

Effect of Integrated Nitrogen Management on Growth and Yield of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during Rabi 2024–25 at Vivekananda Global University, Jaipur, to assess the impact of integrated nitrogen management on growth, yield attributes, yield, and economics of Wheat (*Triticum aestivum* L.). The experiment included nine treatments: T1 - NPK (120:40:40 kg/ha), T2 - FYM @ 10 t/ha + PSB + Azotobacter, T3 - VC @ 5 t/ha + PSB + Azotobacter, T4 - NPK + Gypsum @ 140 kg/ha, T5 - FYM + PSB + Azotobacter + Gypsum @ 140 kg/ha, T6 - VC + PSB + Azotobacter + Gypsum @ 140 kg/ha, T7 - NPK + Gypsum @ 280 kg/ha, T8 - FYM + PSB + Azotobacter + Gypsum @ 280 kg/ha, T9 - VC + PSB + Azotobacter + Gypsum @ 280 kg/ha. Among all treatments, T7 recorded maximum plant height (101.71 cm), dry matter accumulation (1238.0 g/m²), grain yield (4234 kg/ha), biological yield (10713 kg/ha), and net returns (Rs.82,174/ha) with a B:C ratio of 3.35. The results indicate that combining recommended NPK with 280 kg/ha gypsum significantly enhanced wheat productivity and profitability over organic treatments alone.

Keywords: Vermicompost; FYM; Biofertilizers; Gypsum; NPK; Growth traits; Yield attributes; Economics

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important staple crops in India. Despite favourable agro-climatic conditions, productivity remains suboptimal due to imbalanced nutrient application and low soil fertility [1]. Nitrogen, the most limiting nutrient in wheat production, plays a critical role in vegetative growth and yield formation [2]. However, excessive reliance on chemical fertilizers leads to degradation of soil health. Integrated nitrogen management (INM), which combines inorganic fertilizers with organic manures and biofertilizers, offers a sustainable approach for improving soil fertility and crop productivity [3–5].

Organic amendments such as farmyard manure (FYM) and vermicompost (VC) not only supply essential nutrients but also improve microbial activity and soil structure [6, 7]. Biofertilizers like *Azotobacter* and phosphate-solubilizing bacteria (PSB) enhance nutrient availability and uptake [8, 9]. Gypsum, as a calcium and sulphur source, improves nutrient translocation and root development [10]. Previous studies have reported the positive impact of such integrated approaches on yield [11–13]. However, limited research exists on the combined effect of NPK, gypsum, FYM, VC, and biofertilizers on under semi-arid Rajasthan conditions.

The present study was undertaken to evaluate the effect of integrated nitrogen management on growth, yield attributes, yield, and economics of wheat.

Materials and Methods

Experimental site and design

The experiment was conducted during the Rabi season of 2024–25 at the Agronomy Farm, Vivekananda Global University, Jaipur (26.85°N, 75.81°E). The soil was sandy loam, low in nitrogen, medium in phosphorus, and potassium, with a pH of 7.6. The experiment was laid out in a randomized block design (RBD) with three replications and nine treatments.

Treatments

- T1 – NPK (120:40:40 kg/ha)
- T2 – FYM @ 10 t/ha + PSB + Azotobacter

- T3 – VC @ 5 t/ha + PSB + Azotobacter
- T4 – NPK + Gypsum @ 140 kg/ha
- T5 – FYM + PSB + Azotobacter + Gypsum @ 140 kg/ha
- T6 – VC + PSB + Azotobacter + Gypsum @ 140 kg/ha
- T7 – NPK + Gypsum @ 280 kg/ha
- T8 – FYM + PSB + Azotobacter + Gypsum @ 280 kg/ha
- T9 – VC + PSB + Azotobacter + Gypsum @ 280 kg/ha

Agronomic practices

The wheat variety ‘Raj 4238’ was sown at 20 cm row spacing with a seed rate of 100 kg/ha. NPK was applied through urea, DAP, and MOP. Organic manures were applied 15 days before sowing. Biofertilizers were seed-treated as per standard protocols. All cultural practices were followed uniformly. Seed Treatment: Mix 5–10 g each of PSB and Azotobacter per kg of seeds using a sticky agent like gur (jaggery) solution or carboxymethyl cellulose (CMC). Soil Application: Apply 2–5 kg/ha each of PSB and Azotobacter along with 50–100 kg of well-decomposed FYM/compost at the time of sowing.

Observations and statistical analysis

Growth parameters (plant height, dry matter accumulation) were recorded at 30, 60, 90 DAS and at harvest. Yield attributes such as number of effective tillers/m², grains/spike, spike length, and test weight were recorded at maturity. Yield and harvest index were computed. Economics were calculated using prevailing market prices. Data were analyzed using ANOVA at a 5% level of significance.

Results and Discussion

Growth parameters

The application of NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha (T₇) produced significantly highest plant height and dry matter accumulation at 60, 90 DAS and at harvest of wheat. Maximum plant height (101.71 cm) and dry matter accumulation (1238 g/m²) at harvest were recorded under T₇ (NPK + 280 kg/ha gypsum), significantly superior to all other treatments (**Table 1**). This may be due to balanced nutrient supply and gypsum-induced calcium and sulfur availability enhancing root development and photosynthesis [4, 10]. T₁, T₄, and T₆ also recorded comparable growth, indicating that NPK along with organic and gypsum sources improved vegetative traits. Lower values under T₂ (FYM alone) and T₃ (VC alone) highlight the insufficiency of organic nutrients in meeting peak crop demand [6, 12].

Table 1 Effect of integrated nitrogen management on growth traits of wheat

Treatment	Plant height (cm)				Dry matter accumulation (g/m ²)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
N:P:K (120:40:40 kg/ha)	14.53	49.02	85.01	97.28	140.9	394.0	876.2	1184.0
FYM @ 10 t/ha + PSB + Azotobacter	14.21	39.23	67.55	78.81	137.9	313.3	715.3	981.3
VC @ 5 t/ha + PSB + <i>Azotobacter</i>	14.40	40.98	69.88	81.44	139.3	324.0	737.3	998.0
N:P:K (120:40:40 kg/ha) + Gypsum @ 140 kg/ha	14.70	51.89	87.10	100.75	142.0	412.3	902.0	1219.0
FYM @ 10 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 140 kg/ha	14.83	41.84	71.23	83.35	144.2	337.7	751.0	1019.0
VC @ 5 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 140 kg/ha	13.51	49.89	85.88	98.32	130.9	399.3	883.9	1196.0
NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha	13.68	52.64	88.91	101.71	133.0	417.0	923.0	1238.0
FYM @ 10 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 280 kg/ha	13.84	48.78	83.78	96.48	135.1	388.0	868.0	1172.0
VC @ 5 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 280 kg/ha	14.01	50.34	86.34	99.35	136.4	405.0	892.0	1211.8
SEm±	0.66	1.98	3.78	3.89	6.7	15.1	33.4	47.0
C.D. @5%	NS	5.94	11.33	11.68	NS	45.3	100.1	141.0

Yield attributes and yield

Application of NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha (T₇) gave highest number of effective tillers, spike length, number of grains/spike, grain yield, straw yield and biological yield of wheat. (Table 2, Figure 1). The T₇-NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha produced the highest number of effective tillers (365/m²), grains/spike (34.00), and spike length (8.34 cm), leading to maximum grain yield of 4234 kg/ha (Table 2). This reflects the synergistic effect of balanced nutrition, enhanced metabolic activity, and improved sink strength due to gypsum [10, 13]. The harvest index remained statistically unaffected across treatments.

Table 2 Effect of integrated nitrogen management on yield attributes and yields of wheat

Yield attributes								
Treatments	Number of effective tillers/m	Number of grains/spike	Spike length (cm)	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
N:P:K (120:40:40 kg/ha)	342.0	32.24	7.91	38.28	4003	6138	10141	39.5
FYM @ 10 t/ha + PSB + <i>Azotobacter</i>	272.0	25.73	6.38	37.52	3123	4892	8015	39.0
VC @ 5 t/ha + PSB + <i>Azotobacter</i>	286.0	26.56	6.42	37.81	3278	5049	8327	39.4
N:P:K (120:40:40 kg/ha) + Gypsum @ 140 kg/ha	358.0	33.76	8.22	38.58	4178	6391	10569	39.5
FYM @ 10 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 140 kg/ha	292.0	27.12	6.58	38.86	3345	5167	8512	39.4
VC @ 5 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 140 kg/ha	347.0	32.88	7.99	35.78	4067	6184	10251	39.7
NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha	365.0	34.00	8.34	35.93	4234	6479	10713	39.5
FYM @ 10 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 280 kg/ha	338.0	31.89	7.81	36.76	3988	6056	10044	39.7
VC @ 5 t/ha + PSB + <i>Azotobacter</i> + Gypsum @ 280 kg/ha	354.0	33.12	8.07		4123	6322	10445	39.5
SEm±	14.9	1.36	0.33		170	275	439	0.4
CD (P = 0.05)	44.6	4.07	1.00		510	824	1317	NS

The magnitude of increase in grain yield of wheat due to the application of NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha (T₇) was 35.6, 29.2 and 36.6 per cent in comparison to application of FYM @ 10 t/ha + PSB + *Azotobacter* (T₂), vermicompost @ 5 t/ha + PSB + *Azotobacter* (T₃) and FYM @ 10 t/ha + PSB + *Azotobacter* + Gypsum @ 140 kg/ha (T₅), respectively. Among different treatment combinations, application of NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha (T₇), closely followed by application of NPK (120:40:40 kg/ha) (T₁), NPK (120:40:40 kg/ha) + Gypsum @ 140 kg/ha (T₄), VC @ 5 t/ha + PSB + *Azotobacter* + Gypsum @ 140 kg/ha (T₆), FYM @ 10 t/ha + PSB + *Azotobacter* + Gypsum @ 280 kg/ha (T₈) and VC @ 5 t/ha + PSB + *Azotobacter* + Gypsum @ 280 kg/ha (T₉) Yield under T₄ (NPK + 140 kg/ha gypsum) and T₆ (VC + biofertilizers + 140 kg/ha gypsum) was also high, indicating the effectiveness of integrating gypsum with both organic and inorganic sources. Treatments T₂ and T₃ recorded the lowest yield, emphasizing the need for supplemental nutrient inputs [5, 7].

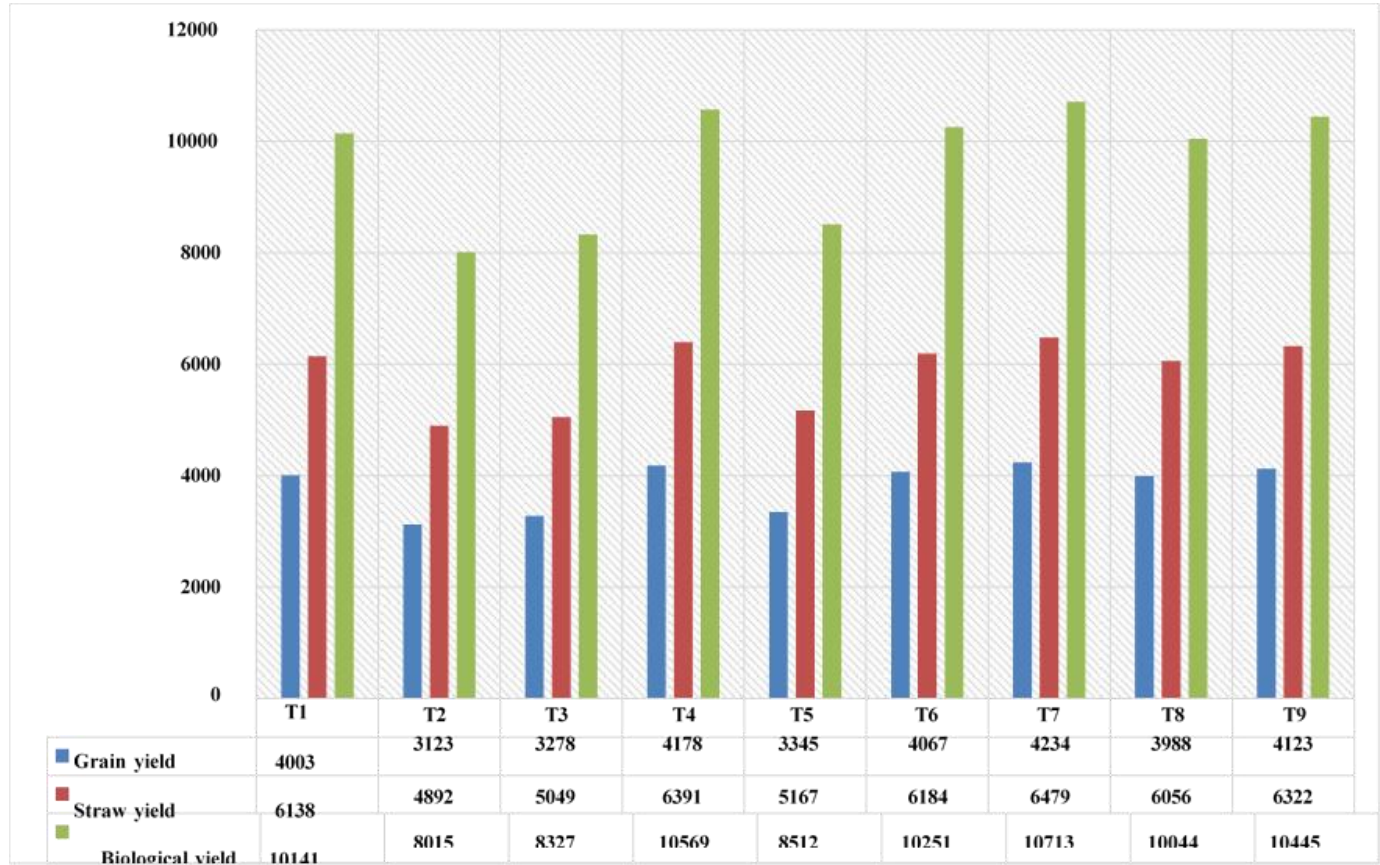


Figure 1 Effect of integrated nitrogen management on yields of wheat

Economics

T7 recorded the highest net returns (Rs. 82,174/ha) and B:C ratio (3.35) followed by T4 and T6 (Table 3). Despite higher cultivation cost, these treatments outperformed others due to superior yield. Sole organic treatments showed lower profitability. Thus, combining NPK with gypsum is economically viable and sustainable [5, 14].

Table 3 Effect of integrated nutrient management on economics of wheat

Treatments	Economics			
	Total cost of cultivation(₹/ha-)	Gross returns(₹/ha)	Net returns(₹/ha)	B: C ratio
N:P:K (120:40:40 kg/ha)	34621	110750	76129	3.20
FYM @ 10 t/ha + PSB + Azotobacter	33060	86920	53860	2.63
VC @ 5 t/ha + PSB + Azotobacter	34840	90805	55965	2.61
N:P:K (120:40:40 kg/ha) + Gypsum @ 140 kg/ha	34761	115515	80754	3.32
FYM @ 10 t/ha + PSB + Azotobacter + Gypsum @ 140 kg/ha	33340	92735	59395	2.78
VC @ 5 t/ha + PSB + Azotobacter + Gypsum @ 140 kg/ha	34700	112260	77560	3.24
NPK (120:40:40 kg/ha) + Gypsum @ 280 kg/ha	34901	117075	82174	3.35
FYM @ 10 t/ha + PSB + Azotobacter + Gypsum @ 280 kg/ha	33340	110040	76700	3.30
VC @ 5 t/ha + PSB + Azotobacter + Gypsum @ 280 kg/ha	34840	114070	79230	3.27
SEm+	--	--	4724	0.14
CD (P = 0.05)	--	--	14162	0.41

Conclusion

The study clearly demonstrates that integrated nitrogen management significantly influences growth, yield, and profitability of wheat. Among all treatments, application of NPK (120:40:40 kg/ha) + gypsum @ 280 kg/ha (T7) was most effective in enhancing growth parameters, yield attributes, and grain yield. It also offered the highest net returns and B:C ratio, confirming its economic superiority. Thus, integrating gypsum with recommended fertilization practices can be adopted as a viable strategy for sustainable wheat production under semi-arid conditions.

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