differences for root: shoot (length basis) among sulphur levels were recorded at 30 DAS, while non significant difference was recorded at 60 DAS, 90 DAS and at maturity. The higher root: shoot (length basis) was attained by control at 30 DAS (5.167), 60 DAS (1.85) 90 DAS (1.85) and at maturity (1.463).A delve to data given in Table 6 presented that no marked differences in root: shoot (weight basis) were observed at 30 DAS between sulphur levels. The higher root: shoot (weight basis) at 30 DAS (0.401), 60 DAS (0.178), 90 DAS (0.097) was recorded in control, while at maturity (0.031) recorded at 60 kg S/ha, compared to other sulphur levels.

The increased growth may be related to sulphur ability to promote more easily formed roots, which in turn encouraged greater uptake of sulphur and other essential nutrients from the soil and work on metabolic movement within the plant, which may be the reason for the increase in plant height and root length.A decrease in shoot growth and an increase in the allocation of carbon from shoots to roots under control are the main causes of the rise in the root/shoot ratio.The maximum number of nodules and dry weight of root nodules increase with successive increase in sulphur levels might be attributed to sulphur, which is a secondary essential plant nutrient required for growth and development. Sulphur plays a crucial role in many physiological and biochemical processes that are essential for plant development, its application to deficient soil can promote overall growth. Sulphur is linked to the enhancement of amino acids and vitamins that contain sulphur and has a direct impact on the growth and nodulation of roots. Stronger apical development and an extension of the photosynthetic surface appear to be the results of increased metabolic activity in plants, which could explain the significant impact of sulphur fertilizer on the number of nodules. The observed association closely matches the results of Kamal *et al*. 2024a; Kamal *et al*. 2024b.

CONCLUSION

The results of the present study revealed that genotypes and sulphur application significantly improved the growth parametersin groundnut.Among genotypes GNH 804 resulted insignificantly higher variation for most of the studied parameters followed by HNG 69.Among sulphur levels, 60 kg S/ha recorded significantly higher variation for most of the studied parametersclosely followed by sulphur level 40 kg S/ha.So, based on the observed findings, it could be concluded that genotype GNH 804 fertilized with 40 kg S/ha, was most suitable for obtaining the better growth of groundnut.

REFERENCES

Ali, M. A., Pal, A. K., Baidya, A. and Gunri, S. K. (2021). Variation in dry matter production, partitioning, yield and its correlation in groundnut (*Arachis hypogaea* L.) genotypes. *Legume Research- An International Journal*.**44**(6): 706-11.

Anonymous (2024). Department of Economics and Statistics, Ministry of Agriculture Cooperation and Farmers Welfare, Government of India.

Chandrasekaran, R., Somasundaram, E., Amanullah, K., Thirukumaran, K. and Sathyamoorthi, K. (2007). Influence of varieties and plant spacing on the growth and yield of confectionery groundnut (*Arachis hypogaea* L.). *Research Journal of Agriculture and Biological Sciences*. **3**(5): 525-528.

Dileep, D., Singh, V., Tiwari, D., George, S. G. and Swathi, P. (2021). Effect of Variety and Sulphur on Growth and Yield of Groundnut (*Arachis hypogaea* L.). *Biological Forum- An International Journal*, **13**(1): 475-478.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research, IRRI: *A Wiley Pub*., New York. pp. 199-201.

Hussainy, S. A. H., Brindavathy, R. and Vaidyanathan, R. (2023). Influence of irrigation regimes on the performance of groundnut (*Arachis hypogaea*) under intercropping situation. *Legume Res*. **46**(4): 496-501. *doi:10.18805/LR-4389.*

Kalaiyarasan, C., Gandhi, G., Vaiyapuri, V., Sriramachandrasekharan, M. V., Jawahar, S., Suseendran, K., Ramesh, S., Elankavi, S. and Kanagaraj, R. (2019). Growth and yield of sunflower genotypes to sulphur fertilization grown under veeranam ayacut regions. *Plant Archives*, **19**(2): 2527-2530.

Kamal, Dhaka, A.K., Kamboj, E., Sharma, A.,Ravi and Preeti (2024a).Effect of Phosphorus and Sulphur Levels on Yield Attributes, Yield and Quality of Groundnut (*Arachis hypogaea* L.). *Agricultural Science Digest*, DOI: 10.18805/ag.D-5947.

Kamal, Dhaka, A. K., Prakash, R., Sharma, A. and Dhaka, B. K. (2023b). Effect of Phosphorus and Sulphur Levels on Nutrient Content and Uptake of Groundnut (*Arachis hypogaea* L.). *BiologicalForum–An International Journal*, **15**(2): 1023-1026. *doi:10.13140/RG.2.2.19270.24641*.

Kamal, Dhaka, A. K., Singh, B., Kamboj, E., Preeti and Sharma, A. (2024b). Effect of phosphorus and sulphur levels on biomass partitioning in groundnut (*Arachis hypogaea* L.). *Research onCrops*, **25**(1): 57-64. *doi:10.31830/2348-7542.2024.ROC-1031*.

Kamal, Kamboj, E., Sharma, A., Ravi, Dhaka, B.K. and Preeti. (2023a). Effect of Phosphorus Application on Groundnut (*Arachis hypogaea* L.): A Review. *International Journal of Plant & Soil Science*, **35**(18):1536-1544. doi:*10.9734/ijpss/2023/v35i183423.*

Nurezannat, Sarkar, Md. A.R., Uddin, Md. R., Sarker, U. K., Kaysar Md. S. and Saha, P. K. (2019). Effect of variety and sulphur on yield and yield components of groundnut. *Journal of Bangladesh Agricultural University*, **17**(1): 1-8.

Sheoran, P., Sardana, V., Singh, S., Sheoran, O. P. and Raj, D. (2013). Optimizing Sulphur application in sunflower (*Helianthus annuus*) under irrigated semi-arid tropical conditions. *Indian Journal of Agronomy*.**58**(3): 384–90. *doi:10.59797/ija.v58i3.4204.*

Table: 1. Effect of sulphur levels on plant height (cm) of groundnut genotypes

Treatment	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**
Genotypes				
MH 4	9.40	29.90	46.94	47.07
HNG 10	12.77	34.21	50.09	52.05
HNG 69	13.66	36.31	51.19	53.18
GNH 804	14.06	37.06	51.90	53.70
SEm ±	0.08	0.23	0.25	0.28
CD at 5%	**0.29**	**0.83**	**0.88**	**0.98**
Sulphur levels (kg S /ha)				
Control	10.62	33.03	48.02	49.22
20	12.24	34.06	49.76	51.34
40	13.41	34.99	50.99	52.53
60	13.62	35.41	51.35	52.91
SEm ±	0.59	0.28	1.11	0.39
CD at 5%	**0.19**	**0.83**	**0.38**	**1.15**

Table: 2. Effect of sulphur levels on root length (cm) of groundnut genotypes

Treatment	Root length (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**
Genotypes				
MH 4	50.75	73.74	86.58	70.75
HNG 10	55.42	78.39	91.00	72.83
HNG 69	57.25	80.84	94.00	73.75
GNH 804	58.41	81.84	94.98	74.16
SEm ±	1.09	0.90	0.76	0.72
CD at 5%	**3.84**	**3.17**	**2.69**	**NS**
Sulphur levels (kg S /ha)				
Control	53.16	74.71	88.75	71.66
20	55.25	78.38	91.68	72.83
40	56.41	80.46	92.75	73.42
60	57.00	81.25	93.33	73.58
SEm ±	0.58	0.727	0.86	0.707
CD at 5%	**1.70**	**2.13**	**2.53**	**NS**

Table: 3. Effect of sulphur levels on number of root nodules per plant of groundnut genotypes

Treatment	Number of root nodules per plant			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**
Genotypes				
MH 4	10.66	45.83	68.25	50.75
HNG 10	12.41	53.41	73.50	54.33
HNG 69	13.58	58.08	78.00	57.41
GNH 804	13.75	60.83	80.25	58.08
SEm ±	0.20	1.22	0.90	0.74
CD at 5%	**0.71**	**4.33**	**3.20**	**2.62**
Sulphur levels (kg S /ha)				
Control	11.75	50.25	70.41	51.83
20	12.83	53.66	74.25	54.58
40	12.91	56.50	77.08	56.83
60	12.91	57.75	78.25	57.33
SEm ±	0.31	0.85	0.89	0.74
CD at 5%	**0.93**	**2.51**	**2.62**	**2.19**

Table: 4. Effect of sulphur levels on dry weight of root nodules (mg/plant) of groundnut genotypes

Treatment	Dry weight of root nodules (mg/plant)			
	30 DAS	**60 DAS**	**90 DAS**	**Maturity**
Genotypes				
MH 4	33.72	185.56	191.24	162.56
HNG 10	36.60	193.25	200.10	173.24
HNG 69	37.50	198.29	206.87	175.86
GNH 804	38.33	202.75	209.50	178.35
SEm ±	0.50	1.37	1.71	3.83
CD at 5%	**1.93**	**4.82**	**6.06**	**2.50**
Sulphur levels (kg S /ha)				
Control	35.68	188.51	196.85	167.17
20	36.40	193.34	201.50	172.43
40	36.75	198.00	204.12	174.67
60	37.33	200.00	205.25	175.68
SEm ±	0.41	1.35	1.46	1.30

CD at 5%	NS	3.98	4.28	3.83

Table: 5.Effect of sulphur levels on root: shoot (length basis) of groundnut genotypes

Treatment	Root: Shoot (length basis)			
	30 DAS	60 DAS	90 DAS	Maturity
Genotypes				
MH 4	5.596	2.468	1.830	1.5.06
HNG 10	4.355	2.293	1.807	1.399
HNG 69	4.213	2.227	1.837	1.388
GNH 804	4.169	2.210	1.803	1.383
SEm ±	0.089	0.029	0.016	0.02
CD at 5%	**0.312**	**0.102**	**NS**	**0.069**
Sulphur levels (kg S /ha)				
Control	5.167	2.273	1.85	1.463
20	4.696	2.310	1.842	1.421
40	4.241	2.311	1.820	1.400
60	4.230	2.304	1.819	1.392
SEm ±	0.144	0.028	0.024	0.019
CD at 5%	**0.422**	**NS**	**NS**	**NS**

Table: 6. Effect of sulphur levels on root: shoot (weight basis) of groundnut genotypes

Treatment	Root: Shoot (Weight basis)			
	30 DAS	60 DAS	90 DAS	Maturity
Genotypes				
MH 4	0.416	0.160	0.100	0.020
HNG 10	0.352	0.161	0.091	0.030
HNG 69	0.335	0.161	0.091	0.034
GNH 804	0.357	0.158	0.093	0.034
SEm ±	0.037	0.002	0.001	0.000

CD at 5%	**NS**	**NS**	**0.002**	**0.002**
Sulphur levels (kg S /ha)				
Control	0.401	0.178	0.097	0.026
20	0.368	0.159	0.093	0.030
40	0.338	0.149	0.092	0.031
60	0.354	0.154	0.093	0.031
SEm ±	0.039	0.002	0.001	0.001
CD at 5%	**NS**	**0.006**	**0.002**	**0.002**