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Synergistic effects of integrated nutrient management and gypsum on productivity and profitability of groundnut [*Arachis hypogaea* (L.)]

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Abstract

A field study was carried out during the *kharif* season of 2024 at the Agricultural Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan) on loamy sand soil. The experiment was laid out in factorial randomized block design with integrated nutrient management practices and gypsum levels in groundnut. The experiment consisted of sixteen treatments viz., two factors with where 4 levels of integrated nutrient management and four levels of gypsum with three replications, using groundnut variety 'HNG-10'. Results clearly showed that application of N₃: 75% RDF + 2.5 ton/ha significantly increased plant height at harvest, plant dry matter at harvest, LAI, pod yield, haulm yield, protein and oil content registered over control. However, the highest net returns and B:C were significantly increased due to application of N₂: 50% RDF + 5 ton FYM over control. Furthermore, application of G₃: 250 kg/ha recorded significantly higher growth, yield and quality parameters over control. Further, net returns and B:C were also affected significantly highly under G₃: 250 kg/ha.

Keywords: Groundnut, INM, growth, yield, gypsum

Introduction

Groundnut (*Arachis hypogaea* L.) is a major oilseed crop of the tropics and subtropics, valued for its high oil (48-50%) and protein (25-30%) content, contributing significantly to food, nutritional and economic security. India is one of the leading producers of groundnut, where the crop plays a vital role in rainfed and irrigated farming systems and improves soil fertility through biological nitrogen fixation (FAO, 2021; Reddy *et al.*, 2022) ^[2, 6].

However, groundnut productivity in many regions remains low due to imbalanced nutrient management and deficiencies of secondary nutrients, particularly calcium and sulphur. Gypsum (CaSO₄·2H₂O) is an important source of calcium and sulphur, both of which are crucial for pod development, kernel filling and oil synthesis in groundnut. Adequate calcium availability in the pegging zone is essential for proper pod formation, while sulphur enhances protein synthesis and oil quality (Alloway, 2020; Tiwari *et al.*, 2021) ^[1, 8].

Integrated Nutrient Management (INM), combining inorganic fertilizers with organic manures and biofertilizers, has emerged as a sustainable strategy for improving nutrient use efficiency, soil health and crop productivity. Several studies have reported that INM enhances growth parameters, yield attributes and quality of groundnut by ensuring balanced nutrient supply and improving soil biological activity (Patel *et al.*, 2020; Meena *et al.*, 2022) ^[5, 4]. Moreover, the integrated application of gypsum with INM practices has shown synergistic effects in improving pod yield, shelling percentage and oil content of groundnut (Singh *et al.*, 2023) ^[7].

Groundnut productivity is often limited by deficiencies of calcium and sulphur, which are essential for pod development, protein synthesis, and oil quality. Integrated Nutrient Management combined with gypsum can improve nutrient availability, soil health, and crop performance. This study is important to evaluate the effect of INM and gypsum on growth, yield, and quality of groundnut, providing practical strategies for sustainable and profitable production.

Materials and Methods

The field experiment entitled “Synergistic Effects of Integrated Nutrient Management and Gypsum on Productivity and profitability of Groundnut [*Arachis hypogaea* (L.)]” was conducted during the *kharif* season of 2024 at the Agricultural Research Farm of Suresh Gyan Vihar University, Jaipur (Rajasthan), on loamy sand soil. The study was laid out in a factorial randomized block design comprising combinations of sixteen treatments viz., two factors with where 4 levels of integrated nutrient management N₀: Control, N₁: 100% RDF, N₂: 50% RDF + 5 ton/ha FYM, N₃: 75% RDF + 2.5 ton/ha FYM and four levels of gypsum G₀: Control, G₁: 100 kg/ha, G₂: 150 kg/ha and G₃: 250 kg/ha. The groundnut variety as test crop “HNG-10” were used. The experimental farm is located in the south-eastern part of Rajasthan at an elevation of 548 m above mean sea level, between 26°92' N latitude and 75°77' E longitude, and falls under agro-climatic zone III-A (Semi-Arid Eastern Plain) of Rajasthan. The region experiences a typical semi-arid climate, characterized by wide variations in temperature during summer and winter seasons. The average annual rainfall of Jaipur ranges from 400 to 450 mm, of which nearly 80-85% is received through the south-west monsoon, mainly from July to early September. During the cropping period, the maximum temperature varied from 31.41 to 38.71 °C, while the minimum temperature ranged between 20.71 and 27.85 °C. The relative humidity fluctuated up to 91% during the season. Average daily sunshine hours ranged from 0.68 to 5.01 hours, whereas wind velocity varied between 0.88 and 2.82 km/h. The recorded observations were statistically analyzed using standard procedures as described by Fisher (1950) [3].

Results and Discussion

Integrated nutrient management with Treatment N₃: 75% RDF + 2.5 ton/ha significantly enhanced growth parameters i.e. plant height (69.70 cm), number of leaf area index (2.92) and dry matter accumulation (27.64 g/plant) at harvest over control but remained statistically at par with N₂: 50% RDF + 5 ton/ha FYM presented in table-1 and fig-1. The significant improvement in growth parameters under treatment N₃ (75% RDF + 2.5 t/ha FYM), as evidenced by higher plant height, leaf area index and dry matter accumulation at harvest over the control, may be attributed to the synergistic effect of inorganic fertilizers and organic manure. Integrated nutrient management ensures a balanced and continuous supply of nutrients, improves soil physical condition, enhances microbial activity and promotes better root growth, which collectively favor photosynthetic efficiency and biomass production. The comparable performance of N₃ with N₂ (50% RDF + 5 t/ha FYM) indicates that partial substitution of chemical fertilizers with FYM can effectively meet the nutrient requirement of the crop and sustain vegetative growth. Similar improvements in growth attributes of groundnut under integrated nutrient management have also been reported by Patel *et al.* (2021) [5], Meena *et al.* (2022) [4] and Singh *et al.* (2023) [7], who attributed enhanced growth to improved nutrient availability and soil health under combined application of organic and inorganic sources. Further results revealed that the application of G₃: gypsum @ 250 kg/ha, recorded which was statistically at par with G₂: gypsum @ 150 kg/ha, recorded maximum growth parameters viz., plant height (69.67 cm), number of leaf area index (2.88) and dry matter accumulation (27.61 g/plant) at harvest over control presented in table-1 and fig-1. Further results revealed that application of

gypsum significantly enhanced growth parameters of groundnut over the control. The treatment G₃ (gypsum @ 250 kg/ha) recorded maximum plant height, leaf area index and dry matter accumulation at harvest, though it remained statistically at par with G₂ (gypsum @ 150 kg/ha). The improvement in growth attributes can be attributed to adequate supply of calcium and sulphur through gypsum, which play a crucial role in cell division, chlorophyll formation, photosynthetic activity and overall biomass production. Calcium availability in the root and pegging zone enhances root growth and nutrient uptake, while sulphur improves protein synthesis and enzymatic activity, leading to better vegetative growth. Similar enhancement in growth parameters of groundnut due to gypsum application has been reported by Tiwari *et al.* (2021) [8], Meena *et al.* (2022) [4] and Singh *et al.* (2023) [7].

Further, results revealed that application of N₃: 75% RDF + 2.5 FYM/ha obtained significantly higher pod yield (3235 kg/ha), haulm yield (3628 kg/ha), protein content in kernel (25.88%) and oil content in kernel (48.05%) being statistically at par with N₂: 50% RDF + 5.0 ton FYM/ha presented in table 2 and fig-2. Further results revealed that application of N₃ (75% RDF + 2.5 t/ha FYM) resulted in significantly higher pod yield, haulm yield, protein content and oil content of groundnut compared to the control, and remained statistically at par with N₂ (50% RDF + 5.0 t/ha FYM). The improvement in yield may be attributed to enhanced growth, better nutrient availability and efficient translocation of assimilates towards reproductive parts under integrated nutrient management. Increased protein and oil content in kernels under N₃ could be due to improved nitrogen availability from inorganic fertilizers and sustained nutrient release from FYM, which favor protein synthesis and lipid metabolism. The comparable performance of N₃ with N₂ suggests that balanced integration of organic and inorganic nutrient sources can optimize yield and quality while reducing dependence on chemical fertilizers. Similar improvements in pod yield and quality parameters of groundnut under integrated nutrient management have been reported by Patel *et al.* (2021) [5], Meena *et al.* (2022) [4] and Singh *et al.* (2023) [7]. Whereas; application of G₃: gypsum @ 250 kg/ha, recorded which was statistically at par with G₂: gypsum @ 150 kg/ha recorded significantly higher pod yield (3231 kg/ha), haulm yield (3626 kg/ha), protein content in kernel (25.82%) and oil content in kernel (48.03%) presented in table 2 and fig-2. Application of gypsum significantly improved pod yield, haulm yield and quality parameters of groundnut over the control. Treatment G₃ (gypsum @ 250 kg/ha) recorded the highest pod yield, haulm yield, protein content and oil content in kernel, though it remained statistically at par with G₂ (gypsum @ 150 kg/ha). The beneficial effect of gypsum may be attributed to adequate supply of calcium and sulphur, which play a vital role in pod development, kernel filling, protein synthesis and oil biosynthesis. Calcium availability in the pegging zone ensures proper pod formation, while sulphur enhances enzymatic activity and improves kernel quality. Similar positive responses of groundnut in terms of yield and quality due to gypsum application have been reported by Tiwari *et al.* (2021) [8], Meena *et al.* (2022) [4] and Singh *et al.* (2023) [7]. Among economics of groundnut crop in terms of net returns (₹105848/ha) and B:C (2.83) were significantly higher under N₂: 50% RDF + 5.0 ton FYM/ha. However, gross returns (₹1147018/ha) followed same pattern of yield and growth parameters. Among gypsum level, application of G₃: gypsum @ 250 ton/ha recorded significantly higher gross returns (₹146726/ha), net returns (₹114434/ha) and

B:C (3.52). The economic analysis indicated that treatment N₂ (50% RDF + 5.0 t/ha FYM) produced significantly higher net returns (₹105,848/ha) and benefit-cost ratio (2.83), reflecting the economic advantage of greater substitution of inorganic fertilizers with organic manure. Although gross returns followed the trend of yield and growth parameters, the lower cost of cultivation under N₂ resulted in superior profitability. This underscores the importance of integrated nutrient management in minimizing input costs while sustaining crop productivity.

Among gypsum levels, application of G₃ (gypsum @ 250 kg/ha) recorded significantly higher gross returns (₹146,726/ha), net returns (₹114,434/ha) and B:C ratio (3.52), which may be attributed to increased pod yield and improved kernel quality due to adequate calcium and sulphur nutrition. Similar economic benefits of integrated nutrient management and gypsum application in groundnut have been reported by Meena *et al.* (2022)^[4] and Singh *et al.* (2023)^[7].

Table 1: Effect of integrated nutrient management and gypsum levels on growth parameters of groundnut

Treatment	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf Area Index
Integrated Nutrient management			
N ₀	52.83	17.42	1.75
N ₁	61.20	22.68	2.36
N ₂	68.41	26.93	2.84
N ₃	69.70	27.64	2.92
S.Em. +	1.22	0.48	0.08
CD (<i>p</i> = 0.05)	3.70	1.41	0.24
Gypsum levels			
G ₀	52.81	17.39	1.73
G ₁	61.16	22.66	2.31
G ₂	68.40	26.89	2.81
G ₃	69.67	27.61	2.88
S.Em. +	1.22	0.48	0.08
CD (<i>p</i> = 0.05)	3.70	1.40	0.24
CV (%)	8.30	8.72	7.36

Table 2: Effect of integrated nutrient management and gypsum levels on yields of groundnut

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Protein content (%)	Oil content (%)
Integrated nutrient management				
N ₀	2240	2640	23.45	42.31
N ₁	2607	3060	24.59	45.71
N ₂	2980	3476	25.76	47.80
N ₃	3235	3628	25.88	48.05
S.Em +	121	136	0.36	0.42
CD (<i>p</i> = 0.05)	362	408	1.09	1.28
Gypsum levels				
G ₀	2236	2636	23.39	42.27
G ₁	2602	3056	24.55	45.69
G ₂	2973	3470	25.74	47.78
G ₃	3231	3626	25.82	48.03
S.Em. +	119	135	0.36	0.42
CD (<i>p</i> = 0.05)	359	405	NS	1.26
CV (%)	8.45	8.78	9.78	9.23

Table 3: Effect of integrated nutrient management and gypsum levels on economics of groundnut

Treatment	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Integrated nutrient management			
N ₀	91420	60128	1.92
N ₁	121800	88508	2.65
N ₂	143140	105848	2.83
N ₃	147018	99226	2.07
S.Em. +	5005	4321	0.30
CD (<i>p</i> = 0.05)	15009	12063	0.90
Gypsum levels			
G ₀	91063	59771	1.91
G ₁	121586	89894	2.83
G ₂	143057	111165	3.48
G ₃	146726	114434	3.54
S.Em. +	5005	4318	0.30
CD (<i>p</i> = 0.05)	15016	12954	0.90
CV (%)	9.89	8.93	7.87

Conclusion

The study concluded that integrated nutrient management with 50% RDF + 5.0 t ha⁻¹ FYM proved most economical, while 75% RDF + 2.5 t ha⁻¹ FYM ensured higher growth, yield and quality of groundnut. Application of gypsum @ 250 kg ha⁻¹ further enhanced productivity and profitability, highlighting the importance of balanced nutrient and secondary nutrient management for sustainable groundnut production.

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