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# Comparative Analysis of Growth Parameters of Wheat (*Triticum aestivum* L.) and Groundnut (*Arachis hypogaea* L.) under Organic and Conventional Farming Systems

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## ABSTRACT

**Background:** Wheat (*Triticum aestivum* L.) and groundnut (*Arachis hypogaea* L.) are essential crops for food and nutritional security in India. This study evaluated growth, yield, nutritional quality and economic factors among organic, conventional and integrated agricultural methods.

**Methods:** The research conducted from 2022 to 2024 at the Organic Farming Research and Training Center, VNMKV, Parbhani, employed a randomized block design with three replications to evaluate conventional, organic and integrated nutrient management (75:25, 50:50, 25:75) and control treatments in wheat and groundnut cultivation. Soil and plant samples were examined for soil characteristics, growth, yield and quality, in addition to the calculation of economic indicators. The data were subjected to statistical analysis *via* one-way ANOVA ($p<0.05$).

**Result:** The findings showed improved soil fertility, with organic carbon rising from 0.41-0.42% to 0.71-0.72% and increased nitrogen and phosphorus, while potassium declined due to crop uptake. Wheat growth was highest under integrated treatments T4 (50% organic + 50% conventional) and T5 (25% organic + 75% conventional). In groundnut, T2 maximized leaf area and biomass, while T5 had the tallest plants and largest nodules. Profitability peaked in T4 `36,300 $ha^{-1}$, B:C 1.72). Overall, integrated management enhanced wheat growth and groundnut nodulation, whereas organic inputs improved groundnut biomass, leaf area and soil health.


**Key words:** Economics, Groundnut, Organic farming, Soil fertility, Wheat, Yield.

## INTRODUCTION

Wheat (*Triticum aestivum* L.) and groundnut (*Arachis hypogaea* L.) are vital crops for global food and nutritional security (Jukanti *et al.,* 2016; Lungaho *et al.,* 2025). Wheat serves as a fundamental food source for more than one-third of the global population, supplying significant calories and protein. In contrast, groundnuts are an essential source of edible oil and plant protein, especially in developing nations. In India, wheat ranks as the second most crucial cereal following rice, while groundnut accounts for around 25% of total oilseed production, underscoring their importance in the agricultural economy (Chilwal *et al.,* 2025; Kumar *et al.,* 2022).

Enhancing agricultural output while reducing environmental harm continues to be a significant problem. Conventional agriculture frequently attains greater yields *via* synthetic inputs and intensive methodologies; yet these practices can adversely affect soil health, biodiversity and long-term sustainability (Kumar *et al.,* 2012; Bhosale *et al.,* 2025). Conversely, organic farming depends on organic amendments, biofertilizers, crop rotations and biological pest management to sustain ecological equilibrium and soil vitality (Akanmu *et al.,* 2023; Mehata *et al.,* 2023). However, its capacity to reliably achieve conventional yields, particularly during the transitional phase, continues to be a subject of contention (Tully *et al.,* 2020).

Prior research indicates that organic management improves soil microbial activity and biomass, but yields may decrease in the initial years (Gunapala *et al.,* 1998). Yield disparities between organic and conventional systems frequently hinge on crop variety and management intensity (De Ponti *et al.,* 2012). Organic techniques have been associated with enhanced wheat grain quality, improved soil health and heightened pest resistance in groundnut (Rempelos *et al.,* 2023; Gelaye *et al.,* 2024). Nevertheless, most of the research has examined these crops in isolation, with few studies analyzing wheat and groundnut concurrently within identical organic and conventional management frameworks (Walkley *et al.,* 1934).

Growth metrics, including germination rate, plant height, leaf area index, biomass accumulation and

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phenology, serve as critical indicators of crop performance and management response (Bray *et al.,* 1945; Ratjen *et al.,* 2018). Evaluating these characteristics for both crops under consistent experimental settings can yield clearer insights into system performance and crop adaptability, particularly in Indian cereal-oilseed systems where integrated research is lacking (AOAC *et al.,* 1965).

Recent ARCC studies underscore the advantages of integrated and organic nutrient management in cereal-legume systems in India, enhancing soil organic carbon, nutrient-use efficiency and yield stability in wheat and groundnut (Mitura *et al.,* 2023). Nonetheless, comparative system-level analyses under consistent settings are still scarce. This study assesses the growth performance of wheat and ground nuts in organic and conventional settings to promote sustainable cereal-oilseed production.

## MATERIALS AND METHODS

### Study design

The study was conducted over two seasons (2022-2024) at the Organic Farming Research and Training Center, VNMKV, Parbhani, Maharashtra, a semi-arid region suitable for *kharif* groundnut and *rabi* wheat. A randomized block design with three replications evaluated six treatments (T1-T6): conventional, organic, three integrated nutrient levels and an unfertilized control. Plots measured 5 × 4 m with 1 m buffers and treatments were randomly assigned within blocks to minimize positional effects.

### Sample collection

Soil (0-15 cm), plant and seed samples were meticulously collected to assess agricultural systems. Soil was collected at sowing and post-harvest, air-dried, sieved and evaluated for pH, electrical conductivity, organic carbon and macro- and micronutrients. Wheat and groundnut were sampled at critical growth stages for morphological characteristics and mature seeds from net plots were evaluated for yield, nutritional content, biochemical properties and pesticide residues. This methodology guaranteed a dependable assessment of soil fertility, crop output and quality across organic, conventional and integrated systems.

### Treatments and crop management

The experiment comprised six treatments to assess nutrient management strategies. T1 employed exclusively conventional inputs (recommended NPK and pesticides), T2 adopted a wholly organic methodology (FYM, vermicompost, biofertilizers), T3-T5 implemented integrated nutrient management with organic to chemical ratios of 75:25, 50:50 and 25:75, while T6 functioned as the control group. Wheat (HD-2189) and groundnut (TAG-24) were planted *via* seed dibbling at rates of 100 and 80 kg $ha^{-1}$, with spacings of 30 × 10 cm and 30 × 15 cm, respectively. Weed management was executed *via* intercultivation at 25 and 40 days after sowing, with irrigation administered as required.

### Growth parameters

Growth parameters were recorded at specific growth stages over two years:

### Wheat

Wheat growth metrics were documented at 60 days after sowing (DAS), 90 DAS and at harvest. Plant height, leaf count per tiller, tiller quantity and panicle length were quantified to evaluate vegetative and reproductive development. Plant height was measured from the base to the spike tip (excluding awns), tillers and leaves were counted non-destructively and panicle length was measured in cm.

### Groundnut

For groundnut, plant height, leaf count per plant, branch quantity and canopy width were measured at 30, 60 and 90 days after sowing, as well as at harvest, to evaluate vegetative growth. Root nodulation was assessed by extracting plants, enumerating nodules and quantifying their dry weight to indicate nitrogen-fixing capacity.

### Economic analysis

An economic study was conducted by determining the cost of cultivation, gross return, net return and benefit-cost (B:C) ratio for each treatment. The cost of cultivation encompassed input and labor expenditures at current market rates. The gross return was calculated based on crop output and market price, while the net return was derived by deducting cultivation costs from the gross return. The B:C ratio was determined by comparing gross return to cultivation cost.

$$\text{B:C ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

### Statistical analysis

All experimental observations were documented in triplicate and the average values for each measured parameter were computed. Data was analyzed utilizing SPSS version 26. A One-way Analysis of Variance (ANOVA) was performed to identify significant differences among treatments at a significance threshold of $p<0.05$. In instances where substantial differences were identified, the least significant difference (LSD) test was utilized for pairwise comparisons of treatment means.

## RESULTS AND DISCUSSION

### Physicochemical analysis of soil before and after sowing of wheat and groundnut

Soil analysis before and after wheat and groundnut cultivation showed improved fertility, with notable increases in organic carbon (wheat: 0.42→0.71%; groundnut: 0.41→0.72%), nitrogen, phosphorus and micronutrients (Cu, Fe, Mn, Zn). pH remained stable, EC slightly increased and $CaCO_3$ and potassium declined marginally, likely due to crop uptake. Both crops enhanced soil nutrients and

organic matter while maintaining optimal soil conditions (Table 1).

**Impact of different treatments on growth parameters in wheat**

Nutrient and pest management significantly influenced wheat growth and yield. Plant height increased from 60 to 90 DAS, with T4 and T5 reaching 82.87 cm in 2023 (Table 2). Leaf count per tiller was highest in T2 and T5 (up to 8.13), tillers per plant peaked in T3 and T5 (up to 7.83) and panicle length was greatest in T5 and T4 (7.37-7.80 cm). Biomass was highest in T5 (7500 kg $ha^{-1}$) and lowest in T6 (6200 kg $ha^{-1}$), indicating that T4 and T5 most effectively enhanced vegetative growth and yield. LSD analysis confirmed significant differences in leaf count and tiller number across treatments.

**Impact of different treatments on growth parameters of groundnut**

Nutrient and pest management markedly affected groundnut growth, physiology and yield over two years. Plant height was highest in T5 (19.53 cm at 30 DAS, 2022), while leaf area and biomass peaked in T2 (38.57 $cm^2$ and 43.33 g, 2024). Yield was maximized under T5 (2,800 kg $ha^{-1}$, 2024), reflecting combined vegetative and physiological performance (Table 3). Chlorophyll content was consistently higher in T2 and T5 and root nodules were largest in T5 and T6 (62.80-63.43 g), indicating enhanced nitrogen fixation. LSD analysis confirmed significant treatment effects on leaf area, biomass, chlorophyll and nodulation.

**Economic analysis of different nutrient management treatments**

The economic assessment of wheat and groundnut indicated that the combination of 50% organic and 50% conventional inputs (T4) yielded the highest profitability, with a net return of `40,000 per hectare and a benefit-cost ratio of 1.69. T1 (100% conventional) and T3 (75% organic + 25% conventional) yielded robust returns of `35,000 $ha^{-1}$, whereas T2 (100% organic) produced somewhat lower yields of `33,500 $ha^{-1}$, however remained economically viable (Table 4). The control (T6) exhibited the lowest yield (`28,000 $ha^{-1}$, B:C 1.56), underscoring the need of nutrient management. In summary, the partial integration of organic and conventional inputs optimized profitability, with T4 proving to be the most economical option.

A comparative evaluation of wheat (*Triticum aestivum* L.) and groundnut (*Arachis hypogaea* L.) within organic and conventional systems underscores the significance of nutrient management in crop development, production and sustainability. Organic methods improve soil fertility and nutrient cycling, facilitating groundnut growth and nodulation, whereas conventional systems encourage quick early wheat growth but may compromise long-term soil production. Their divergent nutrient dynamics render integrated and organic systems crucial for enhancing nutrient-use efficiency and soil sustainability (Fess *et al.,* 2018; Bana *et al.,* 2024; Kiran *et al.,* 2019; Freschet *et al.,* 2015).

Post-harvest soil study indicated that fertilizer and pest management measures have minimal influence on soil chemical characteristics. Soil pH remained neutral to slightly alkaline throughout treatments, suggesting that organic and conventional inputs did not induce detrimental chemical alterations impacting nutrient availability or crop growth, in accordance with the findings of Whetton *et al.* (2022) and Singh *et al.* (2020); (Whetton *et al.,* 2022; Singh *et al.,* 2020). Electrical conductivity remained within acceptable thresholds, indicating an absence of salt stress due to nitrogen treatments, consistent with findings by Paramesh *et al.* (2023) and Kamal *et al.* (2024). A recurring pH and electrical conductivity facilitate effective nutrient absorption, enhance soil biological activity and promote sustained productivity (Paramesh *et al.,* 2023; Kamal *et al.,* 2024).

The organic carbon content exhibited significant variation among treatments, with elevated levels observed under organic management, suggesting enhanced soil biological activity and nutrient retention ability. The increased organic carbon in the totally organic treatment aligns with the results of Das *et al.* (2017), which indicated that farmyard manure and vermicompost augment soil organic matter by slow decomposition (Das *et al.,* 2017).

**Table 1:** Comparative physicochemical analysis of soil before and after sowing of wheat and groundnut.

| Parameters | Before wheat | After wheat | Before groundnut | After groundnut |
|---|---|---|---|---|
| pH | 7.87 | 7.93 | 8.06 | 7.94 |
| EC (dS $m^{-1}$) | 0.15 | 0.21 | 0.16 | 0.22 |
| OC (%) | 0.42 | 0.71 | 0.41 | 0.72 |
| $CaCO_3$ (%) | 4.21 | 2.95 | 4.22 | 2.99 |
| N (kg $ha^{-1}$) | 120.94 | 182.58 | 119.25 | 175.92 |
| P (kg $ha^{-1}$) | 5.72 | 19.75 | 5.78 | 16.98 |
| K (kg $ha^{-1}$) | 493.30 | 470.00 | 497.71 | 442.27 |
| Cu (ppm) | 2.42 | 2.98 | 2.49 | 2.97 |
| Fe (ppm) | 11.90 | 13.25 | 11.99 | 13.23 |
| Mn (ppm) | 14.45 | 17.92 | 14.67 | 18.07 |
| Zn (ppm) | 0.42 | 0.55 | 0.47 | 0.54 |

**Table 2:** Effect of different nutrient and pest management treatments on plant growth and yield attributes of wheat.

| Treatment | Plant height | | | | | Leaf count | Tillers per | Panicle | Yield |
|---|---|---|---|---|---|---|---|---|---|
| | 2022 (60 DAS) | 2022 (90 DAS) | 2022 (Harvest) | 2023 (60 DAS) | 2023 (90 DAS) | 2023 (Harvest) | per tiller (no.) | Plant (no.) | length (cm) | (kg ha$^{-1}$) |
| T1 | 69.93±0.85 | 73.67±3.44 | 75.47±3.44 | 72.07±2.61 | 80.17±4.39 | 82.33±4.39 | 6.20± 0.16$^{ab}$ | 6.33±0.30$^{abc}$ | 7.40±0.09$^{b}$ | 5300±141 |
| T2 | 73.20 ±3.52 | 74.87±3.41 | 75.07±2.89 | 76.20±3.60$^{ab}$ | 79.20±4.05 | 80.37±4.11 | 6.83±0.22$^{abc}$ | 7.00±0.33$^{abc}$ | 8.13±0.10$^{a}$ | 4775±106 |
| T3 | 69.13±2.32 | 71.87±1.57 | 75.53±1.09 | 67.90±4.14 | 71.33±4.01 | 73.83±3.77 | 5.30±0.19$^{a}$ | 5.77±0.10$^{d}$ | 7.83±0.05 | 5075±106 |
| T4 | 75.93±1.61 | 79.07±1.96 | 82.33±1.98 | 76.83±4.61$^{a}$ | 80.87±4.74 | 82.87±5.10 | 5.77±0.33 | 6.27±0.03$^{ef}$ | 7.37±0.47$^{ab}$ | 5125±106 |
| T5 | 75.93±4.13 | 78.60±3.97 | 81.07±3.84 | 77.43±2.90$^{b}$ | 80.53±3.23 | 83.03±3.23 | 5.60±0.19$^{bd}$ | 4.73±0.44$^{ae}$ | 7.80±0.05 | 5175±106 |
| T6 | 75.73±4.03 | 77.87±4.28 | 79.20±4.21 | 78.00±4.95 | 80.97±5.28 | 82.77±5.33 | 4.27±0.11 | 4.47±0.05$^{bc}$ | 7.27±0.05$^{a}$ | 4050±71 |
| LSD (p<0.05) | 6.40 | 7.30 | 6.90 | 8.10 | 8.80 | 9.10 | 0.62 | 0.74 | 0.68 | 230 |

*Different superscript lowercase letters (a-f) within the identical column signify significant differences among treatments at p<0.05, as determined by ANOVA followed by a suitable post hoc test (LSD). Treatments that have at least one common letter are not significantly distinct.

However, Bhattacharyya *et al.* (2022) revealed that reduced levels in chemically dominated treatments correspond with observations of accelerated organic matter depletion due to continuous fertilizer application (Bhattacharyya *et al.*, 2022). Similarly, Mandal *et al.* (2012) Calcium carbonate ($CaCO_3$) remained within moderate thresholds, signifying sustained buffering capability without influencing nutrient availability, (Mandal *et al.,* 2012). These changes affect long-term soil production and sustainability.

The availability of macronutrients differed among treatments and affected crop growth and yield. However, Verma *et al.* (2019) and Masunga *et al.* (2016) revealed that nitrogen concentrations were elevated in fertilizer-enhanced treatments owing to quick nutrient availability, whereas organic additions sustained sufficient nitrogen via gradual mineralization and enhanced nutrient-use efficiency (Verma *et al.*, 2019; Masunga *et al.,* 2016). Das *et al.* (2020) showed that available phosphorus decreased in nutrient-omission treatments but was maintained at moderate levels under integrated management due to balanced nutrient release (Das *et al.,* 2020). Similarly, Rani *et al.* (2023) revealed that potassium concentrations were elevated in nutrient-enriched treatments, aligning with findings of potassium deficiency in input-limited systems (Rani *et al.,* 2023).

The availability of micronutrients significantly influenced physiological activities and yield development. Copper, iron and manganese were sufficient across treatments, corroborating Shukla *et al.* (2020), who observed that these micronutrients are seldom limiting in Indo-Gangetic soils (Shukla *et al.*, 2020). Their adequate levels probably facilitated enzyme activity, chlorophyll production and overall plant vitality without inducing concealed deficits. Nonetheless, zinc remained inadequate in certain treatments, especially under nutrient-omission circumstances, consistent with Rehman *et al.* (2018), who documented prevalent zinc deficits in Indian wheat cultivation areas. Zinc's involvement in enzyme activation and grain formation suggests that its absence may partially account for diminished growth and yield performance under these treatments (Rehman *et al.,* 2018).

Soil analysis conducted before and after harvest indicated that organic and integrated treatments elevated organic carbon and nitrogen levels, hence improving nutrient retention, biological activity and soil fertility. These patterns align with Chen *et al.* (2024), who illustrated that integrated organic-inorganic nutrient management enhances soil organic reserves and nutrient-use efficiency (Chen *et al.,* 2024). These improvements are agronomically important, as higher carbon and nitrogen support extended vegetative growth, stronger roots and more stable yields in wheat and groundnut. In contrast, reductions in phosphorus and potassium in the untreated control indicate nutrient depletion, as elucidated by Ma *et al.* (2019) in systems devoid of external inputs (Ma *et al.,* 2019).

**Table 3:** Effect of treatments on groundnut yield, physiology and root nodules over two years.

| Treatments | Years | Plant height (cm) | Leaf area ($cm^2$) | Biomass (g) | Yield (kg $ha^{-1}$) | Chlorophyll content | Groundnut root nodule weight (g) |
|---|---|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | | Harvest | 30 DAS |
| T1 | 2022 | 15.73±1.20 | 32.80±2.32 | 38.13±1.83 | 2450±110 | 39.73±1.52 | 52.67±1.58 |
| | 2024 | 16.00±1.16 | 29.57±2.05 | 34.30±1.99 | 2500±115 | 35.73±1.24 | 57.10±1.97 |
| T2 | 2022 | 15.00±0.65 | 34.87±0.83 | 39.26±0.39 | 2550±120 | 39.36± 0.33 | 53.73±3.73 |
| | 2024 | 16.07±0.48 | 38.57±1.00 | 43.33±0.50 | 2700±125 | 43.60±0.37 | 55.17±2.78 |
| T3 | 2022 | 13.53±1.51 | 32.07±0.61 | 35.87±0.39 | 2300±105 | 37.60±0.25 | 43.73±3.74 |
| | 2024 | 13.67±0.93 | 32.00±1.03 | 33.40±0.45 | 2350±110 | 34.53±0.55 | 47.70±4.33 |
| T4 | 2022 | 12.20±0.25 | 31.20±0.86 | 36.87±0.30 | 2500±115 | 37.93±0.36 | 38.53±0.89 |
| | 2024 | 12.50±0.45 | 30.13±1.99 | 37.13±1.56 | 2550±120 | 37.70±1.63 | 41.90±0.61 |
| T5 | 2022 | 19.53±0.94 | 32.53±1.69 | 37.73±1.80 | 2600±130 | 38.93±1.62 | 58.20±0.82 |
| | 2024 | 19.40±1.27 | 29.67±1.82 | 36.77±1.99 | 2800±135 | 37.73±2.07 | 62.80±0.82 |
| T6 | 2022 | 13.90±1.11 | 30.27±0.73 | 30.80±0.19 | 2300±100 | 31.20±0.90 | 57.73±3.19 |
| | 2024 | 13.87±0.56 | 28.80±0.25 | 29.60±1.21 | 2200±95 | 31.60±1.63 | 63.43±2.62 |
| LSD ($p<0.05$) | - | 1.63 | 3.26 | 4.0 | 189 | 1.14 | 4.05 |

**Table 4:** Economic analysis of wheat and groundnut under different nutrient management treatments.

| Treatment | Cost of cultivation (` $ha^{-1}$) | Gross return (` $ha^{-1}$) | Net return (` $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|
| T1 - 100% Conventional | 60,000 | 95,000 | 35,000 | 1.58 |
| T2 - 100% Organic | 55,000 | 88,500 | 33,500 | 1.61 |
| T3 - 75% Organic + 25% Conventional | 57,000 | 92,000 | 35,000 | 1.61 |
| T4 - 50% Organic + 50% Conventional | 58,000 | 98,000 | 40,000 | 1.69 |
| T5 - 25% Organic + 75% Conventional | 59,000 | 96,000 | 37,000 | 1.63 |
| T6 - Control | 50,000 | 78,000 | 28,000 | 1.56 |

However, the findings are limited by the short study duration and single location, which may not capture broader environmental variability or long-term soil fertility and yield stability. Short-term results may also underestimate cumulative sustainability and economic impacts due to evolving soil biology and nutrient dynamics.

## CONCLUSION

In conclusion, conventional agriculture accelerated initial growth and productivity, whereas organic practices enhanced soil vitality and nutrient composition. Comprehensive, longitudinal research across multiple locations is essential to thoroughly assess sustainability trade-offs.

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### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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