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Effect of Organic and Inorganic Fertilizers on Growth and Yield of Wheat

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Abstract

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and plays a major role in global food security. Appropriate nutrient management is essential for achieving optimum wheat growth and yield. The present study was conducted to evaluate the effects of organic and inorganic fertilizers, applied individually and in combination, on the growth and yield performance of wheat. The experiment was designed using a randomized complete block design with seven fertilizer treatments and three replications. The treatments consisted of an unfertilized control, farmyard manure (FYM), vermicompost, recommended inorganic NPK fertilizer, FYM combined with 50% of the recommended NPK, vermicompost combined with 50% of the recommended NPK, and FYM combined with the recommended NPK. Growth parameters including plant height, number of tillers per plant, and chlorophyll status were recorded at different growth stages. Yield attributes including spike length, grains per spike, 1000-grain weight, grain yield, straw yield, and biological yield were also evaluated. The illustrative results indicated that combined application of organic and inorganic fertilizers produced superior growth and yield compared with either fertilizer source applied alone. The treatment receiving FYM plus recommended NPK produced the highest plant height, number of productive tillers, grains per spike, thousand-grain weight, and grain yield. Integrated nutrient management also improved soil organic matter and nutrient availability. The findings suggest that combining organic amendments with mineral fertilizers can improve wheat productivity while contributing to sustainable soil fertility management. However, the numerical results presented in this manuscript are illustrative and should be replaced by actual field observations before scientific publication.

Keyword: Wheat, *Triticum aestivum*, organic fertilizer, inorganic fertilizer, farmyard manure, vermicompost, NPK, growth, grain yield, integrated nutrient management

Introduction

Wheat (*Triticum aestivum* L.) is one of the world's most important cereal crops and is cultivated extensively in temperate and subtropical regions. It provides a major source of carbohydrates, protein, minerals, and calories for a large proportion of the world's population. Increasing wheat productivity is therefore important for meeting the food requirements of a growing population.

Crop productivity depends on genetic potential, climatic conditions, soil properties, irrigation, pest and disease management, and nutrient availability. Among these factors, adequate and balanced plant nutrition is particularly important because nutrients directly influence plant growth, photosynthesis, biomass production, reproductive development, and grain formation.

Nitrogen, phosphorus, and potassium are the primary macronutrients required by wheat. Nitrogen promotes leaf development, chlorophyll formation, protein synthesis,

tillering, and grain production. Phosphorus contributes to root development, energy transfer, early crop establishment, and reproductive development. Potassium plays important roles in water regulation, enzyme activation, photosynthesis, and stress tolerance.

In modern agricultural systems, inorganic fertilizers are widely used because they supply nutrients in readily available forms and can rapidly correct nutrient deficiencies. However, continuous and imbalanced use of mineral fertilizers without adequate organic-matter inputs may contribute to declining soil organic matter, deterioration of some soil properties, nutrient imbalance, and reduced long-term soil quality.

Organic fertilizers such as farmyard manure, compost, and vermicompost provide nutrients more gradually and contribute organic matter to the soil. Organic amendments can improve soil aggregation, water-holding capacity, microbial activity, nutrient retention, and soil structure. Their

nutrient concentrations, however, are generally lower and more variable than those of inorganic fertilizers.

Integrated nutrient management combines organic and inorganic nutrient sources to provide immediate plant nutrients while maintaining soil fertility. The concept is particularly relevant to sustainable crop production because mineral fertilizers can supply crop nutrient requirements efficiently, whereas organic materials can improve soil physical, chemical, and biological properties.

Previous studies have reported positive effects of integrated nutrient management on wheat growth, nutrient uptake, and grain yield. The response, however, varies according to soil type, climate, wheat cultivar, fertilizer rate, organic amendment quality, irrigation regime, and management practices.

Therefore, the present study was designed to evaluate the individual and combined effects of organic and inorganic fertilizers on the growth and yield of wheat.

Objectives

The specific objectives of the study were:

1. To evaluate the effect of organic fertilizers on wheat growth.
2. To determine the effect of inorganic NPK fertilizer on wheat growth and yield.
3. To compare individual and combined applications of organic and inorganic fertilizers.
4. To assess the effect of fertilizer treatments on wheat yield components.
5. To identify an effective nutrient-management strategy for improving wheat productivity and maintaining soil fertility.

Materials and Methods

Experimental Site

The study was considered as a field experiment conducted during the wheat-growing season at an agricultural research field. For an actual study, the precise geographic location, climatic conditions, soil type, previous crop, irrigation source, and soil-test values should be reported.

Before sowing, representative soil samples should be collected from the experimental area at a depth of 0–15 cm and analyzed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, and potassium.

Because the present manuscript was prepared without an original experimental dataset, the numerical observations reported below are illustrative.

Experimental Design

The experiment was designed according to a randomized complete block design (RCBD) with seven fertilizer treatments and three replications.

The experimental treatments were:

- T₁: Control – no fertilizer
- T₂: Farmyard manure (FYM) @ 10 t ha⁻¹
- T₃: Vermicompost @ 5 t ha⁻¹
- T₄: Recommended NPK fertilizer
- T₅: FYM @ 10 t ha⁻¹ + 50% recommended NPK
- T₆: Vermicompost @ 5 t ha⁻¹ + 50% recommended NPK
- T₇: FYM @ 10 t ha⁻¹ + 100% recommended NPK

The recommended NPK treatment should be adjusted according to the soil-test-based recommendation for the specific study location and wheat production system.

Land Preparation

The experimental field was prepared by ploughing followed by harrowing to obtain a fine and uniform seedbed. Farmyard manure and vermicompost were incorporated into the soil before sowing according to the respective treatment.

Wheat Variety and Sowing

A suitable locally recommended wheat cultivar was used. For an actual research paper, the cultivar name, seed rate, sowing date, row spacing, and seed treatment should be specified.

Seeds were sown in rows at a suitable spacing under uniform agronomic conditions.

Application of Organic Fertilizers

Well-decomposed farmyard manure was applied according to the treatment schedule and incorporated into the soil before sowing.

Vermicompost was similarly incorporated before sowing. The nutrient composition of the organic amendments should be analyzed before application in an actual experiment so that nutrient inputs can be quantified.

Application of Inorganic Fertilizers

Nitrogen, phosphorus, and potassium were applied according to the assigned treatments. Phosphorus and potassium may be applied as basal fertilizers, whereas nitrogen is commonly divided into multiple applications according to crop growth stage and regional recommendations.

For scientific reporting, the exact fertilizer materials and nutrient rates should be provided.

Irrigation and Crop Management

All plots were maintained under similar irrigation and weed-management conditions. Irrigation was supplied according to crop requirements and local agronomic recommendations. Weeds were controlled manually or using an appropriate recommended method.

Pest and disease management was performed uniformly across treatments whenever required.

Measurement of Growth Parameters

Plant Height

Plant height was measured from the soil surface to the tip of the highest leaf or spike, depending on the growth stage. Measurements were taken from randomly selected plants in each plot.

Number of Tillers

The number of tillers per plant was recorded at the appropriate growth stage. Productive tillers were counted separately at maturity.

Chlorophyll Status

Leaf chlorophyll status can be measured using a SPAD meter or by laboratory-based pigment analysis. Chlorophyll measurements provide an indirect indication of crop nitrogen status and photosynthetic capacity.

Measurement of Yield Attributes

The following yield components were recorded:

- Spike length (cm)
- Number of grains per spike
- Number of productive tillers m⁻²
- Thousand-grain weight (g)
- Grain yield (t ha⁻¹)

- Straw yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

Grain Yield

At physiological maturity, each experimental plot was harvested separately. Grain yield was determined after threshing and cleaning. Yield was converted to tonnes per hectare.

Harvest Index

Harvest index was calculated using the following formula:

$$\text{Harvest Index (\%)} = \text{Grain yield} / \text{Biological yield} \times 100$$

Statistical Analysis

The data were subjected to analysis of variance (ANOVA) appropriate for a randomized complete block design. Treatment means were compared using an appropriate post-hoc test, such as the least significant difference (LSD) or critical difference (CD), at the 5% probability level. The statistical analysis for an actual publication should be conducted using the original replicated observations rather than the illustrative means presented in this manuscript.

Results

Effect of Fertilizer Treatments on Wheat Growth

The illustrative effects of fertilizer treatments on wheat growth are presented in Table 1.

Table 1: Effect of organic and inorganic fertilizers on growth characteristics of wheat

Treatment	Plant height (cm)	Tillers plant ⁻¹	Productive tillers m ⁻²
T ₁ Control	78.4	2.4	286
T ₂ FYM 10 t ha ⁻¹	87.6	2.9	318
T ₃ Vermicompost 5 t ha ⁻¹	90.2	3.1	327
T ₄ Recommended NPK	96.8	3.5	356
T ₅ FYM + 50% NPK	99.5	3.7	371
T ₆ Vermicompost + 50% NPK	101.3	3.8	379
T ₇ FYM + 100% NPK	105.7	4.1	394

The control treatment recorded the lowest growth values. Application of FYM and vermicompost individually

Effect on Grain and Straw Yield

Table 3: Effect of fertilizer treatments on wheat grain and straw yield

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T ₁ Control	3.12	5.24	8.36	37.3
T ₂ FYM 10 t ha ⁻¹	3.61	5.87	9.48	38.1
T ₃ Vermicompost 5 t ha ⁻¹	3.78	6.02	9.80	38.6
T ₄ Recommended NPK	4.32	6.68	11.00	39.3
T ₅ FYM + 50% NPK	4.57	6.92	11.49	39.8
T ₆ Vermicompost + 50% NPK	4.72	7.04	11.76	40.1
T ₇ FYM + 100% NPK	5.03	7.31	12.34	40.8

The highest grain yield was recorded in T₇, where FYM was combined with the full recommended NPK dose. The grain yield under this treatment was 5.03 t ha⁻¹ compared with 3.12 t ha⁻¹ under the unfertilized control.

The vermicompost + 50% NPK treatment also produced a relatively high grain yield of 4.72 t ha⁻¹, indicating that partial substitution of mineral fertilizer with organic nutrient sources may maintain high productivity under suitable conditions.

improved plant height and tillering compared with the unfertilized control.

The recommended NPK treatment resulted in greater plant height and tiller production than the organic fertilizer treatments alone.

However, the combined treatments showed the greatest overall growth. The FYM + 100% NPK treatment recorded the highest plant height of 105.7 cm and approximately 4.1 tillers plant⁻¹.

The improved growth under integrated nutrient management may be attributed to the complementary effects of readily available mineral nutrients and the gradual nutrient release and soil-conditioning effects of organic amendments.

Effect on Yield Attributes

Table 2: Effect of fertilizer treatments on yield attributes of wheat

Treatment	Spike length (cm)	Grains spike ⁻¹	1000-grain weight (g)
T ₁ Control	8.1	35.4	34.8
T ₂ FYM 10 t ha ⁻¹	8.8	39.7	37.2
T ₃ Vermicompost 5 t ha ⁻¹	9.0	41.2	38.1
T ₄ Recommended NPK	9.5	44.8	40.3
T ₅ FYM + 50% NPK	9.8	46.7	41.6
T ₆ Vermicompost + 50% NPK	10.0	47.5	42.3
T ₇ FYM + 100% NPK	10.4	49.8	43.7

The control treatment recorded the lowest yield attributes. Application of organic fertilizers improved spike length, grain number, and thousand-grain weight.

The inorganic NPK treatment produced greater yield attributes than the organic treatments alone. However, combined organic and inorganic fertilizer treatments produced further improvement.

The highest values were recorded under FYM + 100% NPK, followed by vermicompost + 50% NPK.

Percentage Increase in Grain Yield

The percentage increase in grain yield over the control was calculated as:

$$\text{Increase (\%)} = [(\text{Treatment yield} - \text{Control yield}) / \text{Control yield}] \times 100$$

Table 4: Relative improvement in grain yield

Treatment	Grain yield (t ha ⁻¹)	Increase over control (%)
T ₁ Control	3.12	—
T ₂ FYM	3.61	15.7
T ₃ Vermicompost	3.78	21.2
T ₄ Recommended NPK	4.32	38.5
T ₅ FYM + 50% NPK	4.57	46.5
T ₆ Vermicompost + 50% NPK	4.72	51.3
T ₇ FYM + 100% NPK	5.03	61.2

The illustrative data showed that integrated fertilizer treatments substantially increased grain yield compared with the control. The FYM + 100% NPK treatment produced an approximately 61.2% higher grain yield than the control.

Discussion

Effect of Fertilizers on Plant Height

Plant height increased substantially following fertilizer application. The control treatment produced the shortest plants, while the integrated treatments produced the greatest plant height.

Nitrogen plays a major role in vegetative development because it is an essential component of amino acids, proteins, chlorophyll, and nucleic acids. Adequate nitrogen availability promotes leaf expansion and photosynthetic activity, which can contribute to greater biomass accumulation.

The improvement observed with organic amendments may also be associated with gradual nutrient release and improved soil physical conditions.

Effect on Tillering

Tillering is an important component of wheat yield because productive tillers contribute directly to the number of spikes per unit area.

The illustrative data indicated that both organic and inorganic fertilizers increased tiller production. Mineral NPK supplied readily available nutrients, while organic amendments potentially improved nutrient retention and soil biological activity.

The highest number of productive tillers was recorded under FYM + 100% NPK, demonstrating the potential advantage of integrated nutrient management.

Effect on Spike Length and Grains per Spike

Spike length and grains per spike increased with fertilizer application. Adequate nutrient availability during vegetative and reproductive growth promotes spike development and grain formation.

Nitrogen is particularly important for determining the number of reproductive structures and grain protein accumulation, while phosphorus supports energy transfer and reproductive development.

The combined organic and inorganic treatments produced greater spike length and grain number than the unfertilized control.

Effect on Thousand-Grain Weight

Thousand-grain weight is an important component of wheat yield and is influenced by grain-filling duration, assimilate availability, water availability, temperature, and nutrient status.

The higher thousand-grain weight observed in the integrated treatments may be associated with improved plant nutrition and photosynthetic activity during grain filling.

Adequate nutrient supply can support the production and translocation of assimilates from leaves and stems into developing grains.

Effect on Grain Yield

Grain yield is the final outcome of several growth and yield components. The illustrative results indicated that the application of both organic and inorganic fertilizers produced higher yields than the unfertilized control.

The highest grain yield was obtained from FYM + 100% recommended NPK. This suggests that organic and inorganic fertilizer sources may complement each other.

Mineral fertilizers provide nutrients in forms that can become rapidly available to plants, whereas organic amendments contribute organic matter and release nutrients gradually. The combined application may therefore provide a more favorable nutrient supply throughout crop development.

Effect of Organic Fertilizers

FYM and vermicompost treatments produced greater growth and yield than the unfertilized control. Organic amendments can contribute nutrients while also influencing soil structure, moisture retention, microbial activity, and nutrient cycling.

However, organic fertilizers generally have lower nutrient concentrations than concentrated mineral fertilizers. Consequently, very large quantities may be required to supply the entire nutrient requirement of a high-yielding wheat crop.

This is one reason integrated nutrient management can be advantageous.

Effect of Inorganic Fertilizer

The recommended NPK treatment significantly improved growth and yield compared with the control in the illustrative experiment.

The rapid availability of nutrients from mineral fertilizers can be particularly important during periods of high crop demand. However, fertilizer recommendations should be based on soil tests and crop requirements to avoid over-application.

Excessive or imbalanced fertilizer application can reduce nutrient-use efficiency and increase the risk of nutrient losses to the environment.

Integrated Nutrient Management

The overall results support the importance of combining organic and inorganic nutrient sources.

Integrated nutrient management can provide several potential benefits:

1. Immediate nutrient availability from mineral fertilizers.
2. Gradual nutrient release from organic amendments.
3. Improvement of soil organic matter.
4. Better nutrient retention.
5. Improvement in soil physical properties.
6. Support for beneficial soil microorganisms.

7. Potential improvement in nutrient-use efficiency.
8. Maintenance of long-term soil productivity.

The treatment combining FYM with the recommended NPK dose produced the highest yield in the illustrative dataset. However, the optimum combination in an actual farming system will depend on soil fertility, crop variety, fertilizer prices, availability and quality of organic materials, and environmental conditions.

Agronomic Implications

The findings suggest that fertilizer management should focus not only on maximizing short-term yield but also on maintaining long-term soil productivity.

A practical nutrient-management strategy for wheat should include:

- Soil testing before fertilizer application.
- Application of nutrients according to crop requirement.
- Use of well-decomposed FYM or compost.
- Incorporation of available crop residues.
- Balanced application of N, P, and K.
- Split application of nitrogen where appropriate.
- Avoidance of excessive nitrogen application.
- Monitoring of soil organic carbon.
- Regular evaluation of soil fertility.
- Use of integrated nutrient management where suitable.

The use of organic amendments should be based on their nutrient composition and maturity. Immature organic materials may temporarily immobilize nutrients or create other agronomic problems.

Conclusion

The present study evaluated the potential effects of organic and inorganic fertilizers on the growth and yield of wheat. The illustrative results demonstrated that fertilizer application substantially improved plant height, tillering, spike development, grains per spike, thousand-grain weight, and grain yield compared with the unfertilized control.

Organic fertilizers such as FYM and vermicompost improved crop performance when used individually, while inorganic NPK fertilizer produced a stronger yield response. The greatest overall performance was observed when organic and inorganic fertilizers were combined.

The treatment consisting of FYM plus the recommended NPK dose recorded the highest grain yield, suggesting that integrated nutrient management may provide an effective approach for achieving high wheat productivity while contributing to soil fertility maintenance.

Nevertheless, fertilizer recommendations should be based on actual soil-test results, crop requirements, local climatic conditions, and economic considerations. Long-term experiments are recommended to determine whether integrated nutrient management can simultaneously sustain wheat yield, improve soil quality, and increase nutrient-use efficiency over successive cropping seasons.

Recommendations

Based on the findings, the following recommendations are made:

1. Organic fertilizers should be incorporated into wheat production systems wherever suitable organic materials are available.
2. Mineral fertilizers should be applied according to soil-test-based recommendations.

3. Combined use of organic and inorganic fertilizers should be considered as part of an integrated nutrient-management strategy.
4. Nitrogen application should be carefully timed to improve nutrient-use efficiency.
5. Regular soil testing should be carried out to monitor nutrient availability and soil organic matter.
6. Long-term studies should be conducted to evaluate the effects of repeated organic and inorganic fertilizer application on soil health.
7. Economic analysis should be included in future studies to identify the most profitable fertilizer combination.

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Conflict of Interest

The authors declare that there is no conflict of interest associated with this study.

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Data Availability

The numerical results presented in this manuscript are illustrative because no original field dataset was supplied for preparation of the article. The actual experimental dataset should be provided by the authors before submission to a scientific journal.

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