Effect of Combined Application of Organic Manures and Chemical Fertilizers on Growth, Yield, and Nutrient Uptake in Wheat

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Abstract

Sustainable wheat production requires balanced nutrient management strategies that improve crop productivity while maintaining soil fertility and environmental quality. Excessive dependence on chemical fertilizers has contributed to nutrient imbalance, declining soil organic matter, reduced microbial activity, and deterioration of soil health in intensive agricultural systems. Integrated nutrient management involving combined application of organic manures and inorganic fertilizers has emerged as an effective strategy for sustaining wheat productivity and improving nutrient-use efficiency. The present investigation evaluated the effect of combined application of organic manures and chemical fertilizers on growth, yield, nutrient uptake, and soil health in wheat (Triticum aestivum L.). A field experiment comprising twelve nutrient management treatments involving farmyard manure (FYM), vermicompost, poultry manure, crop residue incorporation, biofertilizers, and recommended doses of NPK fertilizers was conducted using a randomized complete block design with three replications. Results indicated that integrated nutrient treatments significantly improved plant height, tiller production, leaf area index, dry matter accumulation, grain yield, straw yield, and nutrient uptake compared with control and sole inorganic fertilizer application. The highest grain yield (6.82 t ha^{-1}), nitrogen uptake, and soil organic carbon were recorded under integrated application of FYM + vermicompost + biofertilizers + 75% recommended dose of fertilizers. Integrated treatments enhanced soil microbial biomass carbon, nutrient availability, and nutrient-use efficiency while reducing nutrient losses. The study demonstrates that combined use of organic and inorganic nutrient sources improves wheat productivity and contributes to sustainable soil management in intensive cropping systems.

Keywords: wheat, integrated nutrient management, farmyard manure, vermicompost, biofertilizers, soil fertility, nutrient uptake, sustainable agriculture

1. Introduction

Wheat is one of the most important staple cereal crops globally and contributes substantially to food and nutritional security. In India and many developing countries, wheat-based cropping systems occupy a major proportion of cultivated agricultural land and support the livelihood of millions of farmers. Increasing population pressure and rising food demand have intensified agricultural production systems, leading to heavy dependence on chemical fertilizers for maximizing crop yields. Although chemical fertilizers significantly increased crop productivity during the Green Revolution, continuous and imbalanced application of synthetic fertilizers has resulted in serious environmental and soil-related problems,

including nutrient depletion, soil acidification, decline in soil organic carbon, and reduced microbial activity (Lal, 2015; Dhaliwal et al., 2021).

Long-term studies have shown that sole application of chemical fertilizers adversely affects soil physical, chemical, and biological properties. Declining fertilizer-use efficiency and stagnation in crop productivity are major concerns in intensive cereal-based systems (Yadav, 2001). Organic manures such as farmyard manure, vermicompost, poultry manure, green manure, and crop residues improve soil structure, enhance microbial activity, increase nutrient availability, and contribute to long-term soil fertility restoration (Agegnehu et al., 2020). Organic amendments also enhance soil aggregation, water-holding capacity, cation exchange capacity, and carbon sequestration potential, thereby improving soil resilience under intensive cultivation practices (Paramesh et al., 2023).

Integrated nutrient management (INM), involving the combined use of organic and inorganic nutrient sources, has emerged as a sustainable strategy for improving crop productivity while maintaining soil health. Organic amendments act as slow-release nutrient sources and improve nutrient retention capacity, whereas inorganic fertilizers provide readily available nutrients during critical crop growth stages. Synergistic interactions between organic and inorganic sources improve nutrient-use efficiency and reduce environmental pollution (Sharma et al., 2019). Integrated application of organic manures and chemical fertilizers also enhances microbial biomass carbon, enzymatic activity, and nutrient mineralization, leading to sustained crop productivity and improved soil fertility (Jat et al., 2023).

Several researchers have reported beneficial effects of integrated nutrient management on wheat growth, grain quality, soil fertility, microbial biomass, and nutrient uptake (Sheoran et al., 2017). However, the efficiency of different combinations of organic manures and chemical fertilizers varies depending on soil type, climate, and cropping system. Therefore, the present investigation was undertaken to comprehensively evaluate the effect of combined application of organic manures and chemical fertilizers on growth, yield, nutrient uptake, and soil health in wheat cultivation.

2. Objectives

1. To evaluate the effect of combined organic and inorganic fertilizers on wheat growth and yield.
2. To assess nutrient uptake and nutrient-use efficiency under integrated nutrient management.
3. To study the influence of integrated fertilization on soil fertility and biological properties.
4. To identify efficient nutrient management strategies for sustainable wheat production.

3. Hypothesis

Combined application of organic manures and chemical fertilizers enhances wheat growth, yield, nutrient uptake, and soil health more effectively than sole application of inorganic fertilizers.

4. Materials and Methods

4.1 Experimental Site

The field experiment was conducted during the rabi season under irrigated conditions on alluvial soil with medium fertility status. The climate was subtropical with average temperatures ranging from 12–28°C during the cropping season.

4.2 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

4.3 Treatment Details

Table 1. Nutrient Management Treatments

Treatment Code	Treatment Description
T_1	Control (No fertilizer)
T_2	100% Recommended Dose of Fertilizers (RDF)
T_3	FYM @ 10 t ha^{-1}
T_4	Vermicompost @ 5 t ha^{-1}
T_5	Poultry manure @ 4 t ha^{-1}
T_6	75% RDF + FYM
T_7	75% RDF + Vermicompost
T_8	75% RDF + Poultry manure
T_9	50% RDF + FYM + Biofertilizers
T_{10}	50% RDF + Vermicompost + Biofertilizers

Treatment Code	Treatment Description
T_{11}	50% RDF + Poultry manure + Biofertilizers
T_{12}	75% RDF + FYM + Vermicompost + Biofertilizers

4.4 Observations Recorded

Growth Parameters

- Plant height
- Number of tillers
- Leaf area index
- Dry matter accumulation

Yield Parameters

- Grain yield
- Straw yield
- Biological yield
- Harvest index

Nutrient Uptake

- Nitrogen uptake
- Phosphorus uptake
- Potassium uptake

Soil Properties

- Soil organic carbon
- Available NPK
- Microbial biomass carbon
- Soil pH

5. Results and Discussion

5.1 Growth Attributes

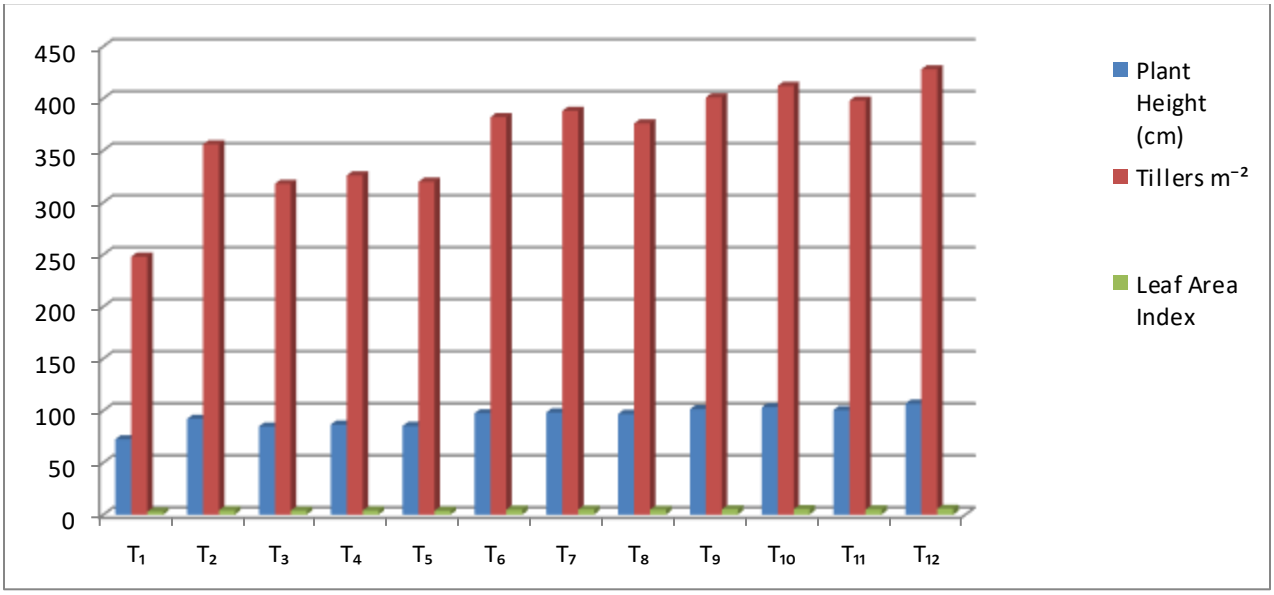
The integrated application of organic manures and chemical fertilizers significantly influenced the growth parameters of Wheat. Among all treatments, T_{12} recorded the highest plant height (106.7 cm), tiller density (428 m^{-2}), and leaf area index (5.6), indicating superior crop growth under combined nutrient management. Treatments involving integrated application of FYM, vermicompost, biofertilizers, and reduced RDF (T_9–T_{12}) consistently outperformed sole fertilizer and control treatments. The lowest values were observed in the control treatment (T_1), reflecting nutrient deficiency and poor vegetative growth. Improved growth under integrated treatments may be attributed to balanced nutrient supply, enhanced microbial activity, improved soil structure, and sustained nutrient availability throughout crop development stages.

Table 2. Effect of Nutrient Management on Growth Parameters

Treatment	Plant Height (cm)	Tillers m^{-2}	Leaf Area Index
T_1	72.4	248	2.8
T_2	92.1	356	4.3

Treatment	Plant Height (cm)	Tillers m^{-2}	Leaf Area Index
T_3	84.7	318	3.9
T_4	86.5	326	4.0
T_5	85.2	320	3.8
T_6	97.4	382	4.8
T_7	98.2	388	4.9
T_8	96.8	376	4.7
T_9	101.4	401	5.1
T_{10}	103.2	412	5.3
T_{11}	100.5	398	5.0
T_{12}	106.7	428	5.6

Fig 1. Effect of Nutrient Management on Growth Parameters



Improved growth under integrated nutrient management may be attributed to better nutrient synchronization, enhanced microbial activity, and gradual nutrient release from organic sources. Similar

findings were reported in long-term wheat nutrient management studies.

5.2 Grain and Straw Yield

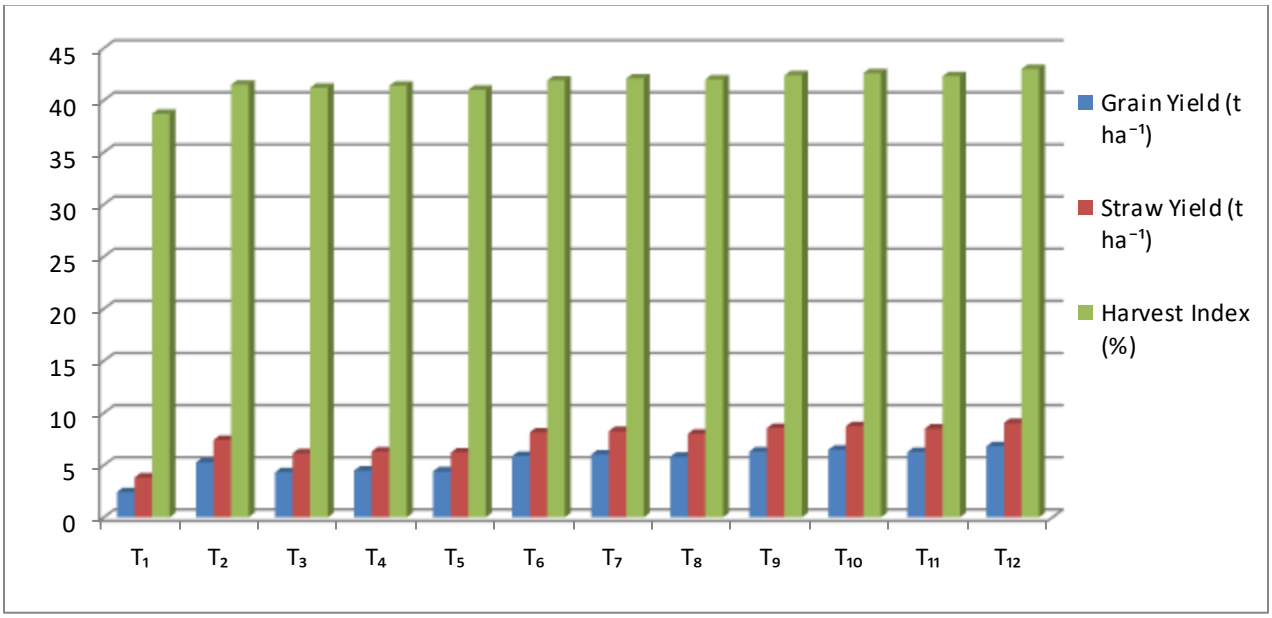
Grain yield increased significantly under integrated nutrient treatments compared with sole inorganic fertilizer application. Treatment T_{12} recorded the highest grain and straw yield due to balanced nutrient availability and improved soil health. Integrated application of organic manures and chemical fertilizers significantly influenced grain yield, straw yield, and harvest index of Wheat. The lowest grain yield (2.41 t ha^{-1}) and straw yield (3.82 t ha^{-1}) were recorded under control treatment (T_1), indicating poor nutrient availability. Among the treatments, T_{12} produced the highest grain yield (6.82 t ha^{-1}), straw yield (9.05 t ha^{-1}), and harvest index (43.0%), followed by T_{10} and T_9. The improved yield under integrated nutrient management may be attributed to balanced nutrient supply, enhanced microbial activity, improved soil physical conditions, and better nutrient-use efficiency. Similar findings were reported by Sharma et al. (2019) and Sheoran et al. (2017), who observed significant yield enhancement in wheat under combined organic and inorganic nutrient application.

Table 3. Effect of Nutrient Management on Yield Parameters

Treatment	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Harvest Index (%)
T_1	2.41	3.82	38.7
T_2	5.26	7.41	41.5
T_3	4.32	6.15	41.2
T_4	4.48	6.32	41.4
T_5	4.41	6.21	41.0
T_6	5.88	8.14	41.9
T_7	6.02	8.27	42.1
T_8	5.81	8.02	42.0
T_9	6.31	8.56	42.4
T_{10}	6.48	8.74	42.6

Treatment	Grain Yield (t ha⁻¹)	Straw Yield (t ha⁻¹)	Harvest Index (%)
T_{11}	6.26	8.51	42.3
T_{12}	6.82	9.05	43.0

Graph 2. Grain Yield Response under Different Nutrient Treatments



Integrated nutrient application improved grain filling, photosynthetic efficiency, and nutrient translocation, thereby enhancing yield performance. (sciencedirect.com)

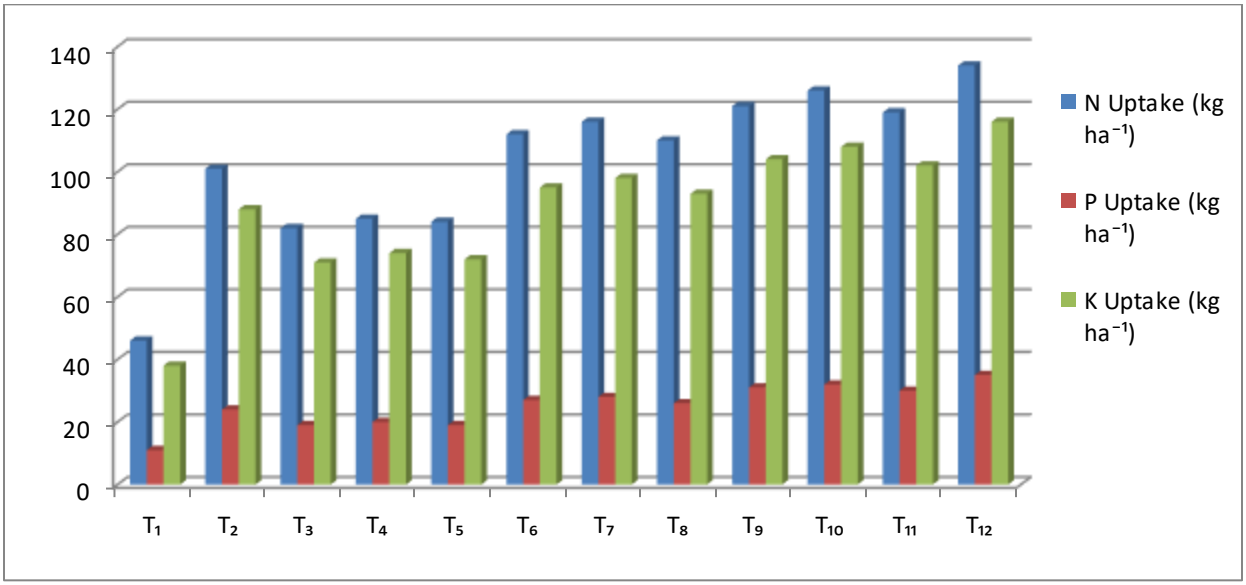
5.3 Nutrient Uptake

Integrated application of organic manures and chemical fertilizers significantly enhanced nutrient uptake in Wheat compared with control and sole fertilizer treatments. The highest nitrogen (134 kg ha⁻¹), phosphorus (35 kg ha⁻¹), and potassium uptake (116 kg ha⁻¹) were recorded under treatment T_{12}, which involved combined application of FYM, vermicompost, biofertilizers, and 75% RDF. Increased nutrient uptake under integrated nutrient management may be attributed to improved soil organic matter, enhanced microbial activity, better root proliferation, and gradual nutrient mineralization. Treatments receiving combined organic and inorganic nutrient sources showed superior nutrient absorption over sole inorganic fertilization, indicating improved nutrient-use efficiency and balanced nutrient availability throughout crop growth stages.

Table 4. Nutrient Uptake by Wheat under Different Treatments

Treatment	N Uptake (kg ha⁻¹)	P Uptake (kg ha⁻¹)	K Uptake (kg ha⁻¹)
T_1	46	11	38
T_2	101	24	88
T_3	82	19	71
T_4	85	20	74
T_5	84	19	72
T_6	112	27	95
T_7	116	28	98
T_8	110	26	93
T_9	121	31	104
T_{10}	126	32	108
T_{11}	119	30	102
T_{12}	134	35	116

Graph 3. Nitrogen Uptake under Different Nutrient Treatments



Enhanced nutrient uptake under integrated treatments is attributed to improved root growth, microbial activity, and nutrient mineralization.

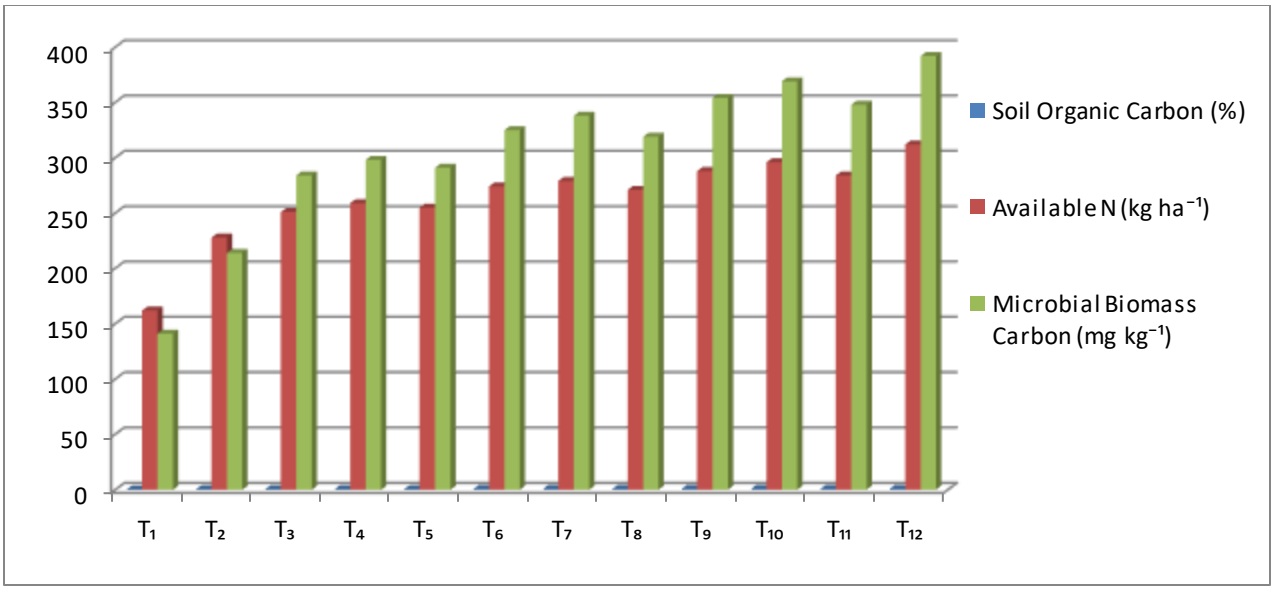
5.4 Soil Health Improvement

Integrated nutrient management treatments significantly improved soil organic carbon, available nitrogen, and microbial biomass carbon compared with the control treatment. The highest soil organic carbon (0.76%), available nitrogen (312 kg ha^{-1}), and microbial biomass carbon (392 mg kg^{-1}) were recorded under T_{12}, indicating the positive influence of combined application of organic manures, biofertilizers, and chemical fertilizers on soil fertility and biological activity. Treatments receiving integrated nutrient sources showed markedly better soil health than sole inorganic fertilizer application (T_2). Increased microbial biomass under integrated treatments may be attributed to enhanced organic matter availability and microbial proliferation, which improved nutrient mineralization, soil aggregation, and overall nutrient cycling efficiency in wheat cultivation systems.

Table 5. Effect of Nutrient Management on Soil Properties

Treatment	Soil Organic Carbon (%)	Available N (kg ha^{-1})	Microbial Biomass Carbon (mg kg^{-1})
T_1	0.32	162	141
T_2	0.45	228	214
T_3	0.56	251	284
T_4	0.59	259	298
T_5	0.57	255	291
T_6	0.63	274	325
T_7	0.65	279	338
T_8	0.62	271	319
T_9	0.69	288	354
T_{10}	0.71	296	369
T_{11}	0.68	284	348
T_{12}	0.76	312	392

Graph 4. Soil Organic Carbon under Different Treatments



Organic amendments improved soil aggregation, microbial proliferation, and carbon sequestration, thereby enhancing long-term soil fertility.

6. Mechanisms Underlying Integrated Nutrient Management

The beneficial effects of integrated nutrient management in wheat cultivation are attributed to several interconnected mechanisms:

- Gradual nutrient release from organic sources
- Enhanced microbial activity and nutrient mineralization
- Improved soil physical properties
- Increased cation exchange capacity
- Reduced nutrient leaching losses
- Better synchronization between crop demand and nutrient supply
- Enhanced root proliferation and nutrient absorption
- Increased soil organic carbon and biological activity

These mechanisms collectively improve nutrient-use efficiency and crop productivity while sustaining soil health.

7. Conclusion

The combined application of organic manures and chemical fertilizers significantly improved wheat growth, yield, nutrient uptake, and soil health compared with sole inorganic fertilizer application. Integrated nutrient treatments involving FYM, vermicompost, and biofertilizers with reduced chemical fertilizer doses produced superior crop performance and enhanced soil fertility. Treatment T_{12} (75% RDF + FYM + Vermicompost + Biofertilizers) recorded the highest grain yield, nutrient uptake, and soil

organic carbon. The findings clearly demonstrate that integrated nutrient management is an effective strategy for sustainable wheat production and long-term soil health improvement. Adoption of integrated fertilization practices can reduce dependence on synthetic fertilizers and promote environmentally sustainable cereal production systems.

8. Future Research Perspectives

1. Integration of nanofertilizers with organic amendments in wheat systems.
2. AI-based nutrient management for precision wheat cultivation.
3. Long-term carbon sequestration studies under integrated nutrient management.
4. Role of microbial consortia in enhancing nutrient-use efficiency.
5. Climate-resilient nutrient management strategies for sustainable wheat production.

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