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Effect of integrated nutrient management in summer green (*Vigna radiata* L.) on yield attributes and residual productivity of *Kharif* Groundnut (*Arachis hypogaea* L.)

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Abstract

At the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, a field experiment with the title "Integrated nutrient management in summer green gram (*Vigna radiata* L.) and its residual effect on *kharif* groundnut (*Arachis hypogaea* L.)" was conducted in medium black clayey soil during the summer and *kharif* seasons of 2022 and 2023. The field trial included integrated nutrient management treatments, such as T₁ - Absolute control, T₂ - 100% RDF (20:40:00 kg N:P:K ha⁻¹), T₃ - 100% RDF (20:40:00 kg N:P:K ha⁻¹) + FYM 2.5 t ha⁻¹, T₄ - 100% RDF (20:40:00 kg N:P:K ha⁻¹) + FYM 2.5 t ha⁻¹ + Soil application of PSB 2.5 l ha⁻¹, T₅ - 50% RDF (10:20:00 kg N:P:K ha⁻¹) + FYM 2.5 t ha⁻¹, and T₆ - 50% RDF (10:20:00 kg N:P:K ha⁻¹) + FYM 2.5 t ha⁻¹ + Soil application of PSB 2.5 l ha⁻¹ with *Rhizobium* 10 ml kg⁻¹ seed common to all plots to green gram in summer season as main plot treatments replicated four times in randomized block design. Each main plot treatment was divided into three sub plot treatments, each with three levels of fertility, namely F₁ -100% RDF (12.5:25:50 kg N:P:K: ha⁻¹), F₂-75% RDF (9.37:18.75:37.50 kg N:P:K: ha⁻¹), and F₃-50% RDF (6.25:12.5:25 kg N:P:K: ha⁻¹), all of which shared a *Rhizobium* 15 ml kg⁻¹ seed to *kharif* groundnut, resulting in eighteen treatment combinations replicated four times in a split plot design.

Keywords: Integrated nutrient management, fertility levels, yield, green gram and groundnut.

Introduction

Mungbean [*Vigna radiata* (L.) R. Wilczek] is a legume crop rich in proteins, amino acids, minerals, dietary fibers, sugars and vitamins (Muchomba et.al., 2023 & Nair et al., 2012). It serves as a vital dietary component for the people in arid and semi-arid regions. The high protein content along with digestibility improves the nutritional intake of vegetarian communities and supports food security (Eapen. 2008). Globally mungbean is grown in 7.3 million hectares with average production of about 721 kg/ha (Nair et al., 2019; Azam et al., 2023). It plays major role in crop rotation systems due to its commercial value as well as its ability to enrich soil fertility through nitrogen fixation resulting in higher yield of subsequent crops, thus enhancing overall agricultural productivity (Hayat et. al., 2008). Being a short duration crop and its ability to withstand moisture stress, mungbean is a better option in cropping systems, owing to increasing the productivity both as an intercrop and fodder crop (Ali et. al., 2024 & Abraheem et.al., 2024). Mungbean is cultivated both as a pulse and vegetable crop.

Despite its commercial value and cultivation, the crop suffers from various biotic and abiotic stresses (Pandey et al., 2018 & Nair et al., 2019). Among the biotic stresses, Dry root rot disease caused by *Macrophomina phaseolina* (Tassi.) Goid is becoming an emerging disease in Asia due to climate change leading to 25% to 48% yield losses (Singh et.al., 2021) [33]. *Macrophomina phaseolina* is a necrotrophic fungus with wide host range and can attack the plants at both seedling and adult stages ((Suriachandraselvan et al., 2005; Khan et al., 2016). The fungus infects the host plants by producing several hydrolytic enzymes, cell wall-degradBeing the third most important pulse crop in India, green gram plays a vital role in agriculture. It represents approximately 16% of the country's total pulse cultivation area. As a leguminous plant, it contributes nitrogen to the soil. Additionally, its seeds are rich in protein, containing between 20% and 25%. Occasionally, plants are cut down and incorporated into the

soil as green manure to enrich nitrogen levels in the ground (Anon., 2022)^[12]. Moreover, incorporating green gram as a catch crop during the summer can further strengthen the system by boosting soil nutrient levels (Venkatesh *et al.*, 2015)^[40].

Groundnut (*Arachis hypogaea* L.), commonly referred to as peanut, is a crop that holds significance worldwide. It is extensively cultivated in tropical and subtropical regions, playing a crucial role for both small-scale farmers and large agricultural enterprises. This plant is categorized as both a legume and an oilseed due to its rich oil content. The oil extracted from groundnuts has a large amount of unsaturated fatty acids, such as linolenic and linoleic acids.

Integrated nutrient management (INM) focuses on maintaining or improving soil fertility and ensuring an adequate supply of nutrients to crops by efficiently combining all available nutrient sources (Tondon, 1992)^[37]. Sustainable crop production systems increasingly emphasize the use of organic materials as nutrient sources in soil (Tayade *et al.*, 2012)^[36]. Findings from long-term fertilizer studies indicate that the combined application of farmyard manure, vermicompost, bio-compost and other organics along with suitable amounts of chemical fertilizers enhances crop productivity and ensures greater stability over time. The efficiency of nitrogen supplied through fertilizers also improves when applied together with FYM or vermicompost, thereby allowing partial substitution of chemical N (Nambiar and Abrol, 1989)^[23]. Organic nutrient sources release nitrogen gradually and approximately 30% of N, 70% of P₂O₅ and 75% of K₂O become available to the first crop, with the remaining portion benefiting subsequent crops (Gour *et al.*, 2017)^[13].

Materials and Methods

The present study entitled “Integrated nutrient management in summer green gram (*Vigna radiata* L.) and its residual effect on kharif groundnut (*Arachis hypogaea* L.)” was conducted for two consecutive seasons (summer-kharif) in 2022 and 2023 at the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh. The experimental field had clayey soil, moderate organic carbon content (4.7 g kg⁻¹), was slightly alkaline with a pH of 7.33, and was non-saline with an electrical conductivity of 0.26 dS m⁻¹. The soil was categorized as low in available nitrogen (212 kg ha⁻¹), moderate in available phosphorus (31.25 kg ha⁻¹), and medium in available potassium (268 kg ha⁻¹).

The field experiment was conducted with six integrated nutrient management treatments, namely T₁ (absolute control), T₂ [100% RDF (20:40:00 kg N:P:K ha⁻¹)], T₃ [100% RDF + FYM @ 2.5 t ha⁻¹], T₄ [100% RDF + FYM @ 2.5 t ha⁻¹ + soil application of PSB @ 2.5 L ha⁻¹], T₅ [50% RDF (10:20:00 kg N:P:K ha⁻¹) + FYM @ 2.5 t ha⁻¹] and T₆ [50% RDF + FYM @ 2.5 t ha⁻¹ + soil application of PSB @ 2.5 L ha⁻¹], with Rhizobium inoculation @ 10 mL kg⁻¹ seed applied uniformly to all summer green gram plots. These six treatments were assigned to main plots and replicated four times in a randomized block design. In the following kharif season, each main plot was split into three fertility levels: F₁ [100% RDF (12.5:25:50 kg N:P:K ha⁻¹)], F₂ [75% RDF (9.37:18.75:37.50 kg N:P:K ha⁻¹)] and F₃ [50% RDF (6.25:12.5:25 kg N:P:K ha⁻¹)], with Rhizobium inoculation @ 15 mL kg⁻¹ seed given to all groundnut plots, resulting in eighteen treatment combinations arranged in a split-plot design with four replications. Standard plant protection practices were followed to safeguard the crops, and the green gram was harvested manually. Observations on growth and yield parameters were recorded at regular intervals, and the economic analysis was carried out based on prevailing input and output

prices. The experimental data were analyzed using the standard ANOVA procedure described by Gomez and Gomez (1984)^[12], and treatment means were compared at the 5% level of significance (P < 0.05).

Results and Discussion

1. Response of integrated nutrient management in summer green gram on yield attributes and yield

1.1 Number of pods per plant

The results presented in Table 1 indicate that the number of pods per plant at harvest in green gram varied significantly across the nutrient management treatments. The treatment comprising 100% RDF + FYM @ 2.5 t ha⁻¹ along with soil application of PSB @ 2.5 L ha⁻¹ (T₄) recorded the highest number of pods per plant, with values of 25.92 in 2022, 28.08 in 2023 and 27.00 in the pooled mean. This treatment was statistically comparable with T₂ (100% RDF) and T₃ (100% RDF + FYM @ 2.5 t ha⁻¹) in both years, and with T₃ in the pooled analysis. The lowest number of pods per plant was observed under the control treatment (T₁), which produced 15.42, 15.92 and 15.67 pods per plant during 2022, 2023 and in the pooled data, respectively.

1.2 Number of seeds per pod

A perusal of the data on seeds per pod (Table 1) indicated that INM treatments exerted a significant effect on this parameter. The application of 100% RDF + FYM @ 2.5 t ha⁻¹ along with PSB applied through soil @ 2.5 L ha⁻¹ (T₄) produced the highest number of seeds per pod, recording 8.59 in 2022, 9.58 in 2023, and 9.08 in the pooled results. During the first year, this treatment was statistically comparable with T₂ (100% RDF), T₃ (100% RDF + FYM @ 2.5 t ha⁻¹) and T₆ (50% RDF + FYM @ 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹). However, in the second year and pooled analysis, T₄ remained statistically at par only with T₂ and T₃. The lowest number of seeds per pod was consistently observed under the control treatment (T₁), registering 6.33, 5.00 and 5.67 in 2022, 2023 and pooled data, respectively.

1.3 Seed yield

An examination of the data in Table 1 showed that seed yield of green gram was markedly affected by the integrated nutrient management (INM) treatments. A clear and consistent improvement in seed yield was observed across both years and in the pooled analysis. The application of 100% RDF combined with FYM @ 2.5 t ha⁻¹ and PSB @ 2.5 L ha⁻¹ through soil (T₄) produced the highest seed yield of 1198, 1215 and 1207 kg ha⁻¹ during 2022, 2023 and in pooled results, respectively. This treatment was statistically comparable with T₂ (100% RDF) and T₃ (100% RDF + FYM 2.5 t ha⁻¹) in both years, and with T₃ in the pooled analysis. The yield advantage under T₄ corresponded to a 56% increase over the control (T₁) based on pooled data. The lowest seed yield, 755, 791 and 773 kg ha⁻¹ in 2022, 2023 and pooled results, respectively, was recorded under the untreated control (T₁).

1.4 Stover yield

The stover yield data presented in Table 1 showed that integrated nutrient management (INM) treatments had a significant effect on green gram productivity. The treatment receiving 100% RDF combined with FYM @ 2.5 t ha⁻¹ and PSB applied through soil @ 2.5 L ha⁻¹ (T₄) produced the highest stover yield, registering 1956, 1961 and 1958 kg ha⁻¹ during 2022, 2023 and in the pooled mean, respectively. This treatment remained statistically comparable with T₂ (100% RDF) and T₃ (100% RDF + FYM 2.5 t ha⁻¹) across both individual years and

in the pooled analysis. On a pooled basis, the application of 100% RDF + FYM 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹ resulted in a 30% increase in stover yield over the control. The lowest stover yield of 1486, 1524 and 1505 kg ha⁻¹ in 2022, 2023 and pooled data, respectively, was recorded under the untreated control (T₁). The results clearly demonstrated that integrated nutrient management (INM) practices were more effective in improving yield attributes of green gram than the application of inorganic fertilizers alone. Among all the treatments, the application of 100% RDF + FYM @ 2.5 t ha⁻¹ combined with soil application of PSB @ 2.5 L ha⁻¹ (T₄) consistently produced the highest number of pods per plant, number of seeds per pod, seed yield and stover yield. This treatment remained statistically comparable with 100% RDF + FYM @ 2.5 t ha⁻¹ (T₃) for most of the growth and yield parameters. The superior performance under these treatments can be attributed to improved nutrient availability and enhanced soil organic matter, which together created a favorable soil environment for better crop growth. Nitrogen, being a key constituent of proteins and chlorophyll, plays a crucial role in physiological processes such as cell division, cell elongation and photosynthesis, ultimately leading to improved vegetative and reproductive growth. Phosphorus, an essential component of nucleic acids, ATP and phospholipids, is vital for energy transfer, root development, genetic functioning and overall plant vigor. Adequate phosphorus availability likely facilitated early root establishment and better nutrient uptake, contributing to higher productivity. In addition, organic inputs like FYM and biofertilizers improved soil physical structure, enriched the soil with organic carbon and enhanced microbial activity, which promoted nutrient mineralization and sustained nutrient supply to the crop, thereby resulting in improved yield attributes.

The application of the recommended dose of fertilizers supplied essential nutrients from the early stages of crop growth, which supported better root and shoot development. This improved root system enabled efficient nutrient uptake, which was subsequently utilized in photosynthesis and translocate towards developing sinks, ultimately enhancing yield. Adequate nitrogen availability promoted vigorous vegetative growth and

contributed to higher seeds per pod, as nitrogen is a major component of chlorophyll and proteins. These nutrients, being integral constituents of plant cells, play crucial roles in various physiological processes such as cell division, cell elongation, and chlorophyll synthesis, all of which collectively improve plant growth, grain formation, and final yield. The present findings are in close agreement with the results reported by Chaudhari *et al.* (2013) [8], Tyagi *et al.* (2014) [38], Elamin and Madhvi (2015) [11], Sushil *et al.* (2015) [35], Mansuri (2016) [21], Patel *et al.* (2018) [25], Barkha *et al.* (2020) [3], Patel *et al.* (2020a) [26] and Patel *et al.* (2020b) [27], who also observed significant improvement in yield-attributing traits under the integrated use of organic and inorganic nutrient sources compared to their sole application.

An optimum supply of nitrogen is essential for promoting vigorous vegetative growth, chlorophyll development and carbohydrate synthesis. Likewise, sufficient phosphorus availability in the soil enhances root development, whereas its deficiency restricts overall plant growth and delays crop maturity. Since phosphorus is mobile within plant tissues, it is absorbed during the early growth stages and later translocated to support reproductive development, particularly seed formation. A balanced and adequate supply of both nitrogen and phosphorus ensures faster growth, better crop quality and ultimately contributes to higher yield.

The combined application of organic and inorganic nutrient sources enhanced nutrient availability, uptake and translocation within the plant system. This improvement facilitated efficient assimilation of nutrients and promoted balanced partitioning of photosynthates between the source and sink, leading to greater dry matter accumulation in reproductive structures and ultimately higher yield-contributing traits and overall productivity. The positive influence of integrating organic manures with chemical fertilizers on growth and yield parameters has also been documented by Patel (2012) [24], Tyagi *et al.* (2014) [38], Joshi *et al.* (2016) [17], Patel *et al.* (2018) [25] and Barkha *et al.* (2020) [3], who reported that such combinations outperform sole applications of either organic or inorganic nutrient source.

Table 1: Effect of integrated nutrient management on number of pod per plant, number of seeds per pod seed yield and stover yield of green gram

Treatments	Number of pods per plant			Number of seeds per pod			Seed yield (kg/ha)			Stover yield(kg/ha)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T ₁ : Absolute control	15.42	15.92	15.67	6.33	5.00	5.67	755	791	773	1486	1524	1505
T ₂ :100% RDF	23.59	24.50	24.04	8.17	8.08	8.13	1036	1067	1051	1909	1836	1872
T ₃ :100% RDF + FYM 2.5 t ha ⁻¹	25.08	25.75	25.42	8.50	8.67	8.58	1159	1165	1162	1936	1933	1935
T ₄ :100% RDF + FYM 2.5 t ha ⁻¹ + Soil application of PSB 2.5 l ha ⁻¹	25.92	28.08	27.00	8.59	9.58	9.08	1198	1215	1207	1956	1961	1958
T ₅ :50% RDF + FYM 2.5 t ha ⁻¹	21.08	21.17	21.13	7.00	7.84	7.42	859	954	906	1599	1663	1631
T ₆ :50% RDF + FYM 2.5 t ha ⁻¹ + Soil application of PSB 2.5 l ha ⁻¹	21.84	22.08	21.96	7.34	7.92	7.63	922	971	946	1626	1676	1651
S.Em.±	1.35	1.22	0.91	0.51	0.52	0.36	57	56	40	106	90	69
CD (P=0.05)	4.06	3.67	2.62	1.54	1.56	1.05	173	169	116	318	271	200
CV (%)	12.17	10.61	11.39	13.31	13.21	13.26	11.64	10.89	11.26	12.05	10.20	11.16
Year (Y)												
S.Em.±	0.52			0.21			23.16			40.05		
CD (P=0.05)	NS			NS			NS			NS		
Interaction (Y × T)												
S.Em.±	1.28			0.51			56.72			98.10		
CD (P=0.05)	NS			NS			NS			NS		

2. Effect of succeeding *kharif* groundnut on yield attributes and yield

2.1 Number of mature pods per plant

The mean data on the number of mature pods per plant in groundnut as influenced by various INM treatments during both years are summarized in Table 2.

Residual effect of integrated nutrient management (Green gram)

The results presented in Table 2 clearly indicate that the nutrient management practices applied to the preceding summer green gram crop had a significant residual impact on the number of mature pods per plant in groundnut during 2022, 2023 and in the pooled analysis. The highest number of mature pods per plant (14.30, 14.78 and 14.54 during 2022, 2023 and pooled data, respectively) was observed under the treatment receiving 100% RDF + FYM 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹ through soil application (T₄). This treatment was statistically comparable with 100% RDF + FYM 2.5 t ha⁻¹ (T₃) during 2022. The lowest number of mature pods per plant (11.11, 11.33 and 11.22 during 2022, 2023 and pooled data, respectively) was recorded under the control treatment (T₁).

Effect of fertility levels (Groundnut)

A detailed examination of the data (Table 2) revealed that fertility levels applied to groundnut significantly influenced the number of mature pods per plant during both years and in the pooled analysis. The application of 100% RDF (F₁) resulted in significantly higher numbers of mature pods (13.50, 14.29 and 13.90 during 2022, 2023 and pooled results, respectively), although it remained statistically similar to 75% RDF (F₂). The lowest values (11.04, 10.86 and 10.95 during 2022, 2023 and pooled results, respectively) were observed when groundnut received 50% RDF (F₃).

Interaction effect

The interaction between INM treatments and fertility levels was found to be significant (Table 3). The combination of 100% RDF + FYM 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹ applied to green gram followed by 100% RDF to groundnut (T₄F₁) produced the maximum number of mature pods per plant (17.08, 17.25 and 17.17 during 2022, 2023 and pooled analysis, respectively). This combination was statistically comparable to T₃F₁ during 2023. The minimum number of mature pods per plant (10.42, 9.33 and 9.87 during 2022, 2023 and pooled results, respectively) was recorded under the treatment combination T₁F₃.

2.2 Pod yield

The data presented in Table 2 indicate that pod yield of groundnut was significantly affected by the different treatments applied during the experiment.

Residual effect of integrated nutrient management (Green gram)

The results clearly showed that the INM treatments imposed on the preceding summer green gram crop had a notable residual impact on the pod yield of groundnut. Application of 100% RDF + FYM @ 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹ through soil (T₄) resulted in significantly higher pod yields of 2332, 2393 and 2363 kg ha⁻¹ during 2022, 2023 and in pooled analysis, respectively. This treatment outperformed the control and other treatments, although it remained statistically at par with 100% RDF + FYM @ 2.5 t ha⁻¹ (T₃) in both years. The increase in pod

yield due to T₄ was about 50% over the control in pooled data. The lowest pod yield of 1602, 1556 and 1579 kg ha⁻¹ was recorded under the control (T₁) in 2022, 2023 and pooled results, respectively. The overall yield trend followed the order: T₄ > T₃ > T₆ > T₅ > T₂ > T₁.

Effect of fertility levels (Groundnut)

The findings in Table 2 also revealed that pod yield responded significantly to the fertility levels applied to groundnut. Application of 100% RDF (F₁) produced the highest pod yields of 2114, 2147 and 2130 kg ha⁻¹ during 2022, 2023 and pooled analysis, respectively. The improvement in pod yield under F₁ corresponded to a 28% increase over the 50% RDF level (F₃) on pooled data. The minimum pod yield (1663 kg ha⁻¹) was consistently observed under F₃ in both years and in pooled results. The order of yield performance was: F₁ > F₂ > F₃.

Interaction effect

The interaction effects between INM treatments and fertility levels were significant for pod yield (Table 4). The combination of 100% RDF + FYM @ 2.5 t ha⁻¹ + PSB @ 2.5 L ha⁻¹ applied to green gram along with 100% RDF to groundnut (T₄F₁) recorded the highest pod yield of 2598, 2636 and 2617 kg ha⁻¹ during 2022, 2023 and pooled analysis, respectively. This combination showed clear superiority over most other treatment combinations and was statistically comparable with T₃F₁, T₃F₂ and T₄F₂ during both years. In pooled results, T₄F₁ was also at par with T₃F₁ and T₄F₂. The lowest pod yield, 1376, 1262 and 1319 kg ha⁻¹ during 2022, 2023 and pooled analysis, respectively, was recorded under the treatment combination T₁F₃.

2.3 Haulm yield

A perusal of the data presented in Table-2 revealed that haulm yield of groundnut was significantly affected by the various treatments imposed.

Residual effect of integrated nutrient management (Green gram)

The residual effect of integrated nutrient management applied to the preceding summer green gram crop showed a notable influence on haulm yield. Application of 100% RDF along with FYM @ 2.5 t ha⁻¹ and PSB through soil application @ 2.5 L ha⁻¹ (T₄) consistently produced the highest haulm yield, recording 4379, 4485 and 4432 kg ha⁻¹ during 2022, 2023 and in pooled data, respectively. This treatment was statistically at par with 100% RDF + FYM 2.5 t ha⁻¹ (T₃) across both years. On a pooled basis, haulm yield under T₄ was 69% higher than the control. The lowest haulm yield, 2705, 2540 and 2623 kg ha⁻¹ during 2022, 2023 and pooled results, respectively, was observed under the control treatment (T₁). The treatments followed the order: T₄ > T₃ > T₆ > T₅ > T₂ > T₁.

Effect of fertility levels (Groundnut)

With respect to fertility levels applied to groundnut, the data showed that 100% RDF (F₁) resulted in significantly higher haulm yield (3788, 3885 and 3837 kg ha⁻¹ during 2022, 2023 and pooled analysis, respectively). Application of 100% RDF increased haulm yield by 27% over 50% RDF on pooled basis. The minimum haulm yield of 3038, 3021 and 3030 kg ha⁻¹ in 2022, 2023 and pooled data, respectively, was recorded under 50% RDF (F₃), with the response following the order: F₁ > F₂ > F₃.

Interaction effect

Interaction effects presented in Table-5 indicated that the combination of INM treatments and fertility levels had a significant influence on haulm yield. The highest haulm yield values of 4859, 4857 and 4858 kg ha⁻¹ during 2022, 2023 and pooled analysis, respectively, were obtained with the combination of 100% RDF + FYM 2.5 t ha⁻¹ + PSB 2.5 L ha⁻¹ to green gram and 100% RDF to groundnut (T₄F₁). This treatment remained statistically at par with T₃F₁, T₃F₂ and T₄F₂. The lowest haulm yield, 2370, 2158 and 2264 kg ha⁻¹ in 2022, 2023 and pooled results, respectively, occurred under the treatment combination T₁F₃.

Yield-contributing characters of *kharif* groundnut, such as the number of mature pods per plant (Table-2), were significantly influenced by the residual effects of integrated nutrient management (INM) applied to the preceding summer green gram crop. Analysis of the data revealed that the application of 100% RDF + FYM 2.5 t ha⁻¹ + PSB through soil application 2.5 L ha⁻¹ (T₄) to green gram, which was statistically at par with 100% RDF + FYM 2.5 t ha⁻¹ (T₃), produced the highest number of mature pods per plant in groundnut. This improvement can be attributed to the increased availability of nutrients from the native soil pool, residual nutrient effects through mineralization, and enhancement of soil physico-chemical properties. Such improvements improve the water and nutrient-holding capacity of the soil, thereby supporting better crop growth and efficient translocation of assimilates to the sink, ultimately enhancing yield attributes. These findings are in agreement with earlier reports by Sohu *et al.* in rice-chickpea, Sindhi *et al.* in green gram-maize, Nemade *et al.* in sorghum-chickpea, Koireng *et al.* in potato-green gram, Thesiya *et al.* in little millet-green gram, Solanki in summer groundnut-green gram, and Rahevar *et al.* in Bt cotton-groundnut cropping sequences.

The results pertaining to pod and haulm yields of groundnut are presented in Table-2. Significant differences were observed in both pod and haulm yields of groundnut during the two years of experimentation as well as in pooled analysis. The preceding summer green gram crop fertilized with 100% RDF + FYM 2.5 t ha⁻¹ + PSB through soil application 2.5 L ha⁻¹ (T₄) resulted in significantly higher pod and haulm yields of the succeeding groundnut crop compared to other treatments, although it was statistically at par with 100% RDF + FYM 2.5 t ha⁻¹ (T₃) in most cases. In contrast, the harvest index was significantly higher under the control treatment (T₁).

The observed response may be attributed to the increased availability of nutrients resulting from the mineralization of organic materials and the improvement of soil physical properties. The higher pod yield in groundnut could be associated with the application of FYM and PSB biofertilizer to the preceding green gram crop, which enhanced soil structure, reduced crusting, and provided an energy source for soil microflora. These improvements likely promoted better root nodulation and enhanced nitrogen fixation. The significantly higher haulm yield under these treatments may be linked to increased vegetative growth, as reflected in greater plant height, more branches, and higher dry matter accumulation. Organic inputs such as FYM and PSB biofertilizer decompose slowly; consequently, only about 25-33% of nitrogen and a small fraction of phosphorus and potassium are available to the immediate crop (green gram), while the remaining nutrients

contribute to the fertility and productivity of the succeeding crop (groundnut), thereby sustaining soil productivity over time. Similar findings have been reported by Maiti *et al.* (2005)^[20] in Indian mustard-green gram, Polara *et al.* in groundnut-garlic, Sohu *et al.* in rice-chickpea, Sindhi *et al.* in maize-green gram, Nemade *et al.*, Koireng *et al.* in potato-green gram, Kumar *et al.* (2018) in maize-green gram, Mangaraj *et al.* in rice-green gram, Solanki in summer groundnut-green gram, and Rahevar *et al.* in Bt cotton-groundnut cropping sequences.

The data on yield attributes and yield, including the number of mature pods per plant, pod yield, and haulm yield of groundnut, are presented in Table-2. Significantly higher number of mature pods per plant in *kharif* groundnut was observed with the application of 100% RDF (N:P₂O₅:K₂O 12.5:25:50 kg ha⁻¹) compared to other treatments. This increase can be attributed to improved vegetative growth and an adequate supply of photosynthates, which facilitated the development of sink organs under higher levels of inorganic fertilizers. Positive effects of inorganic fertilizer application on yield attributes have also been reported by Shinde *et al.* (2000)^[32], Chaithnaya *et al.* (2003)^[7], Hadwani and Gundalia (2005)^[15], Hosamani and Janawade (2007)^[16], Abraham *et al.* (2008)^[1], Somasundaram *et al.* (2010)^[34], Salve and Gunjal (2011)^[29], Sharma *et al.* (2013)^[31], Patil *et al.* (2014)^[28], Chaudhary *et al.* (2015)^[9], Meena and Yadav (2015)^[22], and Satpute *et al.* (2021)^[30].

On a pooled basis, groundnut fertilized with 100% RDF (12.5:25:50 kg N:P₂O₅:K₂O ha⁻¹) produced significantly higher pod and haulm yields (Table-2), which remained statistically at par with 75% RDF (9.37:18.75:37.50 kg N:P₂O₅:K₂O ha⁻¹). The lowest yields were observed under 50% RDF (F₃). Phosphorus, an essential macronutrient, plays a critical role in plant growth and development, being a constituent of enzymes involved in energy transfer, carbohydrate metabolism, and respiration. It also contributes to cell division and development, while promoting root growth, which enhances water and nutrient uptake by the growing plant parts. Improved root development increases photosynthetic area and dry matter accumulation, supports nodulation, and facilitates efficient nitrogen fixation, which benefits grain development and ultimately increases seed yield. The enhanced yield attributes and overall productivity can be attributed to the increased availability of major nutrients (NPK) and effective translocation of photosynthates to economic sinks, leading to higher pod and haulm yields. Potassium, another vital nutrient, supports most physiological processes, including root establishment, water and nutrient uptake, and carbon metabolism, while helping plants withstand biotic and abiotic stresses such as pests, diseases, drought, salinity, cold, frost and waterlogging. The positive impact of nutrient management on groundnut yield has been previously reported by Shinde *et al.* (2000)^[32], Chaithnaya *et al.* (2003)^[7], Hadwani and Gundalia (2005)^[15], Laxminarayana and Patiram (2005)^[19], Dutta and Mondal (2006)^[10], Bordoloi *et al.* (2007)^[6], Hosamani and Janawade (2007)^[16], Kuligod *et al.* (2007)^[18], Abraham *et al.* (2008)^[1], Somasundaram *et al.* (2010)^[34], Salve and Gunjal (2011)^[29], Singh *et al.* (2012)^[33], Sharma *et al.* (2013)^[31], Chaudhary *et al.* (2015)^[9], Gunri *et al.* (2015)^[14], Meena and Yadav (2015)^[22], Vaghasia and Bhalu (2016)^[39], Bhosale and Pisal (2017)^[5], and Benjamin and Williams (2020)^[4], Satpute *et al.* (2021)^[30].

Table 2: Residual effect of integrated nutrient management and direct effect of fertility levels on mature pods per plant, pod and haulm yields of groundnut

Treatments	Number of mature pods per plant			Pod yield (kg ha ⁻¹)			Haulm yield (kg ha ⁻¹)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Integrated nutrient management (Green gram)									
T ₁ :Absolute control	11.11	11.33	11.22	1602	1556	1579	2705	2540	2623
T ₂ :100% RDF	10.97	12.78	11.88	1787	1806	1797	3203	3248	3225
T ₃ :100% RDF + FYM 2.5 t ha ⁻¹	13.33	13.56	13.45	2218	2223	2220	4173	4158	4166
T ₄ :100% RDF + FYM 2.5 t ha ⁻¹ + Soil application of PSB 2.5 l ha ⁻¹	14.30	14.78	14.54	2332	2393	2363	4379	4485	4432
T ₅ :50% RDF + FYM 2.5 t ha ⁻¹	12.25	13.06	12.65	1830	1842	1836	3100	3247	3173
T ₆ :50% RDF + FYM 2.5 t ha ⁻¹ + Soil application of PSB 2.5 l ha ⁻¹	12.69	12.31	12.50	1833	1909	1871	3304	3542	3423
S.Em.±	0.38	0.40	0.27	61	61	43	92	120	76
CD (P=0.05)	1.15	1.19	0.79	184	185	125	278	363	219
CV (%)	10.58	10.54	10.56	10.93	10.88	10.91	9.19	11.79	10.59
Fertility levels (Groundnut)									
F ₁ : 100% RDF	13.50	14.29	13.90	2114	2147	2130	3788	3885	3837
F ₂ : 75% RDF	12.79	13.75	13.27	2025	2054	2039	3606	3704	3655
F ₃ : 50% RDF	11.04	10.86	10.95	1663	1663	1663	3038	3021	3030
S.Em.±	0.24	0.27	0.18	31	34	23	55	66	43
CD (P=0.05)	0.70	0.79	0.52	89	97	65	158	189	121
CV (%)	9.58	10.35	9.99	7.87	8.49	8.19	7.74	9.11	8.46
Interactions									
T × F	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
T × Y	-	-	NS	-	-	NS	-	-	NS
F × Y	-	-	NS	-	-	NS	-	-	NS
T × F × Y	-	-	NS	-	-	NS	-	-	NS

Table 3: Interaction effect of INM and direct effect of fertility levels (T × F) on number of mature pods per plant at harvest of groundnut

Year	2022			2023			Pooled		
Treatments	Fertility levels			Fertility levels			Fertility levels		
INM	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃
T ₁	11.42	11.50	10.42	12.33	12.34	9.33	11.88	11.92	9.87
T ₂	11.08	11.67	10.17	13.84	13.67	10.84	12.46	12.67	10.50
T ₃	14.50	13.67	11.84	15.75	13.08	11.84	15.13	13.37	11.84
T ₄	17.08	13.90	11.92	17.25	15.08	12.00	17.17	14.49	11.96
T ₅	12.67	12.75	11.33	12.25	15.25	11.67	12.46	14.00	11.50
T ₆	14.25	13.25	10.58	14.33	13.08	9.50	14.29	13.17	10.04
S.Em.±	0.60			0.67			0.45		
CD (P=0.05)	1.71			1.92			1.27		

Table 4: Interaction effect of INM and direct effect of fertility levels (T × F) on pod yield (kg ha⁻¹) of groundnut

Year	2022			2023			Pooled		
Treatments	Fertility levels			Fertility levels			Fertility levels		
INM	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃
T ₁	1750	1681	1376	1772	1632	1262	1761	1656	1319
T ₂	2012	1732	1618	1953	1868	1597	1982	1800	1607
T ₃	2485	2469	1700	2469	2417	1781	2477	2443	1741
T ₄	2598	2542	1857	2636	2566	1977	2617	2554	1917
T ₅	1931	1831	1729	2095	1896	1534	2013	1863	1631
T ₆	1906	1897	1697	1955	1943	1828	1930	1920	1763
S.Em.±	76			83			56		
CD (P=0.05)	218			238			159		

Table 5: Interaction effect of INM and direct effect of fertility levels (T × F) on haulm yield (kg ha⁻¹) of groundnut

Year	2022			2023			Pooled		
Treatments	Fertility levels			Fertility levels			Fertility levels		
INM	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃	F ₁	F ₂	F ₃
T ₁	2940	2806	2370	2894	2569	2158	2917	2688	2264
T ₂	3573	2999	3038	3522	3381	2840	3547	3190	2939
T ₃	4765	4714	3041	4703	4647	3124	4734	4681	3083
T ₄	4859	4746	3531	4857	4819	3779	4858	4782	3655
T ₅	3382	2906	3013	3737	3228	2775	3559	3067	2894
T ₆	3210	3468	3233	3597	3578	3452	3403	3523	3342
S.Em.±	135			161			105		
CD (P=0.05)	386			462			296		

Conclusion

The findings of the present study indicate that applying 100% RDF (20:40:00 N-P₂O₅-K₂O kg ha⁻¹) along with FYM @ 2.5 t ha⁻¹ and soil-applied PSB @ 2.5 L ha⁻¹ to summer green gram is the most effective practice for enhancing yield and yield attributes. For the subsequent kharif groundnut crop, continuing this nutrient management approach with 75% RDF (9.37:18.75:37.50 N-P₂O₅-K₂O kg ha⁻¹) proved most beneficial in achieving higher pod and haulm yields along with improved yield-contributing traits.

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