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Effect of integrated nutrient management on growth, yield attributes and soil quality of wheat (*Triticum aestivum* L.)

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Abstract
The field experiment took place at Rama University at Mandhana, Kanpur, to investigate the "Effect of Integrated Nutrient Management on Growth, Yield Attributes, and Soil Quality of Wheat" in the Rabi season crop of 2023-24. The experiment included seven treatments with varying INM levels: N1: Recommended dose fertilizer [RDF] (120:60:40), N2: 100% N through FYM, N3: 100% N through vermi compost, N4: 75% RDF + 25% N through FYM, N5: 50% RDF + 25% N through FYM + 25% N through vermi compost, N6: 75% RDF + 25% vermi compost, and N7: Control (No Fertilizer). Each treatment was replicated three times in Randomized Blocks Design (RBD). The wheat variety utilized in the experiment was Karan Vandana (DBW 187). The pH of the experimental soil ranged from 7.2 to 7.8, with medium organic carbon and medium nitrogen, phosphorus, and potassium concentrations. The results appeared to indicate that the INM level with 50% RDF + 25% N through FYM + 25% N through vermi compost had significant growth, yield attributes, and grain yield varied with the different nutrient levels, and higher nutrient uptake was found to be significantly higher in this pattern. The farmer's practices result in the lowest growth characteristics, yield qualities, and grain yield. The soil quality at the INM levels improved as a result of crop residue decomposition and the application of organic manures. The INM levels has the highest net return and benefit cost ratio, with 50% RDF, 25% FYM, and 25% vermi compost.

Keywords: INM, growth parameters, yield attributes, yield, soil health parameter, wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the most significant cereal crops for both national and international food security. USDA (2024) states that with a 222.69 million hectare area and a production of 785.74 million metric tons in 2023–2024, it ranks #1 in the world among all cereals. Not only is wheat straw an important part of the human diet, but it also provides animals with a substantial amount of dry matter. After rice, it is the second-most significant staple crop in India. India is the second-largest producer of wheat after China. India produced 114 million tons of wheat in 2023–2024 on 31.40 million hectares of total area under cultivation (Food Corporation of India, 2024).

While Uttar Pradesh leads India in area and total wheat output, Punjab leads the nation in productivity. With a productivity of 3604 kg ha^{-1} on 9.42 million hectares, or 31.16% of India's total wheat producing area, Uttar Pradesh produced 33.95 million tons of wheat in 2023–2024. (Anonymous 2023-24) [1]

In the near future, there is little likelihood that extra land will be planted to wheat. Therefore, in order to produce this more wheat, productivity must rise. Numerous factors have contributed to India's declining wheat yield, including poor tillage practices, delayed planting due to unpredictable monsoon seasons, a scarcity of water, weed infestation, subpar seeds, and poor soil from overuse of fertilizers.

Wheat compares favorably to other cereals in terms of nutritional value, with a high nutritional composition of protein (12.1%), lipids (1.8%), ash (1.8%), reducing sugars 2.0%, pentose 6.7%, starch 59.2%, total carbohydrates 70%, and 314 Kcal/100 g of food.

Vitamin B6 (0.1 mg/100 g), calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), and nicotinic acid (5.4 mg/100 g) are among the many vitamins and minerals that are incredibly high in it.

Plant nutrients are essential to the development and progress of the wheat crop. When given nutrients from a range of integrated nutrition management sources, it reacts extremely well to them, optimizing wheat crop yield through sensible fertility control. The main principle of integrated nutrient management (INM) is to maintain and even improve soil fertility in order to sustain crop productivity over an extended length of time. To achieve the highest possible development, yield, and quality of different crops and cropping systems, this can be done by combining the use of all available nutrient sources with scientific management of those sources. The annual application of organic manures improves physical and chemical conditions by promoting a healthy soil structure, improving soil cation exchange capacity, increasing the amount and availability of plant nutrients, raising the humus content, and acting as a substrate for microbial activities.

Concurrent application of organic and inorganic fertilizers improves yield and productivity while maintaining the fertility of the soil. The INM strategy seeks to sustain the availability of plant nutrition in order to achieve a particular level of crop production by carefully exploiting the benefits of every potential source of plant nutrition that is relevant to each croptrend and farming setting.

Adding organic manure to soil enhances its physical, chemical, and biological qualities; it also controls nutrient absorption, promotes growth, and works in concert with crops. The biomass that plants create is primarily responsible for any crop's capacity to absorb nutrients. However, the accumulation of various nutrients within the plant system often impacts the overall absorption of those nutrients.

To offset the scarcity and recent spike in the cost of inorganic fertilizers, the usage of natural sources including FYM, vermicompost, and biofertilizers should be encouraged. These sources increase soil fertility and production, improve soil biodiversity, and feed nutrients to plants.

Nitrogen is a crucial element that affects wheat's growth, development, and quality more than other elements do. However, too much nitrogen reduces wheat's quality and production. As a result, managing nitrogen has received more funding and attention than managing any other natural element. As a component of nucleic acids, which are the building blocks of all proteins, including the enzymes that regulate almost all biological processes, chlorophyll, protoplasm, protein, and other substances that contribute to increased agricultural productivity, nitrogen is also vital.

It is in charge of all biological tissues growth and development. According to reports, the wheat crop responded better to the suggested nitrogen dosage. Overuse of chemical pesticides and fertilizers is endangering the ecosystem. Therefore, creating an appropriate production system is essential to achieving both optimum output and minimal environmental degradation.

Materials and Methods

The current study, titled "Effect of Integrated Nutrient Management on growth, yield attributes, and soil quality of Wheat (*Triticum aestivum* L.)" is being conducted in the 2023–2024 season. This section has provided an overview of the trial's environmental and climatic settings, as well as the materials and techniques that were used there. The fieldwork was carried out in 2023–2024 on Rama University's official land in the central part of Uttar Pradesh, in the rural district of Mandhana, 10 km from Kanpur, during the Rabi season. Because of the lower terrain, the soil is alluvial and somewhat sodic.

The fieldwork was carried out in 2023–2024 on Rama University's official land in the central part of Uttar Pradesh, in the rural district of Mandhana, 10 km from Kanpur, during the Rabi season. Because of the lower terrain, the soil is alluvial and somewhat sodic.

The Indo-Genetic plains' subhumid subtropical zone includes the trial location. Kanpur (U.P.) is located in the Gangetic plain at a height of roughly 125.9 meters above mean sea level. Its coordinates are 25º 56} to 28º 58} North and 79º 31} to 80º 34} East. The experimental farm is tube well irrigated and situated under the Indo-Gangetic alluvial tract.

The area has a subtropical climate, similar to that of North India. With a few showers in the winter, the region receives its mean seasonal rainfall of approximately 816 mm, which is primarily obtained from the second or first week of June until mid-October. Wintertime brings frigid temperatures and sporadic instances of frost. Summertime brings heat and dryness. April marks the beginning of the western hot winds, which last roughly until the monsoon season.

Results and Discussion

Effect of different INM levels on growth

The plant height at 30 DAS of wheat crop was statistically analysed and reported that there was not significant result was observed due to different sources of nutrient (INM) in plant height at 30 DAS of wheat crop. However, the plant height at 60 DAS of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of plant height at 60 DAS of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum plant height at 60 DAS which were statistically at par with treatments N_1 - 100% RDF but statically excellent than N_6 - 75% RDF + 25% vermicompost and other treatments. The lowest plant height at 60 DAS wheat crop was notified in N_7 control plot. However, the plant height at 60 DAS of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of plant height at 60 DAS of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum plant height at 60 DAS which were statistically at par with treatments N_1 - 100% RDF but statically excellent than N_6 - 75% RDF + 25% vermicompost and other treatments. The lowest plant height at 60 DAS wheat crop was notified in N_7 control plot. Dry matter accumulation was significantly affected by tillage practices at different growth stages. Zero tillage resulted into significantly higher dry matter accumulation in comparison to rest of treatments.

The plant height at 90 DAS of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of plant height at 90 DAS wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum plant height at 90 DAS which were statistically at par with treatments N_1 - 100% RDF, N_6 - 75% RDF + 25% vermi compost and N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest plant height at 90 DAS wheat crop was notified in N_7 control plot.

The plant height at Harvest stage of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of plant height at 90 DAS wheat crop. The treatments treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum plant height at harvest stage which were statistically at par with treatments N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest plant height at harvest stage wheat crop was notified in N_7 control plot.

The dry weight at 30 DAS of wheat crop was statistically analysed and reported that there was no significant result was observed due to different sources of nutrient (INM) in dry matter accumulation at 30 DAS of wheat crop. However, the dry weight at 60 DAS of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) in dry weight at 60 DAS of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum dry weight at 60 DAS which were statistically at par with treatments N_1 - 100% RDF but statically excellent than N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest dry weight at 60 DAS wheat crop was notified in N_7 control plot

The dry weight at 90 DAS of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) in dry weight at 90 DAS of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum dry weight at 90 DAS which were statistically at par with treatments N_1 - 100% RDF but statically excellent than N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest dry weight at 90 DAS wheat crop was notified in N_7 control plot.

The dry weight at harvest stage of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of dry weight at harvest stage of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum dry weight at harvest stage which were statistically at par with treatments N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM but statically excellent than N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest dry weight at harvest stage wheat crop was notified in N_7 control plot.

The numbers of tillers at 30 DAS of wheat crop were statistically analysed and reported that there was no significant result was observed due to different sources of nutrient (INM) in numbers of tillers at 30 DAS of wheat crop. However, the numbers of tillers at 60 DAS of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of numbers of tillers at 60 DAS of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum numbers of tillers at 60 DAS which were statistically at par with treatments N_1 - 100% RDF and N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest numbers of tillers at 60 DAS wheat crop were notified in N_7 control plot.

The numbers of tillers at 90 DAS of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of numbers of tillers at 90 DAS and harvest stage of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through verm compost recorded maximum numbers of tillers at 90 DAS which were statistically at par with treatments N_1 - 100% RDF and N_6 - 75% RDF + 25% vermicompost but statically excellent than, N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest numbers of tillers at 90 DAS wheat crop were notified in N_7 control plot.

The numbers of tillers at harvest stage of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) of numbers of tillers at harvest stage of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum numbers of tillers at harvest stage which were statistically at par with treatments N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost, N_4 - 75% RDF + 25% N through FYM and N_3 - 100% N through vermicompost but statically excellent than N_2 - 100% N through FYM. The lowest numbers of tillers at harvest stage wheat crop were notified in N_7 control plot.

Effect of different INM levels on yield attributes

The no. of spikelets of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on no. of spikelets of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermi compost recorded maximum no. of spikelets/ ear which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest no. of spikelets/ ear wheat crop was notified in N_7 control plot.

The Length of spike of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on Length of spike of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum length of spikes which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest length of spike on wheat crop was notified in N_7 control plot.

The weight of spike of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on Length of spike of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum weight of spike which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest weight of spike on wheat crop was notified in N_7 control plot.

The number of grains/spikes of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on number of grains/spikes of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum no. of grain/spikes which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest no. of grain/spike on wheat crop was notified in N_7 control plot.

The grains weight per spikes of wheat crop were statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on number of grain weight of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum grain weight which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest grain weight on wheat crop was notified in N_7 control plot.

The test weight of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on test weight of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum test weight which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest test weight of wheat crop was notified in N_7 control plot.

Effect of different INM levels on yield

The grain yield of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on grain yield of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum grain yield which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest grain yield on wheat crop was notified in N_7 control plot.

The straw yield of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on straw yield of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum straw yield which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest straw yield on wheat crop was notified in N_7 control plot.

The biological yield of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on biological yield of wheat crop. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum biological yield which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest biological yield on wheat crop was notified in N_7 control plot.

The harvesting index of wheat crop was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on harvesting index of wheat crop. The treatments N_1 - 100% RDF recorded maximum harvesting index which were statistically at par with treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost but statistically excellent than N_7 -Control and N_4 - 75% RDF + 25% N through FYM and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM and other treatments. The lowest number of harvest index on wheat crop was notified in N_6 - 75% RDF + 25% vermicompost control plot.

Effect of different INM levels on soil health parameter

The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermi compost recorded maximum pH value which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest Ph value of soil was notified in N_7 control plot.

The soil electric conductivity was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on soil electric conductivity. The treatments N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost recorded maximum soil electric conductivity which were statistically at par with treatments N_1 - 100% RDF and, N_6 - 75% RDF + 25% vermicompost but statically excellent than N_4 - 75% RDF + 25% N through FYM, and N_3 - 100% N through vermicompost and N_2 - 100% N through FYM. The lowest soil electric conductivity was notified in N_7 control plot.

The soil organic carbon was statistically analysed and reported that there was significant result was observed due to different sources of nutrient (INM) on soil organic carbon. The treatments N_3 - 100% N through vermicompost recorded maximum soil electric conductivity which were statistically at par with treatments N_2 - 100% N through FYM and, N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost but statically excellent than N_1 - 100% RDF, and N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM. The lowest soil organic carbon was notified in N_7 Control plot.

The available N found significantly highest under the N_3 - 100% N through vermicompost, followed by N_2 - 100% N through FYM and N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost and N_1 - 100% RDF, and N_4 - 75% RDF + 25% N through FYM and N_6 - 75% RDF + 25% vermicompost while the lowest N recorded under the N_7 Control. There was significant different found among all other N containing treatment.

The available P found significantly highest under the N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost, followed by N_3 - 100% N through vermicompost and N_6 - 75% RDF + 25% vermicompost and N_2 - 100% N through FYM and N_1 - 100% RDF and N_7 Control, while the lowest N recorded under the N_4 - 75% RDF + 25% N through FYM. There was significant different found among all other P containing treatment.

The available K found significantly highest under the N_3 - 100% N through vermicompost, followed by N_2 - 100% N through FYM and N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost and N_6 - 75% RDF + 25% vermicompost and N_4 - 75% RDF + 25% N through FYM and N_1 - 100% RDF, while the lowest K recorded under the N_7 Control. There was significant different found among all other K containing treatment.

Effect of different of INM levels on Economic

The highest value of cost of cultivation was recorded under farmer practice N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost followed by farmer practice N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost, N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost, N_2 - 100% N through FYM and N_7 -Control was recorded lower value of cost of cultivation.

The highest of value gross return was recorded under N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost followed by farmer practice N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost, N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost, N_2 - 100% N through FYM and N_7 -Control was recorded lower value of gross return.

The highest value of net return was recorded under N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost followed by farmer practice N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost, N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost, N_2 - 100% N through FYM and N_7 -Control was recorded lower value of net return.

The highest value of benefits cost ratio was recorded under N_5 - 50% RDF + 25% N through FYM + 25% N through vermicompost followed by farmer practice N_1 - 100% RDF, N_6 - 75% RDF + 25% vermicompost, N_4 - 75% RDF + 25% N through FYM, N_3 - 100% N through vermicompost, N_2 - 100% N through FYM and N_7 -Control was recorded lower value of benefits cost ratio.

Table 1: Effect of INM on initial plant population of wheat crop at different stages

S. N.	Treatments	Initial plant population
N_1	100% RDF	21.98
N_2	100% N through FYM	19.74
N_3	100% N through vermi compost	20.10
N_4	75% RDF + 25% N through FYM	20.65
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	22.30
N_6	75% RDF + 25% vermi compost	21.20
N_7	Control (No Fertilizer)	18.23
		2.92
	CD at 5%	NS

Table 2: Effect of INM on plant height (cm) of wheat crop at different stages

S. N.	Treatments	Plant height			
		30 DAS	60 DAS	90 DAS	At Harvest
N_1	100% RDF	29.98	44.76	94.10	100.98
N_2	100% N through FYM	28.76	43.12	92.93	99.10
N_3	100% N through vermi compost	28.89	43.34	93.43	99.29
N_4	75% RDF + 25% N through FYM	29.12	43.97	93.84	99.62
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	30.16	45.14	94.31	106.36
N_6	75% RDF + 25% vermi compost	29.43	44.28	93.96	99.87
N_7	Control (No Fertilizer)	27.48	42.40	92.17	98.89
	S.Em±	0.98	1.45	1.23	2.46
	CD at 5%	NS	3.32	3.78	2.93

Table 3: Effect of INM levels on Dry weight (gm^{-2}) of wheat crop

S. N.	Treatments	Dry matter accumulation			
		30 DAS	60 DAS	90 DAS	At Harvest
N_1	100% RDF	8.67	22.96	187.36	229.82
N_2	100% N through FYM	7.76	21.78	184.43	228.56
N_3	100% N through vermi compost	7.88	22.10	184.86	229.10
N_4	75% RDF + 25% N through FYM	8.12	22.31	185.10	229.18
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	9.20	23.43	189.49	230.56
N_6	75% RDF + 25% vermi compost	8.23	22.78	185.20	229.32
N_7	Control (No Fertilizer)	6.98	21.11	184.24	215.46
	S.Em±	0.72	2.98	1.56	1.20
	CD at 5%	NS	4.53	5.96	8.54

Table 4: Effect of INM levels on number of tillers of wheat crop

S. N.	Treatments	Number of tillers			
		30 DAS	60 DAS	90 DAS	At Harvest
N_1	100% RDF	48.67	98.87	86.45	83.98
N_2	100% N through FYM	47.29	97.64	84.39	80.22
N_3	100% N through vermi compost	47.63	97.92	84.68	80.40
N_4	75% RDF + 25% N through FYM	47.97	98.45	85.19	82.92
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	49.23	99.89	98.12	96.30
N_6	75% RDF + 25% vermi compost	48.12	98.62	85.43	83.20
N_7	Control (No Fertilizer)	46.20	95.60	79.24	76.45
	S.Em±	0.89	1.58	1.98	1.96
	CD at 5%	NS	5.67	5.76	5.75

Table 5: Effect of INM on number of spike, spike length, weight of spikes, number of grains per spike, grain weight per spike and test weight of wheat crop

S. N.	Treatments	Yield attributes					
		No. of spike (m^2)	Spike length (cm)	Weight of spike (g)	No. of grain per spike	Grain weight per spike	Test weight
N_1	100% RDF	20.79	13.38	1.96	48.97	0.76	44.45
N_2	100% N through FYM	18.96	12.17	1.32	43.67	0.42	41.10
N_3	100% N through vermi compost	19.10	12.79	1.48	44.10	0.45	41.48
N_4	75% RDF + 25% N through FYM	19.76	13.12	1.68	45.38	0.56	42.67
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	21.48	13.65	2.15	50.10	0.89	45.38
N_6	75% RDF + 25% vermi compost	19.98	13.24	1.73	46.54	0.66	43.10
N_7	Control (No Fertilizer)	18.54	11.56	1.10	40.16	0.30	38.78
	S.Em±	2.97	2.79	2.37	1.57	1.65	2.56
	CD at 5%	1.10	0.56	1.86	2.52	2.99	1.76

Table 6: Effect of INM levels on Yield (q ha^{-1}) of wheat crop

S. N.	Treatments	Yield (q ha^{-1})			Harvest index (%)
		Grain	Straw	Biological	
N_1	100% RDF	39.10	57.78	96.88	40.36
N_2	100% N through FYM	27.00	48.98	75.98	35.53
N_3	100% N through vermi compost	27.19	49.19	76.38	35.60
N_4	75% RDF + 25% N through FYM	28.10	49.43	77.43	36.29
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	40.27	64.29	104.56	38.51
N_6	75% RDF + 25% vermi compost	28.37	56.46	84.83	33.44
N_7	Control (No Fertilizer)	25.49	45.65	71.14	35.83
	S.Em±	0.92	0.20	2.46	0.45
	CD at 5%	3.28	1.00	7.32	2.30

Table 7: Effect of INM on soil pH, Soil electrical conductivity (dS m^{-1}) and Organic carbon (%) after harvest of wheat crop

S. N.	Treatments	Soil pH	Electrical conductivity (dS m^{-1})	Organic carbon (%)
N_1	100% RDF	8.18	0.24	0.498
N_2	100% N through FYM	8.10	0.18	0.718
N_3	100% N through vermi compost	8.15	0.22	0.735
N_4	75% RDF + 25% N through FYM	8.17	0.23	0.471
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	8.2	0.25	0.567
N_6	75% RDF + 25% vermi compost	8.17	0.23	0.485
N_7	Control (No Fertilizer)	7.8	0.16	0.357
	S.Em±	0.078	0.02	0.046
	CD at 5%	NS	NS	NS

Table 8: Effect of INM on available N, P and K (kg ha^{-1}) after harvest of wheat crop

S. N.	Treatments	Available Nutrients (kg ha^{-1})		
		N	P	K
N_1	100% RDF	236.35	14.24	220.34
N_2	100% N through FYM	247.38	14.75	233.38
N_3	100% N through vermi compost	248.10	15.20	237.65
N_4	75% RDF + 25% N through FYM	215.79	13.90	229.32
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	240.48	15.30	231.54
N_6	75% RDF + 25% vermi compost	216.15	14.78	230.86
N_7	Control (No Fertilizer)	200.39	14.00	211.68
	S.Em±	2.953	0.683	2.396
	CD at 5%	7.895	0.965	6.923

Table 9: Effect of INM on economics of wheat crop

S. N.	Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio (Re $^{-1}$)
N_1	100% RDF	30675	102012	71337	2.32
N_2	100% N through FYM	29375	85452	56077	1.90
N_3	100% N through vermi compost	30070	90706	60636	2.01
N_4	75% RDF + 25% N through FYM	30635	96457	65822	2.14
N_5	50% RDF + 25% N through FYM + 25% N through vermi compost	30910	104022	73112	2.36
N_6	75% RDF + 25% vermi compost	30651	91953	61302	2.00
N_7	Control (No Fertilizer)	29305	82410	53105	1.81

Conclusion
The study concludes that the treatment N5 (50% RDF + 25% N through FYM + 25% N through vermicompost) significantly enhances wheat growth, yield attributes, soil quality, and economic returns compared to other treatments, including the control. The use of integrated nutrient management, particularly combining RDF with organic sources like FYM and vermicompost, not only improves crop performance but also sustains soil health and offers better economic returns, making it a viable strategy for wheat cultivation in similar agro-climatic conditions.

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