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Sandeep Kumar Yadav
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Ashish Nath
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Bhupesh Kumar Mishra
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Amit Kumar
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Abhishek Tiwari
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Corresponding Author:
Sandeep Kumar Yadav
Department of Agriculture Maharishi University of Information and Technology Lucknow, Uttar Pradesh, India

Impact of varying nutrient management levels on agronomic performance of wheat (*Triticum aestivum* L.) under Lucknow agro-climatic conditions

Sandeep Kumar Yadav, Ashish Nath, Bhupesh Kumar Mishra, Amit Kumar and Abhishek Tiwari

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Abstract
The present field experiment was done during the 2024–25 Rabi season at the Crop Research Centre, Maharishi University of Information Technology, Lucknow, Uttar Pradesh, to investigate the impact of different nutrient dosages on the development and productivity of wheat (*Triticum aestivum* L.).
Three replications of each of the seven treatments were used in the Randomized Block Design (RBD) trial. The treatment structure comprised T_1: 100% RDF (control), T_2: 75% RDF + 5 t ha^{-1} FYM, T_3: 50% RDF + 10 t ha^{-1} FYM, T_4: 100% RDF + 5 t ha^{-1} FYM + 5 t ha^{-1} vermicompost, T_5: 75% RDF + 10 t ha^{-1} FYM + 7.5 t ha^{-1} vermicompost, T_6: 50% RDF + 15 t ha^{-1} FYM + 10 t ha^{-1} vermicompost, and T_7: 125% RDF. The wheat cultivar HD 2967 was selected for experimentation. Among the different nutrient combinations, the treatment receiving 75% RDF + 10 t ha^{-1} FYM + 7.5 t ha^{-1} vermicompost (T_5) displayed considerable improvement in plant height, tiller density, leaf area index, and dry matter accumulation during the growth period.
Additionally, this treatment yielded the highest grain, straw, and total biological yields; the control treatment (100% RDF alone) had the lowest values for all metrics. Offering contributing measures such as the number of earheads m^2, ear length, grains per earhead, spikelets per spike, and test weight indicated a gradual boost with increasing nutrient levels up to T_5, beyond which further nutrient addition did not offer significant benefits. The minimum expression of these features was recorded in the control plot. Overall, under the agroclimatic conditions of Lucknow, the integrated application of 75% RDF supplemented with 10 t ha^{-1} FYM and 7.5 t ha^{-1} vermicompost proved superior in improving wheat growth, yield attributes, and productivity. This can be suggested as an effective and sustainable nutrient management strategy for profitable wheat cultivation.

Keywords: Wheat, HD 2967, nutrient doses, RDF, FYM, and vermicompost, etc.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most significant and strategic cereal crops globally, providing as a primary food supply for a substantial part of the human population. It is the main food source for around two billion people, or roughly 36% of the world's population, and accounts for 20% of daily calorie consumption and 55% of all carbohydrate intake. In India, wheat occupies a crucial significance in maintaining national food security.

The country's wheat output for 2024–25 reached 107.6 million metric tonnes (MT), demonstrating a 3.9% growth over the previous year and marking the greatest yield recorded in the prior five marketing seasons. In a similar vein, the closing wheat stock in 2023–2024 was 27.5 million MT, the highest level in five years. Wheat is the most widely grown cereal crop in a variety of climates worldwide, surpassing other cereals like rice and maize in both acreage and yield. It is typically planted in temperate zones but also thrives at medium and high altitudes in tropical and subtropical countries.

Modern agriculture must place more of a focus on effective nutrient management due to the expanding worldwide demand for food, feed, and fiber from a declining base of cultivable land. Improving nutrient usage efficiency (NUE) is essential to guaranteeing profitability and sustainability. The wise and balanced application of fertilizers not only enhances agricultural yields but also decreases nutrient losses to the environment, hence mitigating ecological damage. Sustainable nutrient management focuses on balanced fertilizer application linked with better agronomic techniques, ensuring long-term soil health and production.

Prolonged and excessive dependency on inorganic fertilizers during the past five decades, frequently without the use of organic amendments, has led to widespread micronutrient shortages and degradation of soil health. Additionally, groundwater pollution has been caused by nutrient losses, particularly nitrogen in the form of nitrate (NO_3^-). These problems highlight the need for alternate nitrogen management strategies that preserve soil fertility and boost output in an ecologically responsible way. Higher yields and better nutrient availability have been demonstrated by combining chemical fertilizers with organic sources such farmyard manure (FYM), crop residues, and green manures. Organic manures improve nutrient utilization efficiency and guarantee a steady supply of nitrogen for the crop by releasing nutrients gradually.

In order to preserve environmental quality and achieve excellent wheat yields, nitrogen control is essential. One of the most important management strategies affecting crop development, growth, and yield formation is the appropriate control of nitrogen rate and application time. Vermicompost has become well-known among organic amendments as a biologically active organic fertilizer made by microorganisms and earthworms breaking down organic materials. While microorganisms aid decomposition, earthworms speed the process by enhancing substrate aeration and promoting microbial activity.

Vermicompost serves as a rich source of macro- and micronutrients and may greatly increase soil structure, biological activity, and nutrient availability when applied in proper ratios with synthetic fertilizers (Suthar, 2008). Similarly, it has been demonstrated that applying FYM and vermicompost along with inorganic fertilizers improves the physical, chemical, and biological characteristics of the soil, resulting in better nutrient absorption and increased crop yields (Sharma *et al*., 2007).

However, because of limited nutrient mobility and restricted absorption, relying only on chemical fertilizers applied to the soil frequently leads to nutritional deficits throughout crucial development phases, especially the reproductive stage. To solve this difficulty, merging organic and inorganic nutrient sources gives a more balanced and sustainable approach to nutrition management. The combined use of organic manures and chemical fertilizers boosts soil fertility, improves nutrient efficiency, and sustains better yield. Therefore, adopting integrated nutrient management strategies is vital for attaining sustainable wheat production, guaranteeing food security, and sustaining soil health under the complex agro-climatic conditions of the Lucknow region and beyond.

Materials and Methods

In order to determine the ideal nutrient dosage for attaining the best growth and yield performance in wheat (*Triticum aestivum* L.), a field experiment was carried out during the Rabi season of 2024–2025 at the Research Farm of the Department of Agronomy, Maharishi University of Information Technology, Lucknow (Uttar Pradesh). The experimental soil was silty loam in texture, neutral in reactivity, and characterized by low accessible nitrogen, medium phosphorus, and high potassium status. A Randomized Block Design (RBD) with seven treatments that were repeated three times was used to set up the experiment. The specifics of the therapy were as follows: 100% RDF (Control), 75% RDF + 5 t ha^{-1} FYM, 50% RDF + 10 t ha^{-1} FYM, 100% RDF + 5 t ha^{-1} FYM + 5 t ha^{-1} vermicompost, 75% RDF + 10 t ha^{-1} FYM + 7.5 t ha^{-1} vermicompost, 50% RDF + 15 t ha^{-1} FYM + 10 t ha^{-1} vermicompost, and 125% RDF. According to the treatment combinations, the required dose of fertilizers (RDF) for wheat was 120 kg N, 60 kg $P2O_2$, and 40 kg K2O ha^{-1}, provided by urea, single superphosphate, and muriate of potash, respectively.

On November 20, 2024, certified wheat variety HD 2967 seed was manually seeded using a seed drill at a distance of 20 cm between rows. Adequate soil moisture was maintained during the crop growing period. A total of five irrigations were administered at important growth stages—crown root initiation, late tillering (jointing), blooming, milking, and dough stages—to promote optimum crop development. Growth and yield indicators were observed at consecutive growth stages at 30-day intervals in order to assess the impact of different nutrient dosages. Three sample plants per plot were chosen at random, tagged, and utilized to record in-depth biometric observations because it was not practical to examine every plant in each plot.

Growth attributes (plant height, number of tillers m^{-2} leaf area index, and dry matter accumulation) and yield and yield-contributing traits (number of earheads m^{-2} ear length, grains earhead^{-1}, spikelets spike^{-1}, test weight, grain yield, straw yield, and biological yield) were the broad categories into which the recorded parameters were divided. All obtained data were subjected to statistical analysis following conventional methods. For every parameter, the standard error of mean (SEm±) was determined, and the significance of treatment mean differences was assessed by computing crucial differences (CD) at the 5% probability level.

Results and Discussion

Stand Count, Plant Height, and Number of Tillers

Table 1 demonstrates that although stand count did not vary considerably, nutrient levels had a notable influence on wheat plant height and tiller number. The tallest plants (90.21 cm) and maximum tiller count (440 m^{-2}) were generated by the combined treatment T∗ (75% RDF + FYM + Vermicompost), followed by 125% RDF, while the control (100% RDF) had the lowest values. Improved nutrient availability, improved soil structure, and higher microbial activity from the combined use of organic and inorganic sources are the causes of the increased growth under T_2. These outcomes are consistent with previous research by Suthar and Sharma *et al*. In general, T— was shown to be the best nutritional dosage for enhancing wheat growth in Lucknow.

Leaf Area Index and Dry Matter Accumulation

Table 2 demonstrates that nutrient levels had a substantial impact on wheat LAI and dry matter accumulation at later stages, even if differences at 30 DAS were not significant. The combined treatment T_5 (75% RDF + FYM + Vermicompost) recorded the greatest LAI (5.00) and DMA (1495.34 g m^{-2}), followed by 125% RDF, while the control (100% RDF) showed the lowest values. The combined advantages of organic and inorganic sources, which enhanced soil conditions, nutrient availability, root development, and photosynthesis, account for T_2's excellent performance. Similar findings were observed by Sharma *et al*. and Suthar. For improving LAI, biomass output, and crop vigor in Lucknow, the combined dosage of 75% RDF + FYM + Vermicompost worked best overall.

Yield Attributes

Table 3 reveals that nutrient levels had a substantial influence on important yield parameters of wheat such as earheads m^{-2}, earhead length, grains per earhead, spikelets per spike, and test weight. The combined treatment T_5 (75% RDF + FYM + Vermicompost) recorded the greatest values for all these metrics, whereas 125% RDF placed second and the control (100% RDF) gave the lowest values. The superiority of T_5 can be due to the combined action of organic manures and inorganic fertilizers, which boosted nutrient availability, root development, photosynthesis, and assimilate transport to the growing grains. The constant nutrient release from FYM and vermicompost, together with the quick availability from chemical fertilizers, enabled improved grain filling.

Grain Yield, Straw Yield, Harvest Index, and Biomass

Table 4 reveals that nutrient dosages substantially influenced wheat grain yield, straw yield, and biomass, whereas the harvest index remained non-significant. The combined treatment T_5 (75% RDF + FYM + Vermicompost) generated the best yields, followed by 125% RDF, whilst the control recorded the lowest. The greater performance of T_5 is attributable to the balanced nutrient supply from organic and inorganic sources, which improved soil conditions, microbial activity, and nutrient availability, leading to better growth and assimilate translocation. The unaltered harvest index implies proportionate gains in grain and biomass. Overall, T_5 showed most beneficial for delivering greater and sustained wheat yields under Lucknow circumstances.

Nutrient Content and Uptake (Nitrogen, Phosphorus, and Potassium)

Table 5 reveals that nutrient treatments considerably altered N, P, and K content and absorption in wheat. The combined treatment T_5 (75% RDF + FYM + Vermicompost) recorded the greatest nutrient concentrations and total absorption, followed by 125% RDF (T_7), while the control (100% RDF) showed the lowest values. The increased absorption under T_5 is attributable to greater microbial activity, enhanced mineralization, improved soil structure, and sustained nutrient release from organic manures together with the fast availability from inorganic fertilizers. Overall, in the agroclimatic conditions of Lucknow, Tē was most successful in boosting nutrient accumulation and absorption, supporting increased productivity and enhanced soil health.

Table 1: Effect of nutrient doses on Stand count, plant height and number of tillers at various growth stages of the crop

Treatments	Stand Count	Plant height (cm)				Number of tillers (m^{-2})			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
100% RDF (Control)	174.00	22.69	61.76	69.40	71.54	177.48	226.16	238.06	242.92
75% RDF+ 5 ton/ha FYM	176.50	22.97	75.88	85.25	87.89	180.03	294.43	350.35	357.50
50% RDF + 10ton/ha FYM	173.17	23.03	76.32	85.52	88.03	180.05	332.83	359.78	367.13
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	177.23	23.29	77.32	86.52	90.21	179.22	341.79	309.93	316.25
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	177.67	23.43	77.88	87.50	89.20	181.35	409.64	431.20	440.00
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	175.83	23.05	72.02	80.92	83.43	178.05	352.77	366.07	373.54
125% RDF	177.50	23.38	77.45	87.21	88.40	181.22	373.56	382.69	390.50
S.Em±	1.757	1.153	1.188	1.335	1.376	1.792	4.903	5.161	5.266
CD at 5%	NS	3.257	3.467	3.896	4.016	4.125	14.309	15.063	15.370

Table 2: Effect of nutrient doses on Leaf area Index and dry matter accumulation at various growth stages of the crop

Treatments	Leaf area Index			Dry Matter Accumulation (g/m^{-2})			
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	At harvest
100% RDF (Control)	1.19	2.48	2.76	58.00	134.45	324.08	383.62
75% RDF+ 5 ton/ha FYM	1.46	3.66	4.06	58.61	508.65	872.75	1027.35
50% RDF + 10ton/ha FYM	1.47	3.75	4.17	58.83	519.16	890.26	1047.95
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	1.45	3.23	3.59	59.00	578.04	963.40	1133.41
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	1.51	4.50	5.00	59.22	762.62	1271.04	1495.34
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	1.39	3.82	4.24	58.85	543.18	930.29	1095.05
125% RDF	1.49	3.99	4.44	59.17	657.08	1095.14	1288.40
SEm±	0.018	0.054	0.060	0.586	9.582	15.970	18.788
CD at 5%	NS	0.157	0.175	NS	27.968	46.613	54.838

Table 3: Effect of nutrient doses on yield attributes

Treatments	Earhead m^{-2}	Length of ear head	No. of grains/ ear head	No. of spikelet' $spike^{-1}$	Test weight
100% RDF (Control)	180.83	9.70	38.50	17.32	33.74
75% RDF+ 5 ton/ha FYM	293.75	10.60	43.00	18.93	35.25
50% RDF + 10ton/ha FYM	285.00	11.00	45.50	19.64	35.53
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	247.50	11.10	45.00	19.82	35.70
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	360.00	12.05	50.25	21.52	38.71
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	299.58	11.35	46.75	20.27	36.78
125% RDF	315.00	11.70	48.50	20.89	36.82
SEm±	4.787	0.173	0.866	0.309	0.553
CD at 5%	13.973	0.506	2.528	0.903	1.616

Table 4: Effect of nutrient doses on Grain Yield, Straw Yield (qha^{-1}), Harvest index (%), and Biomass

Treatments	Grain Yield (qha^{-1})	Straw Yield (qha^{-1})	Harvest index (%)	Biomass (q ha^{-1})
100% RDF (Control)	17.02	23.86	41.79	40.87
75% RDF+ 5 ton/ha FYM	38.32	57.20	40.55	95.51
50% RDF + 10ton/ha FYM	40.11	59.86	40.15	99.97
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	47.66	69.13	39.20	116.79
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	53.96	83.63	40.89	137.58
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	44.90	66.91	40.49	111.75
125% RDF	51.85	77.79	40.48	129.64
SEm±	0.800	1.699	0.800	1.704
CD at 5%	2.334	4.960	NS	4.973

Table 5: Effect of nutrient doses on Nitrogen Content,Nitrogen uptake, Phosphorus content and phosphorus uptake by grains and straw

Treatments	Nitrogen content (%)		Nitrogen Uptake			Phosphorous Content (%)		Phosphorous uptake		
	Grain	Straw	Grain	Straw	Total	Grain	Straw	Grain	Straw	Total
100% RDF (Control)	1.48	0.51	25.12	20.75	45.87	0.35	0.11	5.94	4.35	10.30
75% RDF+ 5 ton/ha FYM	1.52	0.52	59.01	50.21	133.74	0.36	0.11	13.68	11.06	24.74
50% RDF + 10ton/ha FYM	1.55	0.54	63.02	53.44	116.46	0.35	0.13	14.76	12.22	26.97
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	1.57	0.53	72.68	61.07	152.41	0.37	0.11	17.20	13.53	30.46
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	1.66	0.56	89.34	77.12	109.22	0.38	0.13	20.05	17.73	37.78
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	1.52	0.52	71.16	60.51	131.66	0.36	0.12	16.39	13.26	29.91
125% RDF	1.59	0.54	82.30	70.11	166.45	0.37	0.12	19.54	16.33	35.87
SEm±	0.015	0.005	1.280	1.074	1.574	0.003	0.001	0.362	0.235	0.477
CD at 5%	0.043	0.015	3.736	3.135	5.469	0.010	0.004	1.057	0.687	1.391

Table 6: Effect of nutrient doses on Potassium Content and Potassium uptake by grains and straw

Treatments	Potassium content (%)		Potassium Uptake		
	Grain	Straw	Grain	Straw	Total
100% RDF (Control)	0.34	1.34	5.77	54.87	60.64
75% RDF+ 5 ton/ha FYM	0.35	1.38	13.45	133.63	147.07
50% RDF + 10ton/ha FYM	0.35	1.41	14.28	143.11	157.39
100% RDF+ 5 ton/ha FYM +Vermicompost 5 ton/ha	0.36	1.43	16.62	161.74	178.37
75% RDF+ 10 ton/ha FYM +Vermicompost 7.5 ton/ha	0.37	1.51	20.16	207.39	227.55
50% RDF+ 15 ton/ha FYM +Vermicompost 10 ton/ha	0.35	1.38	16.18	161.38	177.56
125% RDF	0.36	1.44	18.69	186.86	205.56
SEm±	0.004	0.013	0.342	3.106	3.178
CD at 5%	NS	0.038	0.997	9.066	9.275

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