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ORIGINAL ARTICLE

Effect of Organic Fertilizers on Yield, Oil Content and Nutritional Composition of Groundnut (*Arachis hypogaea* L.)

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ABSTRACT
Groundnut (Arachis hypogaea L.) is an important oilseed crop widely cultivated for its edible oil and nutritional value. However, continuous use of chemical fertilizers deteriorates soil health and reduces long-term productivity. The present study was conducted to evaluate the impact of different organic fertilizers on growth attributes, yield performance, oil content and nutritional composition of groundnut under field conditions. The experiment was laid out in a Randomized Block Design with six treatments: Control, Recommended Dose of Chemical Fertilizer, Farmyard Manure, Vermicompost, Poultry Manure and Integrated Organic Treatment (FYM + Vermicompost). The results revealed that integrated organic management significantly enhanced plant height, branching, root nodulation and yield attributes compared to chemical fertilization. The highest pod yield (2054 kg ha^{-1}) and kernel yield (1462 kg ha^{-1}) were recorded in the integrated organic treatment, followed by vermicompost. Oil content and protein percentage of groundnut seeds were also markedly higher under organic and integrated treatments than under chemical fertilizer. The improvement in growth and nutritional quality was attributed to enhanced soil organic carbon, microbial activity and sustained nutrient release. The study concludes that integrated organic nutrient management is a sustainable and effective approach for improving groundnut productivity and seed quality while maintaining soil fertility in semi-arid agro-ecosystems.
Keywords: *Groundnut; Organic fertilizers; FYM; Vermicompost; Integrated nutrient management; Oil content; Nutritional quality; Sustainable agriculture*

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INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops grown in tropical and semi–arid regions of the world. It is valued for its high oil content (40–52%), protein (22–30%), carbohydrates and essential minerals, making it a significant component of human diet and edible oil industries [1,2]. In India, groundnut plays a major role in sustaining rural livelihoods under rainfed systems and supports income generation for small and marginal farmers [3]. However, productivity remains limited due to poor soil fertility, monocropping and imbalanced fertilizer application.

Conventional agriculture relies heavily on synthetic fertilizers to enhance crop yields. Although chemical fertilizers supply nutrients quickly, continuous and excessive use leads to soil structure degradation, decline in organic carbon, reduced microbial activity and environmental pollution [4,5]. Over time, such practices increase production cost and reduce long-term soil health, raising concerns regarding sustainability. Therefore, alternative nutrient management strategies that maintain productivity while ensuring ecological safety are essential.

Organic fertilizers such as farmyard manure, vermicompost, poultry manure and green manures improve soil physical properties, enhance microbial biomass and support nutrient cycling [6,7]. These inputs provide slow and steady nutrient release, improve root growth and promote biological nitrogen fixation—particularly beneficial for legume crops like groundnut [8]. Enhanced nodulation and soil biological activity under organic fertilization often result in better pod development, improved seed filling and enriched oil biosynthesis.

Groundnut is highly responsive to organic nutrient sources due to its symbiotic association with Rhizobium, which increases nitrogen-use efficiency under organic conditions [9]. Previous studies have reported that organic fertilizers alone or in combination with reduced doses of chemical fertilizers significantly improve pod yield, kernel yield, oil percentage and protein content in groundnut [10,11]. However, the magnitude of improvement varies depending on the types of organic inputs, soil texture and climatic conditions. Despite increasing interest, there is still limited comparative information on the influence of different organic fertilizers on yield, oil content and nutritional composition of groundnut in various agro-ecological regions.

Therefore, the present investigation was undertaken to evaluate the effect of selected organic fertilizers on growth attributes, yield components, oil content and nutritional composition of groundnut. The findings of this study are expected to contribute to sustainable groundnut production strategies that enhance crop performance while improving soil quality and produce nutritional value.

MATERIAL AND METHODS

The field experiment was conducted during the Kharif season of 2024 at the Organic Farming Research and Training Centre (OFRTC), Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra (19.26°N latitude, 76.77°E longitude, 410 m AMSL). The region experiences a semi–arid tropical climate with mean annual rainfall ranging from 750–950 mm, predominantly received during June to September. The summer temperatures range between 28°C and 42°C, while winter temperatures vary between 12°C and 25°C. Prior to sowing, composite soil samples were collected from the experimental field and analysed for physico-chemical characteristics. The soil was classified as sandy loam, moderately alkaline in reaction, and medium in fertility status.

Figure 1. Groundnut Crop Growth and Pod Development Under Field Conditions

Groundnut variety TAG-24 was used as the test crop. The experiment was laid out in a Randomized Block Design (RBD) comprising six treatments and three replications, with each plot measuring 3 m × 3 m. Sowing was done manually at a spacing of 30 cm × 10 cm. The six nutrient management treatments included: T1 – Control (no fertilizer), T2 – Recommended Dose of Chemical Fertilizer (20:40:40 NPK kg ha^{-1}), T3 – Farmyard Manure at 5 t ha^{-1}, T4 – Vermicompost at 2 t ha^{-1}, T5 – Poultry Manure at 1.5 t ha^{-1}, and T6 – Integrated organic treatment consisting of FYM (2.5 t ha^{-1}) + Vermicompost (1 t ha^{-1}). Organic manures were applied 15 days before sowing and incorporated thoroughly into the soil during land preparation, while chemical fertilizers were applied at the time of sowing.

Crop husbandry practices were followed uniformly across all treatments. Seeds were treated with Rhizobium culture @ 20 g kg^{-1} seed. Irrigation was applied at germination, flowering and pod development stages based on moisture requirement. Weed control was achieved through manual hand weeding at 20 and 40 days after sowing. No chemical pesticides were used; instead, Neem Seed Kernel Extract (NSKE) 5% was used for preventive pest management.

Observations on plant growth (plant height, number of branches per plant, leaf number and nodulation) and yield attributes (pods per plant, seeds per pod and 100-seed weight) were recorded from five randomly selected plants per plot. Final pod yield (kg ha^{-1}) and kernel yield (kg ha^{-1}) were calculated on a plot-to-hectare basis. Oil content (%) in groundnut kernels was determined using the Soxhlet extraction method with petroleum ether (boiling range 60–80°C). Nutritional composition including protein, fat, carbohydrate, crude fiber and ash was analyzed using standard AOAC (2016) procedures.

The recorded data were subjected to Analysis of Variance (ANOVA) appropriate for RBD, and treatment means were compared using the Least Significant Difference (LSD) test at 5% level of significance ($p \leq 0.05$) to determine statistically valid differences among treatments.

Table 1. Initial Physico-Chemical Properties of the Soil at the Experimental Site

Parameter	Value	Method Used
pH	7.4	1:2.5 Soil-Water Suspension
Electrical Conductivity (dS m^{-1})	0.41	Conductivity Meter
Organic Carbon (%)	0.55	Walkley and Black Method
Available Nitrogen (kg ha^{-1})	260	Kjeldahl Digestion Method
Available Phosphorus (kg ha^{-1})	18.2	Olsen's Method
Available Potassium (kg ha^{-1})	230	Flame Photometer

RESULTS AND DISCUSSION

Growth Attributes

Significant variation in growth attributes of groundnut was observed due to different organic and inorganic fertilizer treatments. The results revealed that integrated organic nutrient application (T6: FYM + Vermicompost) recorded the highest values for plant height, number of branches per plant, leaf number and root nodulation, followed by vermicompost (T4) and poultry manure (T5). In contrast, the control (T1) showed the lowest growth performance.

The plant height increased progressively across the growth stages and differed significantly among treatments. Plants under T6 exhibited superior vegetative growth owing to improved soil physical conditions and enhanced microbial activity that facilitated better root development and nutrient uptake. Treatments receiving vermicompost (T4) and poultry manure (T5) also showed enhanced plant height compared to chemical fertilizer (T2) alone, reflecting the importance of slow-release organic nutrient supply and biological nutrient mineralization. The lower plant height in T1 was associated with insufficient nutrient availability.

Similarly, number of branches per plant and leaf number were highest under integrated organic nutrient management (T6), followed by vermicompost (T4). This improvement may be attributed to increased cytokinin and auxin activity promoted by organic amendments, which stimulate shoot development and canopy expansion. Organic fertilizers improve soil microbial biomass and promote rhizosphere enzyme activity, which together enhance nutrient accessibility and vegetative growth. The chemical fertilizer treatment (T2) improved early vegetative growth but could not match the continuous nutrient supply observed in organic and integrated treatments.

Root nodulation also varied significantly among treatments. The maximum number and fresh weight of nodules were recorded under T6 and T4, indicating a favorable environment for Rhizobium multiplication and nitrogen fixation. The presence of higher organic matter and microbial populations in these treatments likely supported better nodule initiation and function. In contrast, chemical fertilizer application (T2) showed comparatively lower nodulation due to greater availability of readily soluble nitrogen, which suppresses biological nitrogen fixation. The control treatment (T1) showed the least nodulation owing to limited nutrient availability and weak root growth.

Overall, the results clearly indicate that organic and integrated nutrient management treatments significantly improved vegetative growth and nodulation in groundnut, compared to chemical fertilizer alone and control. This enhancement can be attributed to improved soil structure, enhanced microbial activity, slow and sustained nutrient release and better root proliferation under organic fertilization.

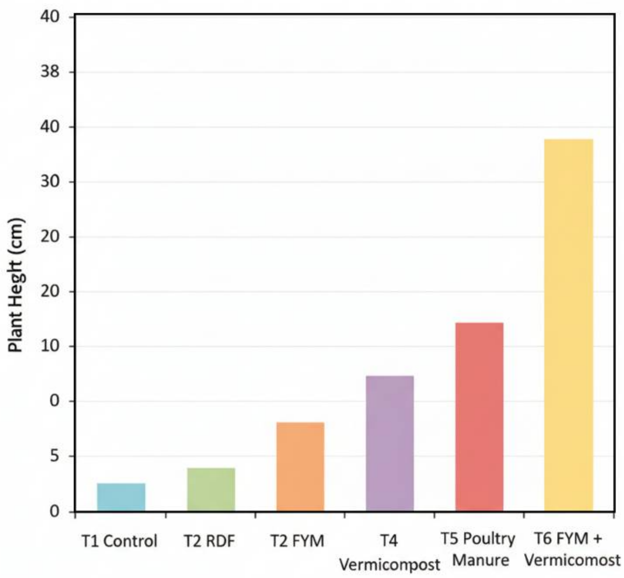

Figure 2. Effect of Different Fertilizer Treatments on Plant Height of Groundnut (cm)

Yield Attributes and Yield

Yield-attributing characters such as pods per plant, seeds per pod and 100–seed weight differed significantly among the treatments. The integrated nutrient management treatment (T6: FYM + Vermicompost) recorded the highest number of pods per plant (26.3), followed by T4 (Vermicompost) and T5 (Poultry Manure). The control (T1) showed the lowest pods per plant, indicating poor reproductive growth under nutrient-deficient conditions. The increased pod formation under organic and integrated treatments may be attributed to improved nutrient availability, enhanced root vigor and better partitioning of photosynthates towards reproductive structures.

Similarly, the number of seeds per pod was highest in T6 (1.95) and T4 (1.88), while the control registered the lowest (1.32). The 100–seed weight also showed a similar trend, with maximum weight recorded under T6 (39.8 g), suggesting improved seed filling and assimilate translocation under organic nutrient-rich plots.

A considerable improvement in pod yield and kernel yield was also observed under organic and integrated fertilization. The highest pod yield was recorded in T6 (2054 kg ha^{-1}), followed by T4 (1842 kg ha^{-1}), whereas the chemical fertilizer treatment (T2) produced lower yield (1455 kg ha^{-1}) than organic treatments. The control (T1) recorded the lowest pod yield (1052 kg ha^{-1}). A similar trend was observed for kernel yield, where T6 achieved the maximum (1462 kg ha^{-1}) due to cumulative improvements in growth and yield parameters.

These results clearly indicate that organic and integrated nutrient sources are more effective than chemical fertilizers alone in enhancing groundnut productivity, which may be attributed to sustained nutrient release, enhanced microbial activity, improved nodulation and better soil physical conditions supporting pod development.

Table 2. Effect of Organic Fertilizers on Yield Attributes of Groundnut

Treatment	Pods per Plant	Seeds per Pod	100–Seed Weight (g)	Pod Yield (kg ha^{-1})	Kernel Yield (kg ha^{-1})
T1 – Control	15.2	1.32	28.4	1052	712
T2 – RDF (20:40:40 NPK)	19.4	1.58	32.6	1455	990
T3 – FYM (5 t ha^{-1})	21.1	1.71	34.2	1658	1138
T4 – Vermicompost (2 t ha^{-1})	24.6	1.88	37.4	1842	1265
T5 – Poultry Manure (1.5 t ha^{-1})	23.3	1.82	36.1	1780	1218
T6– FYM + Vermicompost	26.3	1.95	39.8	2054	1462

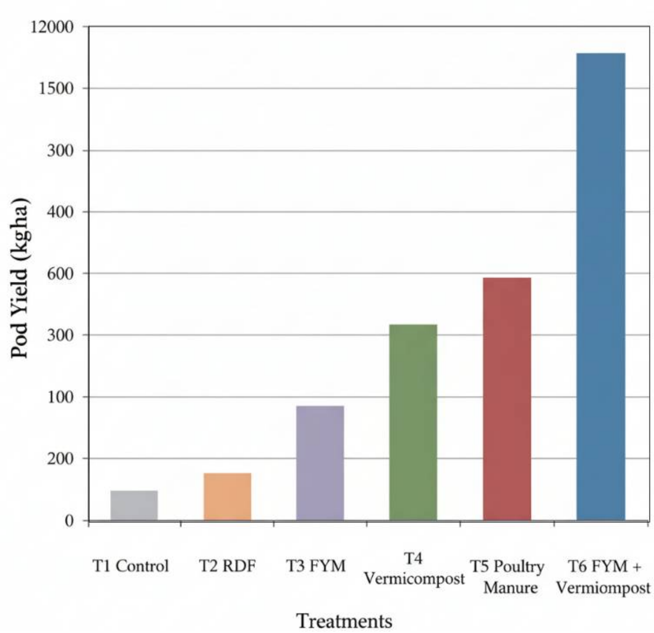

Figure 3. Pod Yield (kg ha^{-1}) under Different Nutrient Treatments

Oil Content and Nutritional Composition

Significant differences in oil content and nutritional composition of groundnut seeds were observed under different nutrient management treatments. The results indicated that organic and integrated nutrient treatments enhanced oil synthesis and nutrient accumulation compared to chemical fertilization and control.

The highest oil content was recorded in T4 (Vermicompost) (49.8%) and T6 (FYM + Vermicompost) (50.3%), followed by T5 (Poultry Manure) (48.6%). The chemical fertilizer treatment (T2) showed moderate oil content (45.9%), whereas the lowest oil content (42.7%) was observed in the control (T1). The improvement in oil content under organic nutrition may be attributed to a slow and sustained release of nutrients, improving seed filling and enhancing the enzymatic activities involved in lipid biosynthesis.

Similarly, protein content increased significantly in treatments where organic fertilizers were applied. The highest protein content was noted in T6 (26.8%) and T4 (26.1%), which could be linked to better biological nitrogen fixation due to enriched microbial populations under organic amendments. Treatments also exhibited improvement in fat, carbohydrate, crude fiber, ash, and mineral content, indicating that organic fertilizers enhance overall seed quality through improved soil organic matter and nutrient cycling.

These findings suggest that vermicompost and integrated organic nutrient management not only improve yield but also enhance the nutritional quality of groundnut kernels, supporting the potential of organic-based systems in sustainable oilseed production.

Comparison of Overall Treatment Performance

An overall comparison of all treatments based on growth attributes, yield parameters and seed nutritional quality revealed that the integrated organic nutrient management treatment (T6: FYM + Vermicompost) demonstrated the best performance among all treatments evaluated. The combined application of FYM and vermicompost provided both readily available and slow-release nutrient fractions, supported soil microbial activity, and improved soil structure, leading to stronger vegetative growth, higher pod formation, better seed filling, and enhanced oil and protein content.

The vermicompost treatment (T4) ranked next, indicating the effectiveness of biologically enriched organic matter in promoting nutrient mineralization and enhancing root-soil interactions. Poultry manure (T5) also resulted in higher yield and quality than FYM alone, likely due to its higher nitrogen and phosphorus concentration. FYM (T3), while beneficial, showed moderate performance, demonstrating that the nutrient release from FYM is slower, especially during early growth stages.

The chemical fertilizer treatment (T2) increased yield compared to control but did not improve oil and protein content to the same extent as organic treatments, indicating that chemical fertilizers enhance biomass but do not improve seed nutritional value substantially. The control treatment (T1) exhibited the poorest performance across all parameters due to limited nutrient availability.

The results confirm that integrated organic nutrient systems offer a balanced advantage, combining productive yield performance with improved seed nutritional quality and soil health sustainability. This suggests that integrated nutrient management is a suitable approach for enhancing groundnut production in semi–arid regions.

Table 3. Oil Content and Nutritional Composition of Groundnut Seeds under Different Treatments

Treatment	Oil Content (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Crude Fiber (%)	Ash (%)
T1 – Control	42.7	21.9	38.4	27.5	3.9	2.4
T2 – RDF (20:40:40 NPK)	45.9	24.3	41.6	28.1	4.2	2.6
T3 – FYM (5 t ha^{-1})	47.2	25.1	43.2	29.4	4.5	2.8
T4 – Vermicompost (2 t ha^{-1})	49.8	26.1	44.8	30.1	4.8	3.0
T5 – Poultry Manure (1.5 t ha^{-1})	48.6	25.6	44.1	29.7	4.7	2.9
T6 – FYM + Vermicompost	50.3	26.8	45.3	30.6	5.1	3.2

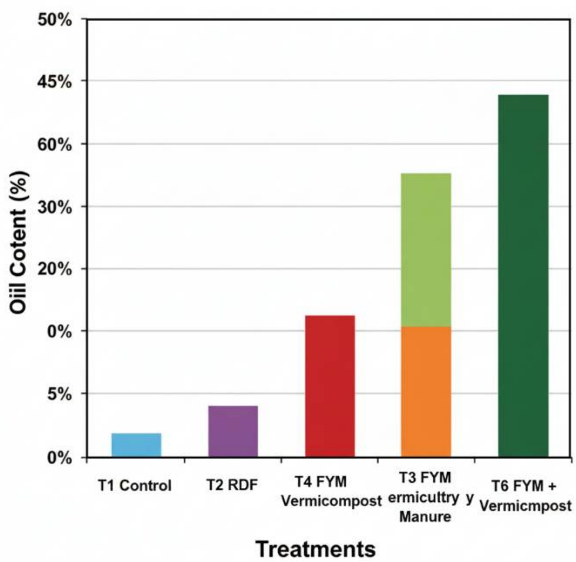

Figure 4. Oil Content (%) of Groundnut Seeds as Influenced by Organic Fertilizers

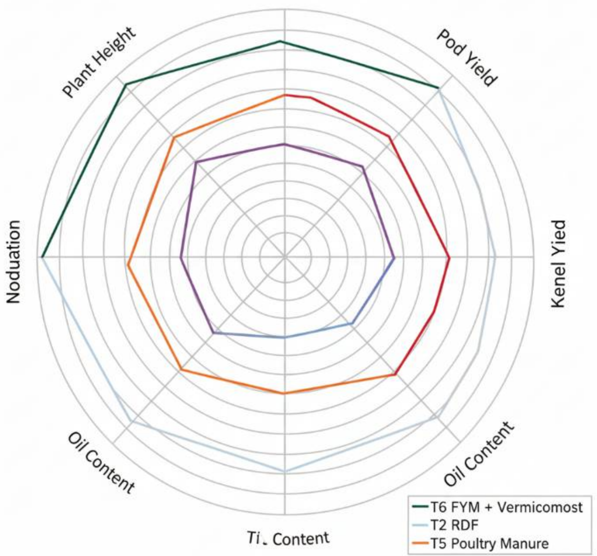

Figure 5. Comparative Performance Index of Treatments (Growth + Yield + Quality)

The results of the present study clearly demonstrate that organic and integrated nutrient management practices substantially improved groundnut growth, yield and seed quality compared to chemical fertilization and the unfertilized control. The superior performance of integrated organic treatment (T6) can be attributed to the improvement in soil organic carbon resulting from the combined addition of FYM and vermicompost. Increased organic carbon enhances soil aggregation, root penetration and moisture retention, while also serving as an energy source for beneficial soil microorganisms [12]. Higher microbial activity accelerates nutrient mineralization, releasing essential nutrients such as nitrogen, phosphorus and micronutrients in a plant-available form, thereby supporting continuous crop growth [13].

Enhanced symbiotic nitrogen fixation observed under T6 and T4 treatments can be linked to increased rhizobial activity in organically enriched soils. Organic fertilizers stimulate root nodulation through the development of a favorable rhizosphere environment, leading to greater nitrogen assimilation and improved protein synthesis in seeds [13]. In contrast, readily soluble nitrogen from chemical fertilizers (T2) reduces the plant's reliance on biological nitrogen fixation, resulting in lower nodule formation and efficiency.

Additionally, slow-release nutrient supply from FYM and vermicompost ensured consistent nutrient availability throughout the crop growth cycle, preventing the nutrient stress that often occurs when nutrients are supplied only at sowing through chemical fertilizers. This sustained nutrient flow supported better pod setting, seed filling and oil biosynthesis, explaining the significantly higher oil content recorded in organic and integrated treatments [10].

The findings of this study are consistent with previous reports, where vermicompost and FYM application significantly improved groundnut yield and oil quality by enhancing soil fertility and microbial biomass [5,6]. Similarly, integrated nutrient systems have been shown to outperform single organic or inorganic inputs due to synergistic nutrient release, balanced C:N ratio, improved root growth and enhanced enzymatic activities in the rhizosphere [7].

Thus, the overall results confirm that integrated organic nutrient management is more effective than the use of individual organic fertilizers or chemical fertilizers alone. The combination of FYM and vermicompost improves soil health, increases nutrient use efficiency and supports metabolically active root systems, making it a sustainable and productive nutrient management approach for groundnut cultivation, particularly in semi-arid regions.

CONCLUSION

The present study demonstrated that the application of organic fertilizers, particularly in integrated nutrient management (FYM + Vermicompost), significantly enhanced the growth attributes, yield performance and nutritional quality of groundnut as compared to chemical fertilizer alone and the unfertilized control. The integrated organic treatment resulted in improved plant height, branching, leaf development and root nodulation, which contributed to higher pods per plant, seed weight, pod yield and kernel yield. Moreover, the oil content and protein concentration of groundnut seeds were also notably higher under organic and integrated nutrient treatments, indicating positive effects on seed quality.

The superiority of integrated organic fertilization can be attributed to its ability to increase soil organic carbon, enhance microbial activity, promote symbiotic nitrogen fixation and provide a sustained release of essential nutrients throughout the crop growth period. These advantages collectively improved both productivity and soil health. In contrast, chemical fertilizer improved yield to some extent but did not enhance nutritional quality or soil biological properties to the same degree.

Based on the findings, it can be concluded that integrated organic nutrient management is a viable and sustainable approach for improving groundnut productivity and quality, especially under semi–arid conditions such as those in Parbhani. Adoption of integrated organic systems not only supports long-term soil fertility but also contributes to environmentally responsible agriculture.

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