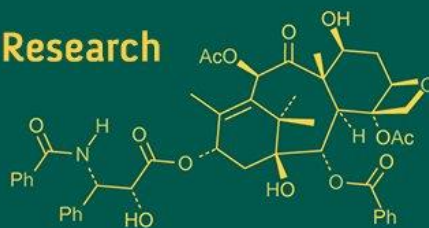


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Influence of phosphogypsum on growth, yield attributes and yield of groundnut (*Arachis hypogaea* L.)

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Abstract

A field experiment was conducted to evaluate the influence of Phosphogypsum on growth, yield attributes, yield and quality of groundnut. The experimental soil was slightly alkaline in reaction with pH 7.4 and contained available nitrogen 255.4 kg/ha, available phosphorus 18.5 kg ha⁻¹ and exchangeable potassium 213.0 kg/ha before sowing. Four Phosphogypsum levels, namely 200, 300, 400 and 500 kg/ha were evaluated. Growth observations were recorded at 100 DAS, whereas yield attributes and yield were recorded after harvest. At 100 DAS, Phosphogypsum at 300 kg ha⁻¹ recorded the highest plant height (43.543 cm), nodules plant⁻¹ (39.583), branches plant⁻¹ (11.048), dry weight (27.302 g plant⁻¹) and crop growth rate (0.272 g m⁻² day⁻¹). Post-harvest observations also showed the best mean performance at 300 kg ha⁻¹ for pods plant⁻¹ (18.60), seed yield (2641.8 kg ha⁻¹), haulm yield (6182.4 kg ha⁻¹), seed index (39.92 g), oil content (40.82%) and corrected calculated oil yield (1078.38 kg ha⁻¹). The 300 kg ha⁻¹ dose was significantly higher than 200 kg/ha for major growth and yield traits and was generally statistically at par with 400 and 500 kg/ha. Thus, phosphogypsum at 300 kg/ha appeared to provide an effective calcium-sulphur environment for groundnut growth, pegging, pod development and kernel filling under the tested field condition.

Keywords: Groundnut, phosphogypsum, calcium, sulphur, seed yield, oil yield

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed legume valued for edible kernels, vegetable oil and nutrient-rich haulm. Its reproductive habit is distinct because flowering occurs above ground, whereas peg penetration, pod development and seed filling occur below the soil surface. Therefore, nutrient availability in the pegging zone is central to pod setting and kernel development (Ariraman and Kalaichelvi, 2020; Singh *et al.*, 2025) ^[1, 9].

Phosphogypsum is a calcium sulphate-based by-product of wet-process phosphoric acid production and is used in agriculture mainly as a source of calcium and sulphur. Depending on material quality and purity, phosphogypsum or gypsum materials supply agronomically useful calcium and sulphur, making them relevant for crops having high Ca-S demand (Korcak, 1998; Chen and Dick, 2011) ^[2, 6].

Calcium is required by developing pegs and pods for shell formation, kernel development and seed quality, while sulphur is involved in chlorophyll formation, enzyme activity, protein metabolism and oil synthesis. Earlier studies on sulphur and gypsum-based amendments in groundnut have reported improvement in dry matter production, pod number, nutrient uptake, yield and quality when Ca-S nutrition is balanced (Jamal *et al.*, 2006; Laxmanarayanan *et al.*, 2020; Laxmanarayanan *et al.*, 2022) ^[4, 7, 8].

The importance of phosphogypsum in groundnut is linked with the limited phloem mobility of calcium. Developing pods require a direct supply of available calcium from the surrounding soil in the peg and pod zone. Application before or during the pegging phase can enrich this zone with soluble calcium and may help reduce unfilled pods, weak shells and kernel shrivelling under calcium-limited conditions (Chen and Dick, 2011; Singh *et al.*, 2025) ^[2, 9].

The sulphur supplied through phosphogypsum is also important because groundnut, being an oilseed legume, has a marked requirement for sulphur during vegetative growth and seed development. Sulphur participates in the formation of sulphur-containing amino acids, chlorophyll, enzymes and oil-related metabolic processes. Adequate sulphur nutrition supports photosynthate production and its movement towards developing pods, which may improve pod filling, seed yield and oil yield (Jamal *et al.*, 2006; Kannan *et al.*, 2017; Ariraman and Kalaichelvi, 2020) ^[1, 4, 5]. Another practical advantage of phosphogypsum is

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that it acts mainly as a calcium-sulphur amendment rather than as a strong liming material. Thus, it can supply Ca and S without sharply increasing soil pH, which is useful where nutrient correction is required without major pH alteration. Calcium sulphate amendments may also improve root-zone ionic balance and favour nutrient uptake, thereby supporting biomass accumulation and reproductive development under field conditions (Korcak, 1998; Chen and Dick, 2011; Laxmanarayanan *et al.*, 2020) [2, 6, 7].

From a resource-use perspective, properly characterized phosphogypsum provides a way to recycle a by-product of the phosphate fertilizer industry as an agricultural input. Its value in groundnut lies in combining calcium supply for peg and pod development with sulphur supply for oilseed metabolism, provided material quality and recommended field doses are followed (Korcak, 1998; Chen and Dick, 2011) [2, 6]. However, groundnut response to phosphogypsum is expected to be dose dependent. A low dose may not fully correct Ca-S limitation in the root and pegging zone, whereas a higher dose may not produce additional benefit once crop demand is satisfied. Therefore, the present investigation was undertaken to compare four phosphogypsum levels for growth at 100 DAS and post-harvest yield performance of groundnut.

Materials and Methods

The field study was conducted during the *kharif* season under the agro-climatic condition of Prayagraj, Uttar

Pradesh. Groundnut was grown following recommended agronomic practices, and phosphogypsum was applied according to the assigned treatment levels. The manuscript presents treatment-wise response to four phosphogypsum levels.

Before sowing, the experimental soil was slightly alkaline with pH 7.4. The available nutrient status showed available nitrogen 255.4 kg ha⁻¹, available phosphorus 18.5 kg ha⁻¹ and exchangeable potassium 213.0 kg ha⁻¹. These values described the initial fertility background of the crop season.

The treatments comprised four levels of phosphogypsum: PG @ 200 kg ha⁻¹, PG @ 300 kg ha⁻¹, PG @ 400 kg ha⁻¹ and PG @ 500 kg ha⁻¹. Observations on plant height, nodules plant⁻¹, branches plant⁻¹, dry weight and crop growth rate were recorded at 100 DAS. Post-harvest observations included pods plant⁻¹, seed yield, haulm yield, shelling percentage, harvest index, seed index, oil yield and oil content.

The data were interpreted using standard analysis of variance procedures. The standard error of mean [SE(m)] and critical difference [C.D. (P = 0.05)] were used for comparing treatment means wherever treatment effects were significant. For traits marked as non-significant (NS), numerical differences were described only as trends and were not used for claiming statistical superiority (Gomez and Gomez, 1984) [3].

Results and Discussion

Table 1: Effect of phosphogypsum on growth parameters of groundnut at 100 DAS

Treatment	Plant height (cm)	Nodules plant ⁻¹	Branches plant ⁻¹	Dry weight (g plant ⁻¹)	CGR (g m ⁻² day ⁻¹)
PG @ 200 kg ha ⁻¹	38.982	35.417	10.013	24.440	0.244
PG @ 300 kg ha ⁻¹	43.543	39.583	11.048	27.302	0.272
PG @ 400 kg ha ⁻¹	43.039	39.133	8.813	26.987	0.269
PG @ 500 kg ha ⁻¹	42.880	38.958	8.439	26.884	0.268
SE(m)	1.091	0.968	0.352	0.683	0.0067
C.D. (P = 0.05)	2.722	2.414	0.878	1.705	0.017

Note: Growth observations were recorded at 100 DAS

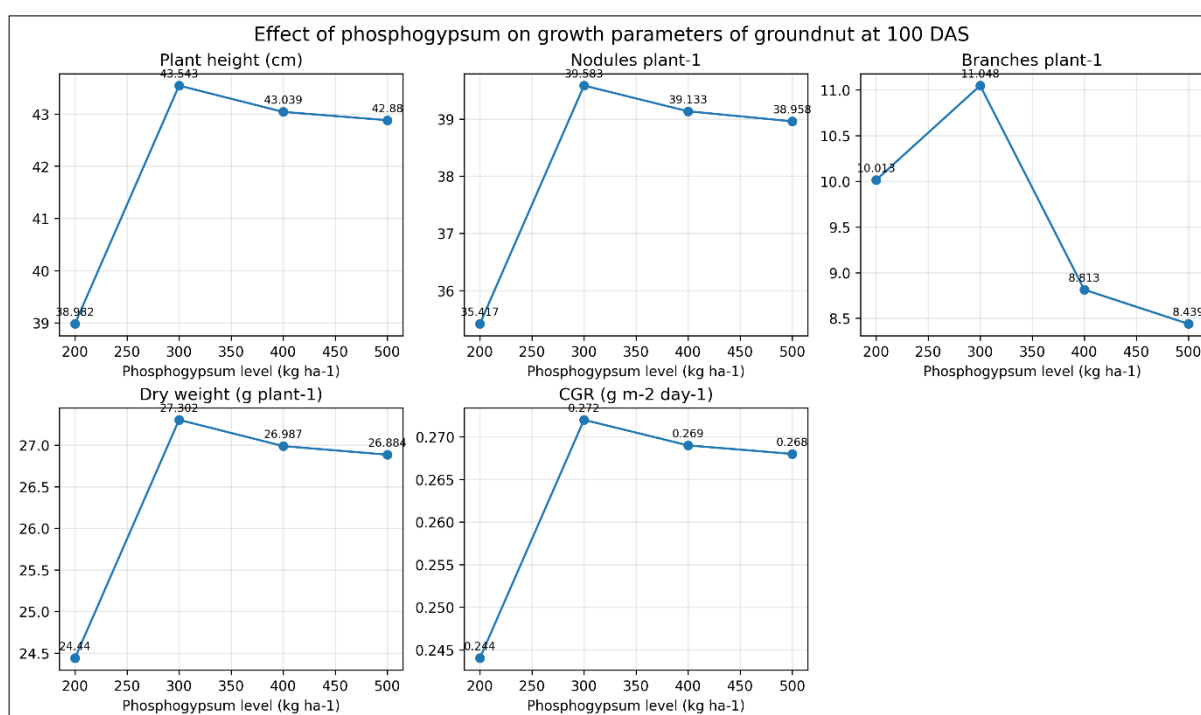


Fig 1: The graph represents the response of five growth traits of groundnut to increasing phosphogypsum levels at 100 DAS. Each panel has its own y-axis; therefore, the figure should be interpreted trait-wise

Growth parameters of groundnut

Plant height: Phosphogypsum at 300 kg ha⁻¹ recorded significantly higher plant height (43.543 cm) than 200 kg ha⁻¹, while it was statistically at par with 400 kg ha⁻¹ (43.039 cm) and 500 kg ha⁻¹ (42.880 cm). The improvement may be due to better calcium and sulphur availability, which supports cell division, chlorophyll formation and vegetative growth in groundnut (Ariraman and Kalaichelvi, 2020; Laxmanarayanan *et al.*, 2022) ^[1, 8].

Number of nodules plant⁻¹: The maximum nodules plant⁻¹ were recorded with phosphogypsum at 300 kg ha⁻¹ (39.583), which was significantly higher than 200 kg ha⁻¹ and statistically at par with 400 kg ha⁻¹ (39.133) and 500 kg ha⁻¹ (38.958). The favourable response may be attributed to improved root-zone calcium and sulphur supply, which encourages root activity, nodule development and biological nitrogen fixation in legumes (Ariraman and Kalaichelvi, 2020; Laxmanarayanan *et al.*, 2022) ^[1, 8].

Number of branches plant⁻¹: Phosphogypsum at 300 kg ha⁻¹ produced significantly higher branches plant⁻¹ (11.048)

than 200, 400 and 500 kg ha⁻¹. This may be because optimum Ca-S supply at 300 kg ha⁻¹ improved vegetative vigour and canopy development, whereas higher doses did not further promote branch initiation (Laxmanarayanan *et al.*, 2022) ^[8].

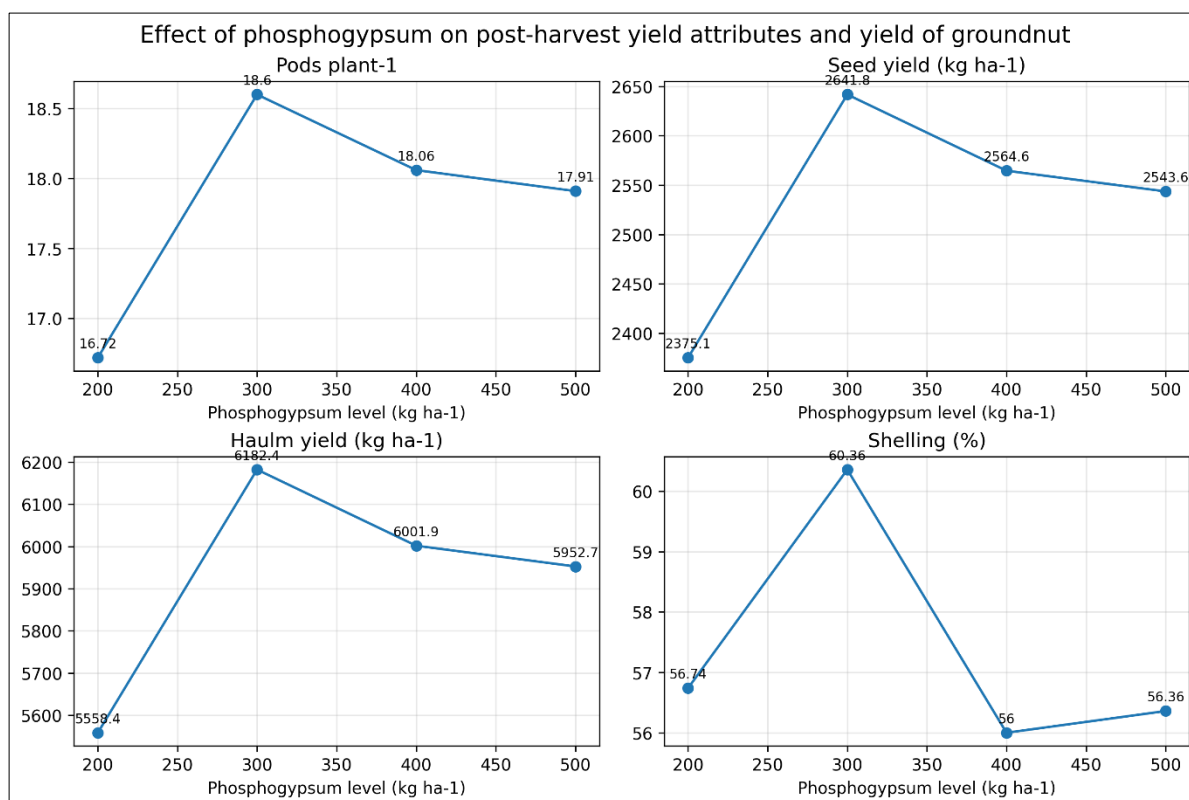
Dry weight: The highest dry weight was observed under 300 kg ha⁻¹ (27.302 g plant⁻¹), which was significantly higher than 200 kg ha⁻¹ and statistically at par with 400 kg ha⁻¹ (26.987 g plant⁻¹) and 500 kg ha⁻¹ (26.884 g plant⁻¹). The increase in dry matter may be related to better photosynthetic activity and nutrient movement under balanced calcium and sulphur nutrition (Kannan *et al.*, 2017; Laxmanarayanan *et al.*, 2022) ^[5, 8].

Crop growth rate: Crop growth rate was highest at 300 kg ha⁻¹ (0.272 g m⁻² day⁻¹), which was significantly higher than 200 kg ha⁻¹ and statistically at par with 400 kg ha⁻¹ (0.269 g m⁻² day⁻¹) and 500 kg ha⁻¹ (0.268 g m⁻² day⁻¹). This response indicates that moderate Ca-S supply supported biomass accumulation during active crop growth (Kannan *et al.*, 2017) ^[5].

Table 2: Effect of phosphogypsum on yield attributes and yield of groundnut at post-harvest

Treatment	Pods plant ⁻¹	Seed yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	Shelling (%)	Harvest index (%)	Seed index (g)	Oil yield (kg ha ⁻¹)	Oil content (%)
PG @ 200 kg ha ⁻¹	16.72	2375.1	5558.4	56.74	29.94	37.52	914.89	38.52
PG @ 300 kg ha ⁻¹	18.60	2641.8	6182.4	60.36	29.94	39.92	1078.38	40.82
PG @ 400 kg ha ⁻¹	18.06	2564.6	6001.9	56.00	29.94	37.03	975.06	38.02
PG @ 500 kg ha ⁻¹	17.91	2543.6	5952.7	56.36	29.94	37.27	965.55	37.96
SE(m)	0.364	51.686	120.95	2.140	NS	1.415	NS	1.187
C.D. (P = 0.05)	0.907	128.92	301.71	NS	NS	NS	NS	NS

Note: Oil yield and harvest index values were corrected using the formulas given in Materials and Methods. NS-Non-Significant. exact SE(m) and C.D. for corrected oil yield should be finalized after recalculating oil yield replication-wise. NS indicates non-significant treatment effect at P = 0.05



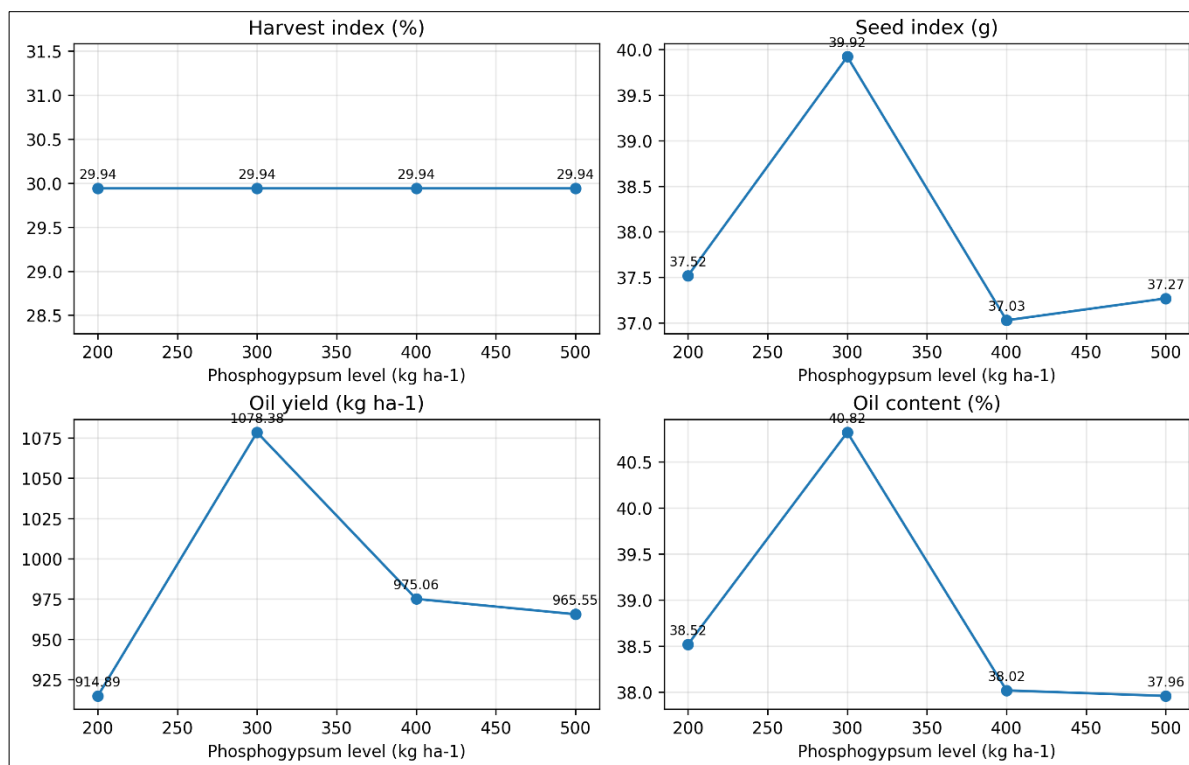


Fig 2: The graph represents post-harvest yield attributes, yield and quality traits of groundnut under four phosphogypsum levels.

Post-harvest yield attributes, yield and quality

Number of pods plant⁻¹: Phosphogypsum at 300 kg ha⁻¹ recorded significantly higher pods plant⁻¹ (18.60) than 200 kg ha⁻¹ and remained statistically at par with 400 kg ha⁻¹ (18.06) and 500 kg ha⁻¹ (17.91). The increase in pod number may be due to adequate calcium in the pegging zone, which supports peg penetration, pod retention and pod development (Laxmanarayanan *et al.*, 2020; Laxmanarayanan *et al.*, 2022) [7, 8].

Seed yield: The highest seed yield was recorded with 300 kg ha⁻¹ phosphogypsum (2641.8 kg ha⁻¹), which was significantly higher than 200 kg ha⁻¹ but statistically at par with 400 kg ha⁻¹ (2564.6 kg ha⁻¹) and 500 kg ha⁻¹ (2543.6 kg ha⁻¹). The higher seed yield may be explained by better pod filling and kernel development under adequate calcium and sulphur supply (Laxmanarayanan *et al.*, 2020; Laxmanarayanan *et al.*, 2022) [7, 8].

Haulm yield: Phosphogypsum at 300 kg ha⁻¹ gave significantly higher haulm yield (6182.4 kg ha⁻¹) than 200 kg ha⁻¹ and was statistically at par with 400 kg ha⁻¹ (6001.9 kg ha⁻¹) and 500 kg ha⁻¹ (5952.7 kg ha⁻¹). This response may be due to improved vegetative biomass production, as calcium and sulphur support cell development, chlorophyll formation and dry matter accumulation (Kannan *et al.*, 2017; Laxmanarayanan *et al.*, 2022) [5, 8].

Shelling percentage: Shelling percentage was numerically highest at 300 kg ha⁻¹ (60.36%), but the treatment effect was non-significant; therefore, all phosphogypsum levels were statistically at par for this trait. The numerical improvement may be associated with better kernel filling under calcium and sulphur nutrition, although this dataset does not support a significant claim (Jamal *et al.*, 2006; Laxmanarayanan *et al.*, 2020) [4, 7].

Harvest index: Corrected harvest index values were almost identical among treatments because seed yield and haulm yield increased proportionately. Therefore, the data do not support a significant treatment effect on harvest index. This indicates that phosphogypsum improved economic and biological yield without causing a clear shift in dry matter partitioning (Gomez and Gomez, 1984; Laxmanarayanan *et al.*, 2020) [3, 7].

Seed index: Seed index was numerically higher under 300 kg ha⁻¹ (39.92 g), but the treatment effect was non-significant and all phosphogypsum levels were statistically at par. The observed trend may reflect better seed filling at the optimum Ca-S dose, but seed-size response requires confirmation through repeated-season data (Jamal *et al.*, 2006; Laxmanarayanan *et al.*, 2022) [4, 8].

Oil yield: Corrected calculated oil yield was highest under 300 kg ha⁻¹ (1078.38 kg ha⁻¹), followed by 400 kg ha⁻¹ (975.06 kg ha⁻¹), 500 kg ha⁻¹ (965.55 kg ha⁻¹) and 200 kg ha⁻¹ (914.89 kg ha⁻¹). Since replicated raw oil-yield values were not available in the uploaded document, statistical superiority for corrected oil yield should be finalized only after recalculating oil yield replication-wise. The numerical increase was mainly due to higher seed yield and higher oil content at 300 kg ha⁻¹, while sulphur may also support oil-forming metabolic pathways in groundnut seed (Jamal *et al.*, 2006; Ariraman and Kalaichelvi, 2020) [1, 4].

Oil content: Oil content was numerically maximum at 300 kg ha⁻¹ (40.82%), but the effect was non-significant and all phosphogypsum levels were statistically at par. Since sulphur is involved in oil synthesis, the numerical trend is physiologically reasonable; however, the significant advantage of phosphogypsum was expressed more clearly through seed yield than through oil percentage (Jamal *et al.*, 2006; Ariraman and Kalaichelvi, 2020) [1, 4].

Overall Discussion

The results indicate a clear improvement in groundnut performance up to 300 kg ha⁻¹ phosphogypsum. For several important traits, the 300 kg ha⁻¹ dose was significantly higher than the lowest level and statistically at par with the two higher doses, showing that 400 and 500 kg ha⁻¹ did not give an additional measurable advantage. This pattern is agronomically meaningful because groundnut needs calcium near the pegging zone for pod and kernel formation, while sulphur contributes to chlorophyll development, enzyme activity, protein metabolism and oil synthesis. Once the crop requirement was likely met at 300 kg ha⁻¹, further application may have produced only marginal or non-significant changes. Similar improvements in growth, nutrient uptake, pod yield and quality of groundnut with gypsum or sulphur-based amendments have been reported earlier (Jamal *et al.*, 2006; Laxmanarayanan *et al.*, 2020; Laxmanarayanan *et al.*, 2022) [4, 7, 8].

Summary

Phosphogypsum at 300 kg ha⁻¹ recorded the highest values for plant height, nodules plant⁻¹, branches plant⁻¹, dry weight and CGR at 100 DAS. At post-harvest, the same dose produced the maximum pods plant⁻¹, seed yield, haulm yield, seed index, oil content and corrected calculated oil yield. Statistical comparison showed that 300 kg ha⁻¹ was significantly higher than 200 kg ha⁻¹ for major traits such as plant height, nodulation, dry weight, CGR, pods plant⁻¹, seed yield and haulm yield, and it remained statistically at par with 400 and 500 kg ha⁻¹ for most of these characters. Corrected harvest index showed almost no treatment variation because seed and haulm yield changed proportionately.

Conclusion

Based on the findings, phosphogypsum at 300 kg ha⁻¹ was the most effective dose among the tested levels for improving growth and yield performance of groundnut. It gave significant improvement over 200 kg ha⁻¹ for major growth and yield traits and was generally statistically at par with 400 and 500 kg ha⁻¹, indicating that higher doses were not agronomically necessary under the tested condition. The treatment may therefore be considered a suitable Ca-S nutrition option for groundnut under the tested field condition, subject to location-specific validation and final verification of calculated oil-yield statistics from replication-wise data.

References

1. Ariraman R, Kalaichelvi K. Effect of sulphur nutrition in groundnut: a review. *Agricultural Reviews*. 2020;41(2):132-138.
2. Chen L, Dick WA. Gypsum as an agricultural amendment: general use guidelines. Columbus (OH): Ohio State University Extension; 2011. Bulletin No. 945.
3. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley and Sons; 1984.
4. Jamal A, Fazli IS, Ahmad S, Abdin MZ. Interactive effect of nitrogen and sulphur on yield and quality of groundnut (*Arachis hypogaea* L.). *Korean Journal of Crop Science*. 2006;51(6):519-522.
5. Kannan P, Swaminathan C, Ponmani S. Sulfur nutrition for enhancing rainfed groundnut productivity in typical alfisol of semi-arid regions in India. *Journal of Plant Nutrition*. 2017;40(6):828-840.
6. Korcak RF. Agricultural uses of phosphogypsum, gypsum and other industrial by-products. In: *Agricultural uses of municipal, animal and industrial byproducts*. Washington (DC): USDA Agricultural Research Service; 1998. p. 120-126.
7. Laxmanarayanan M, Prakash NB, Dhumgond P, Shruthi, Ashrit S. Slag-based gypsum as a source of sulphur, calcium and silicon and its effect on soil fertility and yield and quality of groundnut in Southern India. *Journal of Soil Science and Plant Nutrition*. 2020;20:2698-2713.
8. Laxmanarayanan M, Dhumgond P, Shruthi, Jahir Basha CR, Sarkar S, Prakash NB. Influence of yellow gypsum on nutrient uptake and yield of groundnut in different acid soils of Southern India. *Scientific Reports*. 2022;12:5604.
9. Singh S, Thoms M, Singh H, Tillman B, Matcham E, Carter E. Calcium fertilization in peanuts: importance, sources, and considerations. *EDIS*. 2025;2025(1):SS-AGR-487/AG482.