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Influence of Fertilizer Levels and Integrated Plant Nutrient System (IPNS) on Productivity and Soil Fertility of Groundnut during Kharif

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Abstract

A long-term field experiment initiated during 2020 was conducted during *kharif*, 2025 to evaluate the effect of fertilizer levels and Integrated Plant Nutrient System (IPNS) on yield, soil nutrient status, nutrient content in plant and microbial population of groundnut. The experiment consisted of 10 treatments including 100% RDF, yield target approaches with chemical fertilizers alone, yield target approaches with IPNS, FYM @ 10 t ha⁻¹ and nutrient omission treatments. The results revealed significant variation among treatments for pod yield, haulm yield, soil nutrient status and microbial population. Among all treatments, T₄ (Yield Target of 12 q ha⁻¹ with IPNS) recorded the highest pod yield (793 kg ha⁻¹) and haulm yield (1573 kg ha⁻¹), which were significantly superior to the control (407 and 887 kg ha⁻¹, respectively). Treatment T₄ also recorded higher plant nitrogen (3.0%) and potassium (1.8%) contents, indicating better nutrient uptake under integrated nutrient management. The highest available soil nitrogen (217.20 kg ha⁻¹) was observed in T₇ (RDN and RDK), whereas maximum phosphorus (38.69 kg ha⁻¹) and potassium (212.20 kg ha⁻¹) were recorded in T₁ and T₉, respectively. Soil microbial population was markedly influenced by fertilizer treatments. Application of FYM @ 10 t ha⁻¹ (T₆) resulted in the highest bacterial population (187 × 10⁷ CFU g⁻¹ soil) and actinomycetes population (22 × 10³ CFU g⁻¹ soil), while the highest fungal population (17 × 10² CFU g⁻¹ soil) was recorded with 100% RDF (T₁). The experimental data showed acceptable precision with CV values ranging from 5.94 to 18.68 per cent for different parameters. The study concluded that IPNS-based yield targeting improved productivity, nutrient availability and soil biological health, thereby sustaining soil fertility and groundnut production under *kharif* conditions.

Keywords: Groundnut, IPNS, Yield target, Soil fertility, Microbial population, *kharif*

Introduction

Soil is one of the most important natural resources that supports agricultural productivity and environmental sustainability. Soil quality is defined as the integrated effect of physical, chemical and biological properties of soil that determine its capacity to function effectively for crop production while maintaining environmental health. Good soil quality not only ensures higher crop productivity but also sustains plant, animal and human health. However, with the advancement of intensive agriculture, soils are being degraded at an alarming rate due to erosion, nutrient depletion, salinization and continuous exploitation for short-term productivity gains. Continuous cultivation without adequate replenishment of nutrients has resulted in deterioration of soil fertility and decline in crop productivity (Ghosh *et al.*, 2003) [7].

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops cultivated extensively in India and other tropical and subtropical regions of the world. It is valued for its edible oil, protein-rich kernels and nutritious haulm used as fodder. India occupies a prominent position in groundnut cultivation; however, productivity remains relatively low due to imbalanced nutrient management, declining soil fertility and poor soil biological health (Kumar *et al.*, 2021) [10]. Groundnut is a nutrient exhaustive crop requiring balanced application of nutrients for optimum vegetative growth, nodulation, peg penetration, pod development and kernel filling (Patel *et al.*, 2020) [14]. Deficiency of essential nutrients

significantly reduces nutrient uptake, dry matter accumulation and yield attributes, ultimately leading to lower pod yield (Ramesh *et al.*, 2022) ^[18].

Recent studies have indicated that continuous use of chemical fertilizers alone may deteriorate soil physical, chemical and biological properties, whereas integrated nutrient management improves nutrient availability, soil organic carbon and microbial activity (Meena *et al.*, 2021) ^[12]. Integrated application of organic manures along with inorganic fertilizers enhances nutrient use efficiency and sustains soil fertility under intensive cropping systems (Srinivasarao *et al.*, 2023) ^[21]. Balanced nutrition through Integrated Plant Nutrient System (IPNS) has also been reported to improve nutrient uptake, pod yield and quality parameters in groundnut while maintaining long-term soil productivity (Reddy *et al.*, 2020) ^[19]. Therefore, adoption of integrated nutrient management practices is essential for sustaining groundnut productivity and soil health under modern agricultural systems.

Integrated Plant Nutrient System (IPNS) has emerged as a sustainable approach for maintaining soil fertility and improving crop productivity through the combined use of organic and inorganic nutrient sources. Integration of farmyard manure (FYM) with chemical fertilizers enhances nutrient availability, improves nutrient synchronization and stimulates beneficial microbial activity in soil (Meena *et al.*, 2021) ^[12]. Several recent studies have reported that integrated nutrient management significantly improves soil organic carbon, available nutrient status and biological properties of soil compared to sole application of chemical fertilizers (Kumar *et al.*, 2022; Srinivasarao *et al.*, 2023) ^[11, 21]. Yield target-based nutrient management is another efficient strategy that supplies nutrients according to crop demand and desired productivity levels, thereby increasing fertilizer use efficiency and reducing nutrient losses (Patel *et al.*, 2021) ^[15].

Soil microbial population plays a vital role in nutrient cycling, decomposition of organic matter and maintenance of soil fertility. Beneficial microorganisms such as bacteria, fungi and actinomycetes contribute to mineralization, nutrient solubilization and improved nutrient availability to crops. Application of organic manures along with inorganic fertilizers creates favorable conditions for microbial proliferation and enhances soil biological health (Ramesh *et al.*, 2022) ^[18]. Recent findings also indicated that integrated nutrient management practices significantly enhance microbial biomass carbon, enzymatic activity and rhizospheric microbial population in oilseed cropping systems (Singh *et al.*, 2020; Verma *et al.*, 2024) ^[20, 24]. Considering the importance of balanced nutrient management for sustaining productivity and soil health, the present investigation was undertaken during *kharif*, 2025 to study the effect of fertilizer levels and Integrated Plant Nutrient System (IPNS) on yield, nutrient status and microbial population of groundnut. The study aimed to evaluate the effectiveness of yield target-based nutrient management approaches in improving crop productivity and maintaining soil fertility under groundnut cultivation.

Material and Methods

Experimental Site

A long-term field experiment initiated during 2020 was conducted at the Agricultural Research Station, Utukur to study the effect of fertilizer levels and Integrated Plant

Nutrient System (IPNS) on yield, nutrient status and microbial population of groundnut. The present investigation pertains to the *kharif*, 2025 season of the ongoing long-term experiment planned for duration of ten years to evaluate the sustainability of nutrient management practices on crop productivity and soil health. Observations on pod yield, haulm yield, nutrient content of plant and seed, post-harvest soil available nutrients and soil microbial population were recorded during *kharif*, 2025 and statistically analyzed using analysis of variance (ANOVA) at 5 per cent level of significance. The details of the treatments listed in Table. 1.

Equation for *kharif*:

$$FN = 5.50 T - 0.25 SN$$

$$FP_2O_5 = 14.56 T - 10.38 SP$$

$$FK_2O = 9.60 T - 0.61 SK$$

Table 1: Treatment details for evaluation of fertilizer levels and Integrated Plant Nutrient System (IPNS) in groundnut during *kharif*, 2025

	<i>kharif</i>
T ₁	100% RDF
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone
T ₄	Yield Target of 12 q/ha with IPNS
T ₅	Yield Target of 10 q/ha with IPNS
T ₆	FYM 10 t/ha
T ₇	Recommended dose of Nitrogen and Potassium
T ₈	Recommended dose of Nitrogen and Phosphorus
T ₉	Recommended dose of Phosphorus and Potassium
T ₁₀	Control

Soil Nutrient Analysis

Available Nitrogen (N)

Soil available nitrogen was estimated by alkaline permanganate method as described by Subbiah and Asija (1956) ^[22] and was expressed in kg ha⁻¹.

Available Phosphorus (P)

Soil available phosphorus was extracted by using 0.5M NaHCO₃ adjusted to pH 8.5 (Olsen *et al.*, 1954) ^[13] and color intensity was read in spectrophotometer at 660 nm and was expressed in kg ha⁻¹.

Available Potassium (K)

Soil available potassium was extracted with neutral normal ammonium acetate and the K content was determined using flame photometer systronics model 121 as described by Jackson (1967) ^[8] and was expressed in kg ha⁻¹.

Collection of Seed Samples

Seed samples were collected after the harvest of crop and processed as given by Chapman (1964) ^[6]. The seed samples were used for estimation of nitrogen, phosphorus, potassium.

Seed Analysis

One gram of oven dry seed sample was digested with 10 ml of diacid mixture (Nitric acid and Perchloric acid in 10:4 ratio). The digested seed samples diluted to known volume with double distilled water and filtered (Jackson, 1967) ^[8]. This filtrate was used for the estimation of P, K adopting the standard procedures mentioned below.

Total Nitrogen (N)

The Nitrogen content of seed sample was estimated by Microkjeldahl method (A.O.A.C. 1970) ^[1] and expressed in percentage.

Phosphorus (P)

The phosphorus concentration in diacid extract was determined by Vanadomolybdo phosphoric yellow colour method by using spectrophotometer (Jasco V-530 UV visible spectrophotometer) at 470 nm wavelength (Jackson, 1973) ^[9] and expressed in percentage.

Potassium (K)

The concentration of potassium in diacid extract was determined using the flame photometer (systronics flame photometer 128) (Jackson, 1967) ^[8] and expressed in percentage.

Microbial analysis

Each composite soil sample was air dried, processed with the help of pestle and mortar, passed through 2 mm sieve and used for the analysis of biological properties. The count of microorganisms (bacteria, fungi and actinomycetes) was carried out by using serial dilution pour plate method (Wollum, 1982) ^[25].

Isolation of microorganisms was carried out after harvest of crop and standard plate count (SPC) was performed as given by Pelczar *et al.*, (2003) ^[17]. Ten-fold serial dilutions were made up to 10⁻⁵. An amount of 0.1 ml from the diluted samples was spread on soil extract agar (pH 7; for bacteria) and soil extract with 0.1% (w/v) malt agar plates (pH 5.5; for fungi and actinomycetes) using a glass spreader. Petri plates were then incubated at ambient temperature (30-40°C) for 24 h for bacteria and 4-5 days for fungi. The isolates were maintained on respective media slants. Prevalence of different groups of microorganisms was calculated in terms of percentage. These isolates were identified on the basis of conventional cultural and morphological characteristics (Buchanan & Gibbons, 1986; Barnett & Hunter, 1998; Barnett, 1960; Thom & Raper, 1945) ^[2, 4, 5, 3, 23].

Results and Discussion

Yield Attributes

Total Number of Pods per Plant

Significant differences were observed among treatments with respect to total number of pods per plant. The highest total number of pods per plant (16) was recorded in T₂ (Yield Target of 12 q ha⁻¹ with chemical fertilizers alone). Treatments T₄, T₅ and T₉ recorded 15 pods per plant each and were statistically comparable. Treatments T₇ and T₈ recorded 14 pods per plant, while T₁ recorded 13 pods per plant. Treatment T₃ produced 12 pods per plant. The lowest number of pods per plant (10) was observed in T₆ and T₁₀. The higher number of pods under yield target-based nutrient management treatments might be due to improved nutrient availability and better reproductive growth. The SEm± and CD (5%) values were 1.08 and 3.23, respectively, with a CV of 13.28 per cent, presented in Table.2.

100-Kernel Weight (gms)

The 100-kernel weight ranged from 30 to 35 g among different treatments. The highest 100-kernel weight (35 g) was recorded in T₂ (Yield Target of 12 q ha⁻¹ with chemical fertilizers alone), followed by T₄ and T₅ with 34 g each.

Treatment T₁ recorded 33 g, while T₇, T₉ and T₁₀ recorded 32 g each. Treatments T₆ and T₈ recorded 31 g, whereas the lowest 100-kernel weight (30 g) was observed in T₃. Although numerical differences were observed among treatments, the variations were found to be statistically non-significant. The SEm± value was 1.33 and the CV was 7.14 per cent, presented in Table.2.

Shelling Percentage (%)

Shelling percentage varied from 64 to 69 per cent among the treatments. The highest shelling percentage (69%) was recorded in T₂ and T₅, followed by T₄ with 68 per cent. Treatments T₁, T₃ and T₉ recorded 67 per cent shelling, while T₆ and T₈ recorded 66 per cent. Treatment T₇ recorded 65 per cent shelling percentage, whereas the lowest value (64%) was observed in the control treatment (T₁₀). The higher shelling percentage under integrated nutrient management treatments may be due to better kernel development and efficient translocation of assimilates towards pods. However, differences among treatments were statistically non-significant. The SEm± value was 1.69 and the CV was 4.44 per cent, presented in Table.2.

Pod Yield (kg ha⁻¹)

Groundnut pod yield was significantly influenced by different fertilizer levels and Integrated Plant Nutrient System (IPNS) treatments during *kharif*, 2025. Among all the treatments, T₄ (Yield Target of 12 q ha⁻¹ with IPNS) recorded the highest pod yield of 793 kg ha⁻¹ and was found to be significantly superior to most of the treatments. The higher pod yield under T₄ may be attributed to balanced nutrient supply through integrated use of organic and inorganic nutrient sources, which improved nutrient availability and uptake throughout the crop growth period.

The next highest pod yield was recorded in T₅ (Yield Target of 10 q ha⁻¹ with IPNS) with 740 kg ha⁻¹, followed by T₂ (Yield Target of 12 q ha⁻¹ with chemical fertilizers alone) with 670 kg ha⁻¹. Treatment T₃ (Yield Target of 10 q ha⁻¹ with chemical fertilizers alone) recorded a pod yield of 657 kg ha⁻¹, which was comparable with T₁ (100% RDF) that produced 650 kg ha⁻¹. Nutrient omission treatments such as T₇ (RDN and RDK), T₈ (RDN and RDP) and T₉ (RDP and RDK) recorded pod yields of 640, 593 and 617 kg ha⁻¹, respectively. Treatment T₆ (FYM @ 10 t ha⁻¹) recorded a comparatively lower pod yield of 560 kg ha⁻¹. The lowest pod yield (407 kg ha⁻¹) was observed in the control treatment (T₁₀), indicating poor crop performance under nutrient deficient conditions. The SEm± and CD (5%) values for pod yield were 42.50 and 127.26, respectively, with a CV of 11.64 per cent, presented in Table.2.

Haulm Yield (kg ha⁻¹)

Haulm yield of groundnut was also significantly affected by fertilizer levels and nutrient management practices during *kharif*, 2025. The highest haulm yield (1573 kg ha⁻¹) was recorded in T₄ (Yield Target of 12 q ha⁻¹ with IPNS), which was significantly superior to most of the treatments and closely followed by T₂ (1533 kg ha⁻¹). The increased haulm yield under integrated nutrient management treatments might be due to enhanced vegetative growth, improved nutrient availability and better biomass accumulation.

Treatment T₈ (RDN and RDP) recorded a haulm yield of 1473 kg ha⁻¹, followed by T₆ (FYM @ 10 t ha⁻¹) with 1467 kg ha⁻¹ and T₇ (RDN and RDK) with 1460 kg ha⁻¹.

Treatment T₉ produced 1373 kg ha⁻¹ haulm yield, while T₅ recorded 1353 kg ha⁻¹. Treatments T₁ and T₃ recorded comparatively lower haulm yields of 1187 and 1147 kg ha⁻¹, respectively. The lowest haulm yield (887 kg ha⁻¹) was recorded in the control treatment (T₁₀). The significant increase in haulm yield under IPNS treatments indicates the

beneficial effect of balanced nutrient management on vegetative growth and dry matter production. The SEM_± and CD (5%) values for haulm yield were 121.68 and 364.33, respectively, with a CV of 15.66 per cent, presented in Table.2.

Table 2: Yield attributes of groundnut as influenced by fertilizer levels during *kharif* 2025

	Treatments	Total no. of pods/plant	100 Kernel wt (g)	Shelling%	Pod yield(kg/ha)	Haulm yield(kg/ha)
T ₁	100% RDF	13	33	67	650	1187
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone	16	35	69	670	1533
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone	12	30	67	657	1147
T ₄	Yield Target of 12 q/ha with IPNS	15	34	68	793	1573
T ₅	Yield Target of 10 q/ha with IPNS	15	34	69	740	1353
T ₆	FYM 10 t ha ⁻¹	10	31	66	560	1467
T ₇	RD N and RDK	14	32	65	640	1460
T ₈	RDN and RDP	14	31	66	593	1473
T ₉	RDP and RDK	15	32	67	617	1373
T ₁₀	Control	10	32	64	407	887
	SEm _±	1.08	1.33	1.69	42.50	121.68
	CD (5%)	3.23	NS	NS	127.26	364.33
	CV (%)	13.28	7.14	4.44	11.64	15.66

Post-Harvest Soil Nutrient Status

Available Nitrogen (kg ha⁻¹)

Post-harvest soil available nitrogen was significantly influenced by fertilizer levels and nutrient management practices during *kharif* 2025. The highest available nitrogen content was recorded in T₇ (RDN and RDK) with 217.20 kg ha⁻¹, which was significantly superior to all other treatments. This may be due to omission of phosphorus resulting in lower nutrient utilization and greater residual nitrogen accumulation in soil. Treatments T₂ (152.22 kg ha⁻¹), T₆ (150.49 kg ha⁻¹) and T₄ (146.30 kg ha⁻¹) also maintained higher nitrogen levels, while the lowest values were observed in T₁₀ (123.88 kg ha⁻¹) and T₃ (126.34 kg ha⁻¹). Increased nitrogen availability under FYM and integrated nutrient management treatments may be attributed to gradual mineralization of organic matter and enhanced microbial activity. The SEM_±, CD (5%) and CV values were 10.54, 31.57 and 12.41 per cent, respectively, presented in Table.3.

Available Phosphorus (kg ha⁻¹)

Available phosphorus in soil after harvest differed significantly among treatments. The highest phosphorus content was recorded in T₁ (100% RDF) with 38.69 kg ha⁻¹, followed by T₂ with 37.71 kg ha⁻¹. Treatments receiving

integrated nutrient management and FYM also maintained comparatively higher phosphorus levels. The lowest phosphorus content (22.04 kg ha⁻¹) was observed in T₇, where phosphorus was omitted from fertilizer application. Higher phosphorus availability under RDF and IPNS treatments may be due to balanced fertilizer application and improved phosphorus solubilization through decomposition of organic matter. The SEM_±, CD (5%) and CV values were 3.36, 10.08 and 18.68 per cent, respectively, presented in Table.3.

Available Potassium (kg ha⁻¹)

Available potassium status was significantly influenced by fertilizer treatments. The highest potassium content (212.20 kg ha⁻¹) was recorded in T₉ (RDP and RDK), which may be due to continuous potassium application and lower nutrient removal by crop under nutrient omission conditions. Treatments T₂ and T₄ recorded 178.10 and 161.61 kg ha⁻¹, respectively, whereas the lowest potassium content (132.23 kg ha⁻¹) was recorded in T₅. Balanced fertilization and integrated nutrient management improved potassium availability by reducing nutrient depletion and enhancing nutrient retention in soil. The SEM_±, CD (5%) and CV values were 11.60, 34.76 and 13.05 per cent, respectively, presented in Table.3.

Table 3: Post harvest available soil nutrient status (kg/ha) after harvest of *kharif* groundnut 2025

	Treatments	Nitrogen	Phosphorus	Potassium
T ₁	100% RDF	137.20	38.69	142.00
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone	152.22	37.71	178.10
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone	126.34	29.08	143.70
T ₄	Yield Target of 12 q/ha with IPNS	146.30	32.65	161.61
T ₅	Yield Target of 10 q/ha with IPNS	141.45	34.69	132.23
T ₆	FYM 10 t ha ⁻¹	150.49	34.37	136.43
T ₇	RDN and RDK	217.20	22.04	142.86
T ₈	RDN and RDP	131.32	27.61	137.40
T ₉	RDP and RDK	145.60	29.77	212.20
T ₁₀	Control	123.88	25.51	154.66
	SEm _±	10.54	3.36	11.60
	CD (5%)	31.57	10.08	34.76
	CV (%)	12.41	18.68	13.05

Major Nutrient Status in Seed

Nitrogen Content (%)

Nitrogen content in groundnut seed was significantly affected by fertilizer levels and nutrient management practices. The highest nitrogen content (4.20%) was recorded in T₆ (FYM @ 10 t ha⁻¹), followed by T₄ and T₅ (3.96%). The lowest nitrogen content (3.16%) was observed in the control treatment (T₁₀). Higher nitrogen accumulation under FYM and IPNS treatments may be due to gradual nutrient release and improved nutrient uptake under enhanced soil biological activity. The SEM_±, CD (5%) and CV values were 0.16, 0.49 and 7.59 per cent, respectively, presented in Table.4.

Phosphorus Content (%)

Phosphorus content in seed ranged from 0.31 to 0.38 per cent. The highest phosphorus content (0.38%) was recorded in T₂, followed by T₉ (0.37%). Although numerical

differences existed among treatments, the variations were statistically non-significant. Improved phosphorus uptake under fertilizer-applied treatments may be due to enhanced phosphorus availability in soil. The SEM_± and CV values were 0.02 and 8.24 per cent, respectively, presented in Table.4.

Potassium Content (%)

Potassium content in seed was significantly influenced by fertilizer treatments. The highest potassium content (0.82%) was recorded in T₉, followed by T₅ (0.78%) and T₂ (0.77%). The lowest potassium content (0.55%) was observed in the control treatment. Higher potassium concentration under balanced fertilization and integrated nutrient management may be due to improved nutrient availability and efficient translocation of potassium to seeds. The SEM_±, CD (5%) and CV values were 0.04, 0.07 and 5.94 per cent, respectively, presented in Table.4.

Table 4: Major nutrient status in seed (%) after harvest of *kharif* groundnut 2025

	Treatments	Nitrogen	Phosphorus	Potassium
T ₁	100% RDF	3.50	0.35	0.66
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone	3.80	0.38	0.77
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone	3.86	0.36	0.68
T ₄	Yield Target of 12 q/ha with IPNS	3.96	0.33	0.67
T ₅	Yield Target of 10 q/ha with IPNS	3.96	0.35	0.78
T ₆	FYM 10 t ha ⁻¹	4.20	0.36	0.76
T ₇	RDN and RDK	3.70	0.35	0.67
T ₈	RDN and RDP	3.86	0.35	0.71
T ₉	RDP and RDK	3.70	0.37	0.82
T ₁₀	Control	3.16	0.31	0.55
	SEM _±	0.16	0.02	0.04
	CD (5%)	0.49	NS	0.07
	CV (%)	7.59	8.24	5.94

Major Nutrient Status in Plant

Nitrogen Content (%)

Nitrogen content in plant after harvest was significantly influenced by nutrient management practices. The highest nitrogen content (3.5%) was recorded in T₉, followed by T₇ (3.3%). Treatments under IPNS also maintained comparatively higher nitrogen content, while the lowest value (2.4%) was recorded in the control treatment. Enhanced nitrogen uptake under integrated nutrient management may be attributed to improved nutrient availability and root growth. The SEM_±, CD (5%) and CV values were 0.20, 0.59 and 11.96 per cent, respectively, presented in Table.5.

Phosphorus Content (%)

Plant phosphorus content differed significantly among treatments. The highest phosphorus content (0.4%) was

recorded in T₃, T₅, T₈ and T₉, whereas lower values (0.2%) were observed in T₁, T₄ and T₁₀. Improved phosphorus content under balanced fertilization and IPNS treatments may be due to enhanced phosphorus solubilization and uptake. The SEM_±, CD (5%) and CV values were 0.02, 0.06 and 13.12 per cent, respectively, presented in Table.5.

Potassium Content (%)

Potassium content in plant was significantly influenced by fertilizer treatments. Treatments T₂, T₄, T₅ and T₈ recorded the highest potassium content (1.8%), while the lowest value (1.2%) was observed in the control treatment. Integrated nutrient management improved potassium uptake due to balanced fertilization and better soil biological activity. The SEM_±, CD (5%) and CV values were 0.07, 0.22 and 8.08 per cent, respectively, presented in Table.5.

Table 5: Major nutrient status in plant (%) after harvest of *kharif* groundnut 2025

	Treatments	Nitrogen	Phosphorus	Potassium
T ₁	100% RDF	2.5	0.2	1.6
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone	2.6	0.3	1.8
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone	2.9	0.4	1.7
T ₄	Yield Target of 12 q/ha with IPNS	3.0	0.2	1.8
T ₅	Yield Target of 10 q/ha with IPNS	3.1	0.4	1.8
T ₆	FYM 10 t ha ⁻¹	2.9	0.3	1.7
T ₇	RDN and RDK	3.3	0.3	1.7
T ₈	RDN and RDP	2.9	0.4	1.8
T ₉	RDP and RDK	3.5	0.4	1.4
T ₁₀	Control	2.4	0.2	1.2
	SEM _±	0.20	0.02	0.07
	CD (5%)	0.59	0.06	0.22
	CV (%)	11.96	13.12	8.08

Soil Microbial Population

Bacterial Population

Bacterial population after harvest was significantly influenced by fertilizer levels and nutrient management practices. The highest bacterial population (187×10^7 CFU g^{-1} soil) was recorded in T₆ (FYM @ 10 t ha^{-1}), followed by T₈ and T₁. The lowest bacterial population (125×10^7 CFU g^{-1} soil) was observed in the control treatment. Increased bacterial population under FYM and integrated nutrient management treatments indicates improved soil biological activity and nutrient cycling. The SEm $\pm$, CD (5%) and CV values were 6.75, 20.22 and 7.96 per cent, respectively, presented in Table.6.

Fungal Population

Fungal population differed significantly among treatments. The highest fungal population (17×10^2 CFU g^{-1} soil) was recorded in T₁, followed by T₆ (16×10^2 CFU g^{-1} soil). The

lowest fungal population (11×10^2 CFU g^{-1} soil) was observed in T₂. Improved fungal growth under FYM and balanced fertilization may be due to increased organic matter decomposition and favorable soil conditions. The SEm $\pm$, CD (5%) and CV values were 1.06, 3.01 and 12.06 per cent, respectively, presented in Table.6.

Actinomycetes Population

Actinomycetes population was significantly influenced by nutrient management practices. The highest population (22×10^3 CFU g^{-1} soil) was recorded in T₆, while the lowest value (10×10^3 CFU g^{-1} soil) was observed in the control treatment. Higher actinomycetes population under FYM and IPNS treatments indicates improved decomposition activity and enhanced soil biological health. The SEm $\pm$, CD (5%) and CV values were 0.90, 2.69 and 9.53 per cent, respectively, presented in Table.6.

Table 6: Microbial population as influenced by fertilizer levels after harvest of *kharif* groundnut 2025

Treatments		Bacteria ($\times 10^7$)	Fungi ($\times 10^2$)	Actinomycetes ($\times 10^3$)
T ₁	100% RDF	155	17	19
T ₂	Yield Target of 12 q/ha with chemical fertilizers alone	135	11	15
T ₃	Yield Target of 10 q/ha with chemical fertilizers alone	144	14	13
T ₄	Yield Target of 12 q/ha with IPNS	146	12	18
T ₅	Yield Target of 10 q/ha with IPNS	142	14	16
T ₆	FYM 10 t ha^{-1}	187	16	22
T ₇	RDN and RDK	137	15	17
T ₈	RDN and RDP	160	14	17
T ₉	RDP and RDK	134	15	13
T ₁₀	Control	125	13	10
	SEm $\pm$	6.75	1.06	0.90
	CD (P=0.05)	20.22	3.01	2.69
	CV (%)	7.96	12.06	9.53

The results of the present investigation clearly indicated that fertilizer levels and Integrated Plant Nutrient System (IPNS) significantly influenced yield attributes, pod and haulm yield, post-harvest soil nutrient status, nutrient content in plant and seed, and soil microbial population of groundnut during *kharif*, 2025 under the long-term experiment initiated in 2020. The superiority of integrated nutrient management treatments over sole chemical fertilization emphasized the importance of balanced nutrient supply for sustaining productivity and soil health.

Among the treatments, T₄ (Yield Target of 12 q ha^{-1} with IPNS) recorded the highest number of filled pods per plant, pod yield and haulm yield. The improved performance under IPNS treatments may be attributed to synchronized nutrient release from organic and inorganic sources, resulting in better nutrient availability during critical growth stages. Integrated application of FYM along with fertilizers might have improved soil physical properties, root growth and nutrient uptake efficiency, thereby enhancing reproductive growth and biomass accumulation. Similar findings were reported by Kumar *et al.* (2021) [10] and Srinivasarao *et al.* (2023) [21], who observed higher yield and nutrient uptake in groundnut under integrated nutrient management practices. The lower yields observed in nutrient omission treatments and control plots highlighted the importance of balanced fertilization for optimum crop growth and pod development. Patel *et al.* (2022) [16] also reported that omission of major nutrients significantly reduced pod yield and dry matter production in groundnut.

Post-harvest soil nutrient status was significantly affected by fertilizer treatments. Higher available nitrogen in T₇ (RDN and RDK) may be due to lower nitrogen utilization under phosphorus omission. Integrated nutrient management treatments maintained comparatively higher soil nutrient availability because of gradual mineralization of organic matter and improved nutrient retention. Similar results were reported by Meena *et al.* (2021) [12] and Verma *et al.* (2024) [24], who observed improvement in residual soil fertility under long-term integrated nutrient management systems.

Nutrient content in plant and seed was also improved under IPNS and FYM treatments. Higher nitrogen and potassium contents indicated enhanced nutrient uptake and efficient translocation under balanced fertilization. Ramesh *et al.* (2022) [18] similarly reported increased nutrient concentration and uptake in groundnut under combined application of organic and inorganic nutrient sources.

Soil microbial population responded positively to organic manure application. T₆ (FYM @ 10 t ha^{-1}) recorded the highest bacterial and actinomycetes populations, indicating enhanced microbial activity due to increased organic carbon availability. Higher microbial population under integrated nutrient management treatments confirmed the beneficial effect of combined nutrient application on soil biological health. Similar observations were reported by Singh *et al.* (2020) [20] and Verma *et al.* (2024) [24]. Overall, the study demonstrated that long-term IPNS practices improved crop productivity, soil fertility and microbial activity, thereby supporting sustainable groundnut production.



Fig 1: Field view of longterm experiment in groundnut-groundnut cropping sequence



Fig 2: Field view of longterm experiment in groundnut-groundnut cropping sequence

Conclusion

The findings of the present investigation revealed that fertilizer levels and Integrated Plant Nutrient System (IPNS) significantly influenced yield attributes, pod yield, haulm yield, soil nutrient status, nutrient content and microbial population of groundnut during *khari*, 2025 under the ongoing long-term experiment initiated in 2020. Among all the treatments, T₄ (Yield Target of 12 q ha⁻¹ with IPNS) proved superior by recording the highest pod yield and haulm yield, indicating the effectiveness of integrated nutrient management in enhancing crop productivity. Integrated application of FYM and inorganic fertilizers improved nutrient availability, nutrient uptake and balanced crop nutrition, which ultimately enhanced reproductive growth and yield performance.

Post-harvest soil nutrient status and microbial population were also considerably improved under integrated nutrient management and FYM application treatments. The higher bacterial, fungal and actinomycetes populations under FYM and IPNS treatments indicated enhanced soil biological activity and improved soil health. The study clearly demonstrated that sole dependence on chemical fertilizers is

less effective in sustaining productivity and soil fertility compared to integrated nutrient management approaches.

Overall, the results suggest that yield target-based IPNS is an effective and sustainable nutrient management strategy for improving groundnut productivity, maintaining soil fertility and enhancing soil biological health under long-term cultivation systems. Hence, integration of organic manures with inorganic fertilizers should be promoted for sustainable groundnut production and long-term soil health management.

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