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Effect of various fertilizer combinations on growth of timely sown wheat (*Triticum aestivum* L.)

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Abstract

An experiment entitled “Effect of Various Fertilizer Combinations on Productivity of Timely Sown Wheat (*Triticum aestivum* L.)” was conducted during the Rabi season of 2025 at the Agronomy Research Farm, Rama University, Kanpur (U.P.), using wheat variety DBW-187. The study aimed to evaluate the influence of integrated nutrient management practices on growth of wheat. The experiment was laid out in a Randomized Block Design with eleven treatments and three replications. Treatments included different combinations of recommended dose of fertilizers (RDF), vermicompost, farmyard manure (FYM), zinc sulphate, and sulphur. Wheat was sown on 23 November 2025 at a seed rate of 100 kg ha⁻¹ with 20 cm row spacing.

The results revealed that fertilizer combinations had no significant effect on initial plant population. However, growth parameters such as plant height, dry matter accumulation, tiller number, and leaf area index were significantly improved under integrated nutrient management.

The study concluded that the application of 75% RDF combined with 25% RDN through vermicompost along with ZnSO₄ @ 25 kg ha⁻¹ is an effective nutrient management strategy for enhancing productivity, profitability, and soil health in timely sown wheat.

Keywords: Nanourea, Conventional Urea, Growth, LAI, Yield and Wheat.

Introduction

Wheat (*Triticum aestivum* L.) belongs to the Poaceae family and is widely regarded as one of the most important staple food crops in the world, forming the backbone of food security in India. It is cultivated across diverse agro-climatic regions globally, with major producers including China, India, the United States, Russia, France, and Australia. As a principal cereal crop of the rabi season, wheat holds a crucial place in agricultural systems. Its wide adaptability, high productivity, and nutritional importance make it indispensable in ensuring food security for many countries. Owing to its extensive cultivation and economic significance, wheat is often referred to as the “king of cereals” and occupies a prominent position in the global grain economy.

In India, three major species of wheat are cultivated: *Triticum aestivum*, *Triticum durum*, and *Triticum dicoccum*. Among these, *Triticum aestivum* accounts for about 87% of the total wheat area and is predominantly grown in the north-western states. Owing to its higher gluten content, it is well suited for the preparation of bread, cakes, and biscuits, while medium-strength cultivars are preferred for chapati making. Wheat is a nutritionally rich cereal, containing relatively high levels of thiamine and niacin. Although about 10% of the total production is reserved for seed and industrial uses—such as the manufacture of starch, malt, dextrose, and gluten—the majority is consumed by humans. The wheat grain, with approximately 12% moisture content, provides a well-balanced composition of essential nutrients. It contains about 60–80% carbohydrates, primarily in the form of starch, along with 8–15% protein that supplies most essential amino acids, though it is limited in lysine, tryptophan, and methionine. Additionally, it includes 1.5–2% fats, important vitamins such as those in the B-complex group and vitamin E, and around 2.2% crude fibre. Wheat straw is also commonly used as fodder for cattle.

In India, wheat is cultivated over an area of about 31.83 million hectares, with a total production of 113.29 million tonnes and an average productivity of 3559 kg ha⁻¹ (DES, 2023–24). Uttar Pradesh holds the largest share, with approximately 9.53 million hectares under cultivation and a production of 35.34 million tonnes. Major wheat-growing states in the country include Uttar Pradesh, Punjab, and Haryana. Among these, Uttar Pradesh ranks first in both area (around 9.85 million hectares) and production (about 36.61 million tonnes). However, despite its leading position, the state's productivity, ranging from 2.7 to 3.7 tonnes ha⁻¹, remains lower than the national average. The global population is increasing by nearly 74 million people per year and is expected to grow by about 2.4 billion by 2050. Consequently, the demand for crop-derived calories is projected to nearly double between 2005 and 2050. To meet this rising demand, adequate plant nutrition is crucial for the proper growth and development of wheat. The crop responds strongly to nutrient application, making integrated nutrient management essential for sustaining soil fertility and improving productivity.

Nitrogen is one of the most critical nutrients for wheat production. The application of nitrogen fertilizers is an effective way to enhance grain yield, protein content, and overall (Ma *et al.*, 2019)^[2]. However, excessive nitrogen application does not contribute to further yield improvement once plant uptake capacity is exceeded. Instead, surplus nitrogen is lost from the soil through processes such as nitrate leaching and emissions of nitrous oxide, leading to environmental concerns.

Zinc is an essential micronutrient involved in a wide range of physiological functions. It serves as a key component of several enzymes responsible for nitrogen metabolism, energy transfer, and protein synthesis. Zinc deficiency can make plants more susceptible to stress conditions such as high light intensity, elevated temperatures, and fungal infections. Moreover, zinc plays an important role in regulating water uptake and transport within plants. Other micro nutrients, including manganese (Mn) and zinc (Zn), also influence protein synthesis by controlling peptidase activity and overall protein metabolism.

Integrated nutrient management (INM) involves the combined and judicious use of organic, inorganic, and biological sources of nutrients. Under this approach, the adverse effects of excessive chemical fertilizer use can be mitigated by incorporating bio-inputs such as *Rhizobium* culture, phosphorus-solubilizing bacteria (PSB), other biofertilizers, and vermicompost (Jamal *et al.*, 2023)^[3]. A field study evaluating the combined application of phosphorus fertilizer and farmyard manure (FYM) in calcareous soils under sub-humid conditions revealed that their integration improved soil organic matter content and residual phosphorus availability. This, in turn, significantly enhanced wheat yield and phosphorus use efficiency.

The application of organic inputs, either alone or in combination with inorganic fertilizers, has proven effective in sustaining soil fertility and meeting crop nutrient requirements. Organic matter, applied in various forms and stages of decomposition at rates of several tonnes per hectare, has been widely used to improve crop performance. However, wheat yields have shown stagnation in recent years, suggesting the need for integrated approaches. The combined use of organic manures and composts with chemical fertilizers offers a viable strategy to further enhance productivity. Vermicompost is considered an effective organic amendment for improving soil fertility. It is environmentally safe and does not harm the soil or crops; instead, it supplies both macro- and micronutrients that enhance plant growth. In addition, vermicompost positively influences soil physical and biological properties by increasing macropore space, thereby improving soil

aeration and water relations. It also helps regulate soil pH, microbial populations, and enzymatic activities (Reena *et al.*, 2017)^[4].

The combined application of farmyard manure (FYM), vermicompost, and chemical fertilizers has been shown to improve the overall physical, chemical, and biological properties of soil, resulting in higher crop productivity (Sharma *et al.*, 2016)^[5]. Additionally, FYM improves soil permeability and contributes significantly to maintaining long-term soil fertility (Babli *et al.*, 2017)^[6].

Sulphur application has been reported to significantly influence the leaf area index (LAI) of crops. As plants mature, LAI increases, with sulphur application up to 30 kg ha⁻¹ showing a marked improvement. Similarly, dry matter accumulation also increases with sulphur application up to this level, indicating that balanced nutrient availability from the early stages of growth leads to more vigorous plant development.

Materials and Methods

The field experiment was conducted during the Rabi season of 2025 at Agronomy Research farm of Rama University, Kanpur Uttar Pradesh. The soil of the experimental field was sandy clay loam in texture, neutral in reaction (pH 7.2), which is common in the district's alluvial soils. The soil was low in available nitrogen (247.60 kg ha⁻¹) as determined by the alkaline permanganate method (Subbiah and Asija, 1956). The available phosphorus content was medium (14.6 kg ha⁻¹), estimated by Olsen's method (Olsen *et al.*, 1954). The soil was found medium to moderately high in available potassium (294.40 kg ha⁻¹), determined through the flame photometric method (Metson, 1956) at 0–15 cm soil depth prior to the initiation of the experiment. These fertility levels are generally representative of the Indo-Gangetic alluvial soils of the district.

The experiment was laid out in a Randomized block design (RBD) with three replications with eleven treatments T1-Control, T2-100% RDF (120:60:40) NPK ha⁻¹, T3- 100% RDF + ZnSO₄ @ 25 kg ha⁻¹, T4-100% RDF + Sulphur @ 35 kg ha⁻¹, T5-100% RDF + ZnSO₄ @ 25 kg ha⁻¹ + Sulphur @ 35 Kg ha⁻¹, T6-75% RDF + 25% RDN through Vermicompost, T7-75% RDF + 25% RDN through FYM, T8-75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹, T9-75% RDF + 25% RDN through FYM + ZnSO₄ @ 25 kg ha⁻¹, T10-75% RDF + 25%RDN through Vermicompost + Sulphur @ 35 kg ha⁻¹, T11-75% RDF + 25% RDN through FYM + Sulphur @ 35 kg ha⁻¹. Variety DBW-187.

Result and Discussion

A. Growth Parameter

1. Initial plant population (m⁻²)

The data on initial plant population (m²), recorded at 20 days after sowing (DAS), were statistically analysed and are presented in Table 1. The results indicated that the initial plant population was not significantly affected by the different fertilizer combinations. However, the highest plant population (184.75 plants m⁻²) was recorded with the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹, whereas the lowest plant population (168.75 plants m⁻²) was observed in the control treatment. The non-significant variation in plant population among treatments may be attributed to the uniform seed rate maintained across all treatments. Similar observations regarding enhanced plant population due to integrated nutrient management practices were also reported by Singh *et al.* (2016)^[7], Parewa *et al.* (2018)^[8].

2. Plant height (cm)

Data pertaining to plant height as influenced by different treatments are presented in Table 2. In general, plant height increased progressively with advancing crop growth stages across all treatments, attaining its maximum value at maturity. The most pronounced increase in plant height was observed during the period between 30 and 90 days after sowing (DAS).

At 30 days after sowing (DAS), the data presented in Table 2 revealed that plant height was significantly influenced by the different fertilizer combinations. The tallest plants (27.75 cm) were recorded under the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹, which was statistically at par with the treatment receiving 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹, and significantly superior to the remaining treatments. The shortest plants (20.53 cm) were observed in the control treatment.

Similarly, at 60 DAS, 90 DAS, and at harvest, the maximum plant heights of 75.25 cm, 99.15 cm, and 99.84 cm, respectively, were recorded under the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹. This treatment remained statistically at par with 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹ and proved significantly superior to the other treatments throughout the crop growth period. Similar observations regarding enhanced plant height due to integrated nutrient management practices were also reported by Singh *et al.* (2016) [7], Kumar *et al.* (2017) [9], Patyal *et al.* (2018).

3. Number of tillers (m⁻²)

The data on the number of tillers m⁻², presented in Table 3, clearly indicate that different fertilizer combinations significantly influenced tiller production at all growth stages of the wheat crop. The maximum number of tillers was recorded with the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹, producing 223.66 tillers m⁻² at 30 DAS, 382.01 at 60 DAS, 389.34 at 90 DAS, and 380.17 at harvest.

This treatment was statistically at par with 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹, and significantly superior to the remaining treatments.

The number of tillers increased rapidly up to 60 DAS, after which the rate of increase slowed, although tiller production continued up to 90 DAS and remained comparatively stable until harvest. Similar results were also reported by Laghari *et al.* (2010), Fazily

et al. (2021), and Choudhary *et al.* (2022) [10].

4. Dry matter accumulation (g m⁻²)

Similar to the growth parameters, dry matter accumulation increased progressively with each successive growth stage of the wheat crop, with the highest accumulation recorded at harvest.

The most rapid increase in dry matter accumulation occurred between 30 and 60 DAS, followed by 60 to 90 DAS, and subsequently from 90 DAS to harvest. Dry matter accumulation at different growth stages was significantly influenced by the various fertilizer combinations. These findings are presented in Table 4.

The maximum dry matter accumulation was recorded with the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹, registering 89.00 g m⁻² at 30 DAS, 609.65 g m⁻² at 60 DAS, 951.91 g m⁻² at 90 DAS, and 1179.48 g m⁻² at harvest. This treatment was statistically at par with 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹, and significantly superior to the remaining treatments. Similar findings were also reported by Singh *et al.* (2016) [7], Maurya *et al.* (2019) [11, 2], Patel *et al.* (2017) [12].

5. Leaf area index (LAI)

As per the data presented in Table 5 the leaf area index (LAI) of the wheat crop increased progressively up to 60 DAS. The LAI was significantly influenced by the different fertilizer combinations applied at various growth stages of the crop.

At 30 and 60 DAS, the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹ recorded the maximum leaf area index values of 1.59 and 5.09, respectively. This treatment was statistically at par with 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹, and significantly superior to the other treatments.

At 90 DAS, the leaf area index was also significantly affected by the various fertilizer combinations. The maximum LAI (5.22) was observed under the application of 75% RDF + 25% RDN through vermicompost + ZnSO₄ @ 25 kg ha⁻¹. This treatment was statistically comparable with 75% RDF + 25% RDN through vermicompost + sulphur @ 35 kg ha⁻¹, and significantly higher than the remaining treatments. Similar findings were also reported by Kumar and Niwas (2022) [13] and Kumawat *et al.* (2021) [14].

Table 1: Initial plant population (m⁻²) at 20 DAS of wheat crop as influenced by effect of various fertilizer combinations

Treatments		Plant population (m ⁻²)
T ₁	Control	168.75
T ₂	100% RDF (120:60:40) NPK ha ⁻¹	170.58
T ₃	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹	175.14
T ₄	100% RDF + Sulphur @ 35 kg ha ⁻¹	172.54
T ₅	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹ + Sulphur @ 35 kg ha ⁻¹	181.67
T ₆	75% RDF + 25% RDN through Vermicompost	173.85
T ₇	75% RDF + 25% RDN through FYM	171.57
T ₈	75% RDF + 25% RDN through Vermicompost + ZnSO ₄ @ 25 kg ha ⁻¹	184.75
T ₉	75% RDF + 25% RDN through FYM + ZnSO ₄ @ 25 kg ha ⁻¹	178.64
T ₁₀	75% RDF + 25% RDN through Vermicompost + Sulphur @ 35 kg ha ⁻¹	182.47
T ₁₁	75% RDF + 25% RDN through FYM + Sulphur @ 35 kg ha ⁻¹	176.84
SEm (±)		7.77
CD at 5 %		NS

Table 2: Plant height (cm) at successive growth stages of wheat crop as influenced by effect of various fertilizer combinations

Treatments		Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T ₁	Control	20.53	52.09	66.92	67.05
T ₂	100% RDF (120:60:40) NPK ha ⁻¹	21.08	56.80	71.79	73.42
T ₃	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹	23.39	62.04	82.06	83.58
T ₄	100% RDF + Sulphur @ 35 kg ha ⁻¹	22.42	58.23	76.77	78.59
T ₅	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹ + Sulphur @ 35 kg ha ⁻¹	23.69	65.45	86.57	87.52
T ₆	75% RDF + 25% RDN through Vermicompost	22.77	61.07	78.79	80.91
T ₇	75% RDF + 25% RDN through FYM	22.15	57.84	75.33	76.73
T ₈	75% RDF + 25% RDN through Vermicompost + ZnSO ₄ @ 25 kg ha ⁻¹	27.25	75.25	99.15	99.84
T ₉	75% RDF + 25% RDN through FYM + ZnSO ₄ @ 25 kg ha ⁻¹	23.65	64.36	85.68	86.66
T ₁₀	75% RDF + 25% RDN through Vermicompost + Sulphur @ 35 kg ha ⁻¹	25.70	72.47	95.58	97.61
T ₁₁	75% RDF + 25% RDN through FYM + Sulphur @ 35 kg ha ⁻¹	23.60	63.62	85.10	85.83
SEm (±)		1.18	3.20	3.78	3.93
CD at 5 %		3.50	9.51	11.25	11.69

Table 3: Number of tiller (m⁻²) at successive growth stages of wheat crop as influenced by effect of various fertilizer combinations

Treatments		Number of tiller (m ⁻²)			
		30 DAS	60 DAS	90 DAS	At harvest
T ₁	Control	172.01	264.33	276.33	265.17
T ₂	100% RDF (120:60:40) NPK ha ⁻¹	178.18	306.67	318.00	310.54
T ₃	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹	189.84	323.67	332.67	322.47
T ₄	100% RDF + Sulphur @ 35 kg ha ⁻¹	182.68	312.33	329.00	315.74
T ₅	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹ + Sulphur @ 35 kg ha ⁻¹	194.24	336.52	340.87	331.00
T ₆	75% RDF + 25% RDN through Vermicompost	185.87	318.67	328.33	320.15
T ₇	75% RDF + 25% RDN through FYM	180.51	309.33	320.33	312.13
T ₈	75% RDF + 25% RDN through Vermicompost + ZnSO ₄ @ 25 kg ha ⁻¹	223.66	382.01	389.34	379.17
T ₉	75% RDF + 25% RDN through FYM + ZnSO ₄ @ 25 kg ha ⁻¹	193.17	332.33	339.33	329.39
T ₁₀	75% RDF + 25% RDN through Vermicompost + Sulphur @ 35 kg ha ⁻¹	214.33	364.34	374.84	362.09
T ₁₁	75% RDF + 25% RDN through FYM + Sulphur @ 35 kg ha ⁻¹	192.50	327.33	335.33	325.87
SEm (±)		1.18	9.79	15.30	15.68
CD at 5 %		3.50	29.10	45.454	46.59

Table 4: Dry matter accumulation (g m⁻²) at successive growth stages of wheat crop as influenced by effect of various fertilizer combinations

Treatments		Dry matter accumulation (g m ⁻²)			
		30 DAS	60 DAS	90 DAS	At harvest
T ₁	Control	71.97	394.38	589.37	714.39
T ₂	100% RDF (120:60:40) NPK ha ⁻¹	74.52	497.47	793.49	909.28
T ₃	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹	79.21	530.26	845.32	1034.25
T ₄	100% RDF + Sulphur @ 35 kg ha ⁻¹	77.26	514.44	813.28	978.99
T ₅	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹ + Sulphur @ 35 kg ha ⁻¹	81.97	554.64	854.24	1066.49
T ₆	75% RDF + 25% RDN through Vermicompost	78.85	519.74	838.72	1029.29
T ₇	75% RDF + 25% RDN through FYM	76.58	501.29	805.3	949.28
T ₈	75% RDF + 25% RDN through Vermicompost + ZnSO ₄ @ 25 kg ha ⁻¹	89.80	609.65	951.91	1179.48
T ₉	75% RDF + 25% RDN through FYM + ZnSO ₄ @ 25 kg ha ⁻¹	80.96	544.15	852.29	1052.39
T ₁₀	75% RDF + 25% RDN through Vermicompost + Sulphur @ 35 kg ha ⁻¹	86.91	597.34	939.25	1129.29
T ₁₁	75% RDF + 25% RDN through FYM +Sulphur @ 35 kg ha ⁻¹	79.91	537.25	845.78	1046.48
SEm (±)		1.18	2.54	18.28	28.79
CD at 5 %		3.50	7.55	54.32	85.53

Table 5: Leaf area index (LAI) at successive growth stages of wheat crop as influenced by effect of various fertilizer combinations

Treatments		30DAS	60DAS	90DAS
		Leaf area index (LAI)		
T ₁	Control	1.32	3.67	3.67
T ₂	100% RDF (120:60:40) NPK ha ⁻¹	1.36	4.04	4.09
T ₃	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹	1.44	4.39	4.48
T ₄	100% RDF + Sulphur @ 35 kg ha ⁻¹	1.41	4.34	4.41
T ₅	100% RDF + ZnSO ₄ @ 25 kg ha ⁻¹ + Sulphur @ 35 kg ha ⁻¹	1.46	4.60	4.73
T ₆	75% RDF + 25% RDN through Vermicompost	1.43	4.36	4.45
T ₇	75% RDF + 25% RDN through FYM	1.38	4.28	4.35
T ₈	75% RDF + 25% RDN through Vermicompost + ZnSO ₄ @ 25 kg ha ⁻¹	1.59	5.09	5.22
T ₉	75% RDF + 25% RDN through FYM + ZnSO ₄ @ 25 kg ha ⁻¹	1.45	4.57	4.68
T ₁₀	75% RDF + 25% RDN through Vermicompost + Sulphur @ 35 kg ha ⁻¹	1.53	4.98	5.05
T ₁₁	75% RDF + 25% RDN through FYM + Sulphur @ 35 kg ha ⁻¹	1.44	4.43	4.56
SEm (±)		1.18	0.04	0.16
CD at 5 %		3.50	0.13	0.47

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