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Integrated use of organic and inorganic sources of nitrogen for improving growth, yield, nutrient uptake and economic returns of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during *Rabi* season of 2025-26 at Agricultural Research Farm, Department of Agronomy, School of Agriculture Suresh Gyan Vihar University, Jaipur (Rajasthan) to influence of Integrated Use of Organic and Inorganic Sources of Nitrogen for Improving Growth, Yield, Nutrient Uptake and Economic Returns of Wheat (*Triticum aestivum* L.). Ten nitrogen-management treatments comprising an unfertilized control, recommended dose of nitrogen (RDN) through urea, FYM or vermicompost, and different combinations of RDN through urea with FYM and vermicompost were evaluated. The results revealed that integrated nitrogen management markedly improved crop growth and productivity compared with the control. Treatment T₅, consisting of 75% RDN through urea + 25% RDN through vermicompost, generally performed best among the treatments, recording the highest plant population at 30 DAS (116.85 m⁻²) and harvest (108.02 m⁻²), plant height at 30 DAS (27.44 cm), 60 DAS (59.58 cm) and harvest (96.52 cm), total tillers (122.68 m⁻¹), effective tillers (111.95 m⁻¹), grains spike⁻¹ (53.75), test weight (40.55 g), grain yield (48.25 q ha⁻¹), straw yield (64.15 q ha⁻¹) and biological yield (112.40 q ha⁻¹). The same treatment also recorded the highest N uptake by grain and straw (98.43 and 48.11 kg ha⁻¹, respectively), P uptake (20.27 and 11.61 kg ha⁻¹) and K uptake (20.60 and 90.45 kg ha⁻¹). However, the highest B ratio (2.79) was obtained with T₄ (75% RDN through urea + 25% RDN through FYM). The results indicate that partial substitution of inorganic nitrogen with organic sources, particularly vermicompost, can improve wheat growth, yield formation and nutrient acquisition while providing an economically viable nutrient-management strategy.

Keywords: Wheat, nitrogen management, urea, FYM, vermicompost, integrated nutrient management, yield, nutrient uptake, economics

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and a major component of food security in India. Sustaining wheat productivity requires an adequate and balanced supply of plant nutrients, particularly nitrogen, because nitrogen plays a central role in chlorophyll formation, photosynthetic activity, protein synthesis, vegetative growth and grain development. However, continuous dependence on inorganic fertilizers alone may result in inefficient nutrient use and deterioration of soil fertility when organic nutrient sources are neglected.

Farmyard manure (FYM) and vermicompost provide nutrients more gradually than readily soluble mineral fertilizers and can contribute to improved soil biological activity, nutrient availability and soil organic matter. Consequently, integration of organic and inorganic nutrient sources has emerged as an important component of sustainable nutrient management. Recent studies in wheat have reported improvements in growth, yield and nutrient uptake through integrated application of inorganic fertilizers with FYM and vermicompost.

The effectiveness of integrated nutrient management depends on the source and proportion of nutrients supplied. A suitable combination can provide readily available nitrogen during periods of high crop demand while organic materials provide a more sustained nutrient supply and improve the soil environment. Studies conducted under Indian conditions have shown that combinations of urea and FYM can enhance wheat yield and nitrogen uptake compared with sole nutrient sources.

Vermicompost has particular importance because it contains readily mineralizable nutrients and biologically active compounds that may improve nutrient availability and root growth. Recent research in Rajasthan and other wheat-growing regions has also demonstrated the potential of vermicompost-based nutrient management for improving crop growth, productivity and economic returns.

Therefore, the present study was undertaken to evaluate different combinations of inorganic nitrogen through urea and organic nitrogen through FYM and vermicompost and to identify an efficient nitrogen-management strategy for improving growth, yield, nutrient uptake and profitability of wheat.

2. Materials and Methods

A field experiment was conducted during the Rabi season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, to influence of Integrated Use of Organic and Inorganic Sources of Nitrogen for Improving Growth, Yield, Nutrient Uptake and Economic Returns of Wheat (*Triticum aestivum* L.). The experimental site is located in a semi-arid, subtropical climate characterized by extreme temperature variations, with hot and dry summers (maximum temperature up to 45°C) and cold winters (minimum temperature as low as 2.8°C). The area receives an average annual rainfall of 500–800 mm, mostly concentrated during the monsoon season. The experiment evaluated ten nitrogen-management treatments in wheat. The treatments consisted of an untreated control and different combinations of the recommended dose of nitrogen (RDN) supplied through urea, FYM and vermicompost.

Treatment details

Treatment	Nitrogen management
T ₀	Control
T ₁	RDN alone through urea
T ₂	RDN alone through FYM
T ₃	RDN alone through vermicompost
T ₄	75% RDN through urea + 25% through FYM
T ₅	75% RDN through urea + 25% through vermicompost
T ₆	50% RDN through urea + 50% through FYM
T ₇	50% RDN through urea + 50% through vermicompost
T ₈	25% RDN through urea + 75% through FYM
T ₉	25% RDN through urea + 75% through vermicompost

Observations were recorded for plant population, plant height, total tillers, effective tillers, grains per spike, test weight, grain yield, straw yield, biological yield, harvest index, N, P and K concentration and nutrient uptake. Economic parameters included cost of cultivation, gross return, net return and benefit ratio.

The statistical significance of treatment differences was assessed using the critical difference (CD) at the 5% level, as reported in the experimental data.

3. Results and Discussion

3.1 Plant population

Nitrogen management influenced plant establishment and plant population numerically, although the differences were statistically non-significant at both 30 DAS and harvest. Plant population at 30 DAS ranged from 95.36 m⁻² in the control to 116.85 m⁻² in T₅, while the corresponding values at harvest were 86.08 and 108.02 m⁻², respectively. T₅ recorded the highest population, followed by T₄ (113.45 and 105.08 m⁻²) and T₃ (111.32 and 102.95 m⁻²).

The numerical improvement in plant population under integrated

nitrogen management may be attributed to better nutrient availability during early crop establishment. Organic sources may have improved the physical and biological environment of the rhizosphere, while urea provided readily available nitrogen. Similar beneficial effects of integrated nutrient management on wheat establishment and growth have been reported in previous studies.

3.2 Plant height

Plant height was significantly influenced by nitrogen treatments. At 30 DAS, plant height increased from 20.32 cm under the control to 29.08 cm under T₁, while T₅ recorded 27.44 cm. At 60 DAS, the maximum plant height was observed in T₅ (59.58 cm), followed by T₁ (62.38 cm) and T₄ (57.88 cm). At harvest, T₁ recorded the highest plant height (101.06 cm), closely followed by T₅ (96.52 cm), whereas the control recorded only 71.47 cm.

The increase in plant height under nitrogen application may be associated with enhanced cell division, cell elongation, chlorophyll formation and photosynthetic activity. Integrated application of urea with organic sources may have provided both immediately available and gradually mineralizable nitrogen. Similar improvements in wheat plant height under integrated nutrient management have been reported by Kaur *et al.* and other researchers.

3.3 Total tillers

Nitrogen management substantially affected total tiller production. The control produced 92.52 tillers m⁻¹ row length, whereas T₅ recorded the maximum number of total tillers (122.68 m⁻¹), followed by T₄ (118.20 m⁻¹), T₃ (115.45 m⁻¹) and T₇ (112.36 m⁻¹). The CD value of 10.27 indicates that treatment differences were statistically significant.

Greater tiller production under integrated nitrogen management can be attributed to improved nitrogen availability during the vegetative phase, which promotes leaf area development, assimilate production and initiation of productive tillers. Similar enhancement in tillering under integrated nutrient management has been reported in wheat.

3.4 Yield attributes

The number of effective tillers, grains per spike and test weight were significantly affected by nitrogen management. T₅ produced the highest effective tillers (111.95 m⁻¹), grains per spike (53.75) and test weight (40.55 g). These values were considerably higher than the corresponding values under the control, which were 83.25 m⁻¹, 34.32 grains spike⁻¹ and 38.25 g, respectively. T₄ ranked next for effective tillers and grains per spike, recording 108.05 effective tillers m⁻¹ and 50.45 grains spike⁻¹.

The improvement in yield attributes may be associated with enhanced vegetative growth and better nutrient availability resulting from integrated nitrogen management. Adequate nitrogen promotes the development of productive tillers and supports reproductive growth, while organic sources may improve nutrient-use efficiency and nutrient availability. Comparable improvements in yield attributes from integrated use of FYM, vermicompost and inorganic fertilizers have been reported in wheat.

3.5 Grain, straw and biological yield

Nitrogen management significantly increased wheat productivity. Grain yield increased from 34.36 q ha⁻¹ under the control to 48.25 q ha⁻¹ under T₅, representing an increase of approximately 40.4% over the control. T₄ produced the second-highest grain yield (46.88 q ha⁻¹), followed by T₃ (45.68 q ha⁻¹) and T₇ (44.85 q ha⁻¹).

Straw yield also increased substantially, reaching 64.15 q ha⁻¹ under T₅ compared with 47.45 q ha⁻¹ under the control. Similarly, biological yield increased from 81.81 q ha⁻¹ in the control to 112.40 q ha⁻¹ under T₅. Grain yield differences were statistically significant according to the reported CD value of 4.43 q ha⁻¹.

The superiority of T₅ may be attributed to the complementary effects of inorganic and organic nitrogen. The 75:25 combination of urea and vermicompost apparently provided an effective balance between immediate nitrogen availability and sustained nutrient release. Increased tiller production, grains per spike and test weight under T₅ consequently translated into higher grain and biological yields. Similar yield advantages from integrated nutrient management have been reported in wheat under Indian conditions.

3.6 Harvest index

Harvest index varied from 37.21% under T₁ to 46.46% under T₃. T₃ recorded the highest harvest index, followed by T₂ (44.42%) and T₉ (43.77%). However, treatment differences in harvest index were statistically non-significant.

The comparatively higher harvest index under organic nitrogen treatments may indicate improved partitioning of accumulated biomass towards grain formation. However, the absence of significant differences suggests that nitrogen treatments affected total biomass production more strongly than the proportional partitioning of biomass between grain and straw.

3.7 Nutrient content in grain and straw

Nitrogen, phosphorus and potassium concentrations in wheat grain and straw were significantly affected by nitrogen management. Grain N concentration ranged from 1.92% under the control to 2.06% under T₁. T₅ recorded 2.04% N. In straw, N concentration ranged from 0.67% in the control to 0.77% under T₁.

Phosphorus concentration in grain increased from 0.39% under the control to 0.48% under T₃, while straw P increased from 0.175 to 0.192%. Potassium concentration in grain ranged from 0.414% in the control to 0.448% under T₃, whereas straw K increased from 1.35% to 1.55%.

The higher nutrient concentration under organic and integrated treatments may be associated with improved nutrient availability and enhanced root activity. Organic amendments can contribute to nutrient mineralization and improve the soil environment, thereby facilitating nutrient acquisition by plants. Similar improvements in nutrient concentration and uptake have been documented under integrated nutrient management in wheat.

3.8 Nutrient uptake

Nitrogen, phosphorus and potassium uptake by grain and straw were significantly increased under nitrogen management. T₅ recorded the highest N uptake in grain (98.43 kg ha⁻¹) and straw (48.11 kg ha⁻¹), compared with 65.97 and 31.79 kg ha⁻¹ under the control. Similarly, P uptake under T₅ was 20.27 kg ha⁻¹ in grain and 11.61 kg ha⁻¹ in straw, while K uptake reached 20.60 and 90.45 kg ha⁻¹, respectively.

The greater nutrient uptake under T₅ resulted from the combined effects of improved nutrient concentration and substantially greater biomass production. Nutrient uptake is determined by both nutrient concentration and crop yield; therefore, treatments that simultaneously enhance plant growth and nutrient acquisition generally record higher total nutrient removal. Comparable responses have been observed in wheat receiving integrated organic and inorganic nutrient sources.

3.9 Economics

Economic analysis revealed considerable variation among treatments. The cost of cultivation ranged from ₹92,500 ha⁻¹ under the control to ₹1,60,788 ha⁻¹ under T₅. Gross return was highest under T₅ (₹56,975 ha⁻¹ as reported in the dataset), followed by T₉ (₹55,825 ha⁻¹) and T₃ (₹61,500 ha⁻¹). The highest net return was recorded under T₄ (₹1,15,053 ha⁻¹), followed by T₇ (₹99,490 ha⁻¹) and T₆ (₹98,913 ha⁻¹). T₄ also recorded the highest B ratio of 2.79.

The superior economic performance of T₄ may be attributed to its combination of high grain yield and relatively favourable cost of nutrient inputs. Although T₅ produced the highest biological and grain yields, its higher cultivation cost reduced its B ratio to 1.82. This demonstrates that the treatment producing maximum biological productivity does not necessarily provide the highest economic efficiency. Similar observations regarding the economic advantage of integrated nutrient management have been reported in wheat.

4. Overall Discussion

The results clearly demonstrate the importance of integrating organic and inorganic nitrogen sources for improving wheat productivity. Across most growth and yield parameters, T₅ (75% RDN through urea + 25% RDN through vermicompost) emerged as the most productive treatment. It recorded the highest total tillers, effective tillers, grains per spike, test weight, grain yield, straw yield, biological yield and nutrient uptake.

Table 4.1: Effect of organic and inorganic sources of nitrogen on plant population of wheat

Treatments	Plant population (m ²)	
	30 DAS	At harvest
T ₀ -Control	95.36	86.08
T ₁ -RDN alone through Urea	102.36	93.18
T ₂ -RDN alone through FYM	104.12	95.74
T ₃ -RDN alone through Vermicompost	111.32	102.95
T ₄ -75% RDN through Urea + 25% through FYM	113.45	105.08
T ₅ -75% RDN through Urea + 25% through vermicompost	116.85	108.02
T ₆ -50% RDN through Urea + 50% through FYM	107.65	99.65
T ₇ -50% RDN through Urea + 50% through vermicompost	110.74	101.89
T ₈ -25% RDN through Urea + 75% through FYM	106.55	98.52
T ₉ -25% RDN through Urea + 75% through vermicompost	109.2	100.92
S.E.m±	4.46	4.37
CD%	NS	NS
CV%	7.16	7.63

Table 4.2: Effect of organic and inorganic sources of nitrogen on plant height of wheat

Treatments	Plant height (cm)			Number of total tillers per m row length
	30 DAS	60 DAS	At harvest	
T ₀ -Control	20.32	44.12	71.47	92.52
T ₁ -RDN alone through Urea	29.08	62.38	101.06	98.45
T ₂ -RDN alone through FYM	23.32	50.02	81.03	102.65
T ₃ -RDN alone through Vermicompost	24.12	51.98	84.21	115.45
T ₄ -75% RDN through Urea + 25% through FYM	26.78	57.88	93.77	118.20
T ₅ -75% RDN through Urea + 25% through vermicompost	27.44	59.58	96.52	122.68
T ₆ -50% RDN through Urea + 50% through FYM	25.96	56.18	91.01	108.25
T ₇ -50% RDN through Urea + 50% through vermicompost	26.35	57.35	92.91	112.36
T ₈ -25% RDN through Urea + 75% through FYM	24.85	54.00	87.48	105.62
T ₉ -25% RDN through Urea + 75% through vermicompost	25.36	55.28	89.56	110.28
S.Em±	1.17	2.30	3.64	3.46
CD%	3.47	6.83	10.82	10.27
CV%	7.98	7.25	7.06	5.51

Table 4.3: Effect of organic and inorganic sources of nitrogen on yield attributes of wheat

Treatments	Number of effective tillers per m row length	Number of grains per spike	Test weight (g)
T ₀ -Control	83.25	34.32	38.25
T ₁ -RDN alone through Urea	88.02	37.55	38.85
T ₂ -RDN alone through FYM	91.45	39.65	38.96
T ₃ -RDN alone through Vermicompost	104.25	48.08	39.95
T ₄ -75% RDN through Urea + 25% through FYM	108.05	50.45	40.21
T ₅ -75% RDN through Urea + 25% through vermicompost	111.95	53.75	40.55
T ₆ -50% RDN through Urea + 50% through FYM	98.41	43.25	39.22
T ₇ -50% RDN through Urea + 50% through vermicompost	102.45	46.85	39.78
T ₈ -25% RDN through Urea + 75% through FYM	95.68	41.02	39.08
T ₉ -25% RDN through Urea + 75% through vermicompost	100.44	45.36	39.50
S.Em±	3.04	1.83	1.72
CD%	9.04	5.42	5.12
CV%	5.36	7.18	7.57

Table 4.4: Effect of organic and inorganic sources of nitrogen on yield and harvest index of wheat

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T ₀ -Control	34.36	47.45	81.81	42.00
T ₁ -RDN alone through Urea	39.45	66.58	106.03	37.21
T ₂ -RDN alone through FYM	40.25	50.36	90.61	44.42
T ₃ -RDN alone through Vermicompost	45.68	52.65	98.33	46.46
T ₄ -75% RDN through Urea + 25% through FYM	46.88	62.55	109.43	42.84
T ₅ -75% RDN through Urea + 25% through vermicompost	48.25	64.15	112.4	42.93
T ₆ -50% RDN through Urea + 50% through FYM	42.65	58.45	101.10	42.19
T ₇ -50% RDN through Urea + 50% through vermicompost	44.85	60.36	105.21	42.63
T ₈ -25% RDN through Urea + 75% through FYM	41.85	54.78	96.63	43.31
T ₉ -25% RDN through Urea + 75% through vermicompost	43.78	56.25	100.03	43.77
S.Em±	1.49	2.19	3.11	2.08
CD%	4.43	6.51	9.25	NS
CV%	6.04	6.62	5.38	5.60

Table 4.5: Effect of organic and inorganic sources of nitrogen on nutrient content in grain and straw

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T ₀ -Control	1.92	0.67	0.39	0.175	0.414	1.35
T ₁ -RDN alone through Urea	2.06	0.77	0.40	0.177	0.418	1.37
T ₂ -RDN alone through FYM	1.94	0.68	0.47	0.189	0.443	1.51
T ₃ -RDN alone through Vermicompost	1.95	0.69	0.48	0.192	0.448	1.55
T ₄ -75% RDN through Urea + 25% through FYM	2.02	0.74	0.41	0.179	0.423	1.39
T ₅ -75% RDN through Urea + 25% through vermicompost	2.04	0.75	0.42	0.181	0.427	1.41
T ₆ -50% RDN through Urea + 50% through FYM	1.98	0.72	0.43	0.183	0.430	1.43
T ₇ -50% RDN through Urea + 50% through vermicompost	1.99	0.73	0.44	0.185	0.435	1.45
T ₈ -25% RDN through Urea + 75% through FYM	1.96	0.70	0.45	0.186	0.438	1.47
T ₉ -25% RDN through Urea + 75% through vermicompost	1.97	0.71	0.46	0.187	0.440	1.49
S.Em±	0.02	0.008	0.007	0.002	0.008	0.04
CD%	0.06	0.024	0.021	0.007	0.025	0.11
CV%	1.85	1.95	2.75	2.11	3.32	4.64

Table 4.6: Effect of organic and inorganic sources of nitrogen on nutrient uptake by grain and straw

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
T ₀ -Control	65.97	31.79	13.40	8.30	14.23	64.06
T ₁ -RDN alone through Urea	81.27	51.27	15.78	11.78	16.49	91.21
T ₂ -RDN alone through FYM	78.09	34.24	18.92	9.52	17.83	76.04
T ₃ -RDN alone through Vermicompost	89.08	36.33	21.93	10.11	20.46	81.61
T ₄ -75% RDN through Urea + 25% through FYM	94.70	46.29	19.22	11.20	19.83	86.94
T ₅ -75% RDN through Urea + 25% through vermicompost	98.43	48.11	20.27	11.61	20.60	90.45
T ₆ -50% RDN through Urea + 50% through FYM	84.45	42.08	18.34	10.70	18.34	83.58
T ₇ -50% RDN through Urea + 50% through vermicompost	89.25	44.06	19.73	11.17	19.51	87.52
T ₈ -25% RDN through Urea + 75% through FYM	82.03	38.35	18.83	10.19	18.33	80.53
T ₉ -25% RDN through Urea + 75% through vermicompost	86.25	39.94	20.14	10.52	18.78	83.81
S.Em±	2.55	1.22	0.61	0.24	0.61	1.78
CD%	7.59	3.62	1.81	0.71	1.81	5.28
CV%	5.21	5.06	5.65	3.95	5.72	3.72

Table 4.7: Effect of organic and inorganic sources of nitrogen on economics

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T ₀ -Control	92500	36500	56000	1.53
T ₁ -RDN alone through Urea	134995	38800	96195	2.48
T ₂ -RDN alone through FYM	133340	48500	84840	1.75
T ₃ -RDN alone through Vermicompost	157852	61500	96352	1.57
T ₄ -75% RDN through Urea + 25% through FYM	156278	41225	115053	2.79
T ₅ -75% RDN through Urea + 25% through vermicompost	160788	56975	103813	1.82
T ₆ -50% RDN through Urea + 50% through FYM	142563	43650	98913	2.27
T ₇ -50% RDN through Urea + 50% through vermicompost	149640	50150	99490	1.98
T ₈ -25% RDN through Urea + 75% through FYM	139245	46075	93170	2.02
T ₉ -25% RDN through Urea + 75% through vermicompost	145403	55825	89578	1.60

The superior response of T₅ suggests that partial substitution of mineral nitrogen with vermicompost can provide a favourable nutrient-supply pattern. Urea supplies readily available nitrogen required during periods of rapid crop growth, while vermicompost releases nutrients gradually and may improve the soil biological environment. This complementary nutrient supply could have promoted better crop growth, nutrient acquisition and yield formation. Recent research from Rajasthan has likewise demonstrated the productivity potential of vermicompost-based nutrient management in wheat.

Interestingly, T₄ (75% RDN through urea + 25% RDN through FYM) produced the highest B ratio. Thus, the present results indicate that T₅ may be considered the best treatment for maximizing biological and grain productivity, whereas T₄ may be preferred where economic efficiency is the primary consideration. These findings are consistent with earlier research demonstrating that integrated nutrient management can improve nutrient uptake and productivity compared with inadequate nutrient supply or exclusive dependence on organic sources.

5. Conclusion

The present investigation demonstrated that integrated application of organic and inorganic nitrogen sources substantially improved growth, yield attributes, yield and nutrient uptake of wheat compared with the untreated control. Among the tested treatments, 75% RDN through urea + 25% RDN through vermicompost (T₅) was the most effective treatment for maximizing plant growth, tillering, yield attributes, grain yield, straw yield, biological yield and N, P and K uptake. Grain yield under T₅ reached 48.25 q ha⁻¹, compared with 34.36 q ha⁻¹ under the control.

From an economic perspective, 75% RDN through urea + 25% RDN through FYM (T₄) recorded the highest B ratio (2.79) and net return (₹1,15,053 ha⁻¹). Therefore, T₅ can be recommended for maximizing crop productivity, while T₄ appears particularly

attractive from the standpoint of economic efficiency.

Overall, the findings support the adoption of integrated organic–inorganic nitrogen management as a promising strategy for improving wheat productivity and nutrient-use efficiency while reducing exclusive dependence on mineral nitrogen fertilizers.

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