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Influenced of different levels of nitrogen on yield and economics of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during the *rabi* season of 2024-25 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh, to evaluate the effect of graded nitrogen levels on yield and economics of wheat. The experiment was laid out in a randomized block design with ten treatments and three replications. The nitrogen treatments comprised control (0 kg N ha⁻¹), 40, 60, 80, 100, 120, 140, 160, 180 and 200 kg N ha⁻¹. The crop responded positively to nitrogen application up to 120 kg N ha⁻¹, after which further increase in nitrogen dose did not produce a proportional gain in yield or profitability. The application of 120 kg N ha⁻¹ recorded the highest test weight (43.2 g), grain yield (54.8 q ha⁻¹), straw yield (72.6 q ha⁻¹), biological yield (127.4 q ha⁻¹) and harvest index (43.01%). The same treatment also resulted in maximum gross return (₹1,20,560 ha⁻¹), net return (₹70,920 ha⁻¹) and benefit-cost ratio (2.43). The results indicated that 120 kg N ha⁻¹ was the most productive and economically efficient nitrogen level for wheat under the semi-arid conditions of Gwalior.

Keywords: Benefit-cost ratio, economics, grain yield, nitrogen, wheat

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of India and forms a major component of national food and nutritional security. The grain is widely consumed in the form of flour, chapati, bread, suji and other processed products, and it contributes dietary energy, protein, minerals and B-complex vitamins to the human diet (Shewry and Hey, 2015) [14]. In India, wheat continues to occupy a key place after rice, and improvement in its productivity is therefore essential for sustaining food supply and farm income.

Among the agronomic factors affecting wheat productivity, nitrogen management is one of the most critical because wheat is highly responsive to nitrogen under irrigated conditions. Nitrogen is a major constituent of chlorophyll, amino acids, proteins, enzymes and nucleic acids; therefore, it directly influences photosynthesis, tiller production, biomass accumulation and grain formation. Deficient nitrogen supply restricts vegetative growth and sink development, whereas excessive nitrogen increases input cost and may reduce nutrient-use efficiency (NFSM, 2016; Kumar *et al.*, 2024) [10, 8].

Several studies have shown that grain yield and profitability of wheat increase with nitrogen application up to an optimum level, beyond which further addition of nitrogen produces marginal or statistically non-significant gains. Rathore *et al.* (2015) [12], Jat *et al.* (2017) [5], Saini *et al.* (2019) [13] and Choudhary *et al.* (2023) [3] reported that balanced nitrogen application improved effective tillering, grain filling, test weight and economic returns in wheat. However, the economic optimum dose may vary with soil fertility, variety, climate and local cost-price conditions.

The semi-arid conditions of Gwalior require location-specific nutrient recommendations because many farmers either apply nitrogen below the recommended dose due to cost constraints or apply higher doses without proportional yield advantage. Therefore, the present study was undertaken to assess the effect of different nitrogen levels on yield and economics of wheat and to identify the most profitable nitrogen dose under the agro-climatic conditions of Gwalior, Madhya Pradesh.

Materials and Methods

The field experiment was conducted during *rabi* 2024-25 at the Agriculture Research and Development Centre, Sakatpura, Vikrant University, Gwalior, Madhya Pradesh. The experimental site falls under the semi-arid agro-climatic region of central India, characterized by hot summers and cool winters. The soil of the experimental field was sandy loam in texture, alluvial in origin, light brown in colour and well drained. The initial soil status showed pH 7.5, electrical conductivity 0.33 dS m⁻¹, organic carbon 0.45%, available nitrogen 184 kg ha⁻¹, available phosphorus 16.7 kg ha⁻¹ and available potassium 347 kg ha⁻¹.

The experiment was laid out in a randomized block design with ten nitrogen treatments and three replications. The treatments were: T₁ - control (0 kg N ha⁻¹), T₂ - 40 kg N ha⁻¹, T₃ - 60 kg N ha⁻¹, T₄ - 80 kg N ha⁻¹, T₅ - 100 kg N ha⁻¹, T₆ - 120 kg N ha⁻¹, T₇ - 140 kg N ha⁻¹, T₈ - 160 kg N ha⁻¹, T₉ - 180 kg N ha⁻¹ and T₁₀ - 200 kg N ha⁻¹. The gross and net plot sizes were 4.0 m × 3.6 m and 3.4 m × 3.0 m, respectively. Wheat was sown by line sowing at a spacing of 22.5 cm × 10 cm using a seed rate of 100-125 kg ha⁻¹. Phosphorus and potassium were applied uniformly as per the crop requirement, while nitrogen was applied according to treatment schedule.

The crop was raised with recommended agronomic practices and irrigated at critical growth stages as per requirement. At maturity, grain and straw yields were recorded from the net plot area and converted into q ha⁻¹. Biological yield was calculated as the sum of grain and straw yield, and harvest index was computed as the ratio of grain yield to biological yield expressed in percentage. Gross return, net return and benefit-cost ratio were calculated using treatment-wise cost of cultivation and prevailing wheat price. The data were statistically analysed as per the procedure for randomized block design, and treatment means were compared using critical difference at 5% probability wherever the F-test was significant.

Results and Discussion

Yield attributes and yield

Nitrogen levels exerted a marked influence on test weight and yield of wheat (Table 1). Test weight increased from 36.4 g under control to 43.2 g under 120 kg N ha⁻¹. The improvement in test weight may be ascribed to better photosynthetic activity and efficient translocation of assimilates towards the developing grains under adequate nitrogen supply. Higher nitrogen levels above 120 kg N ha⁻¹ did not produce meaningful improvement, indicating that grain filling was optimized at the recommended dose.

Grain yield increased consistently with nitrogen application up to 120 kg N ha⁻¹. The maximum grain yield of 54.8 q ha⁻¹ was recorded under 120 kg N ha⁻¹, which was statistically at par with 140 kg N ha⁻¹ (54.6 q ha⁻¹), 160 kg N ha⁻¹ (54.2 q ha⁻¹), 180 kg N ha⁻¹ (53.8 q ha⁻¹) and 200 kg N ha⁻¹ (53.1 q ha⁻¹). The control treatment produced the lowest grain yield (31.4 q ha⁻¹). Thus, the application of 120 kg N ha⁻¹ increased grain yield by 74.5% over the control. This response may be due to greater tiller formation, improved spike development, better grain filling and higher dry-matter production under adequate nitrogen supply.

Straw yield and biological yield followed a similar trend. The highest straw yield (72.6 q ha⁻¹) and biological yield (127.4 q ha⁻¹) were obtained with 120 kg N ha⁻¹, representing increases of 57.1% and 64.2% over the control, respectively. Harvest index was also highest under 120 kg N ha⁻¹ (43.01%), suggesting better partitioning of assimilates towards grain. The present findings are in close agreement with Rathore *et al.* (2015)^[12], Chauhan *et al.* (2016)^[2], Jat *et al.* (2017)^[5], Saini *et al.* (2019)^[13], Pandey *et al.* (2020)^[11] and Choudhary *et al.* (2023)^[3], who reported that wheat yield increased with nitrogen up to the optimum level and higher doses generally remained at par because of diminishing response.

Table 1: Effect of different levels of nitrogen on test weight and yield of wheat

Treatment	Test weight (g)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁ - Control (0 kg N ha ⁻¹)	36.4	31.4	46.2	77.6	40.47
T ₂ - 40 kg N ha ⁻¹	37.8	36.8	52.1	88.9	41.40
T ₃ - 60 kg N ha ⁻¹	39.1	41.5	57.8	99.3	41.79
T ₄ - 80 kg N ha ⁻¹	40.5	46.2	63.4	109.6	42.15
T ₅ - 100 kg N ha ⁻¹	42.1	50.6	68.4	119.0	42.52
T ₆ - 120 kg N ha ⁻¹	43.2	54.8	72.6	127.4	43.01
T ₇ - 140 kg N ha ⁻¹	43.1	54.6	72.4	127.0	42.92
T ₈ - 160 kg N ha ⁻¹	42.9	54.2	72.1	126.3	42.91
T ₉ - 180 kg N ha ⁻¹	42.7	53.8	71.8	125.6	42.83
T ₁₀ - 200 kg N ha ⁻¹	42.5	53.1	71.2	124.3	42.72
SEm±	0.58	1.42	1.88	2.54	0.42
CD (P = 0.05)	1.72	4.22	5.58	7.54	1.25
CV (%)	8.84	8.76	8.21	8.48	9.14

SEm± = standard error of mean; CD = critical difference at P = 0.05; CV = coefficient of variation. Source data: thesis experimental results.

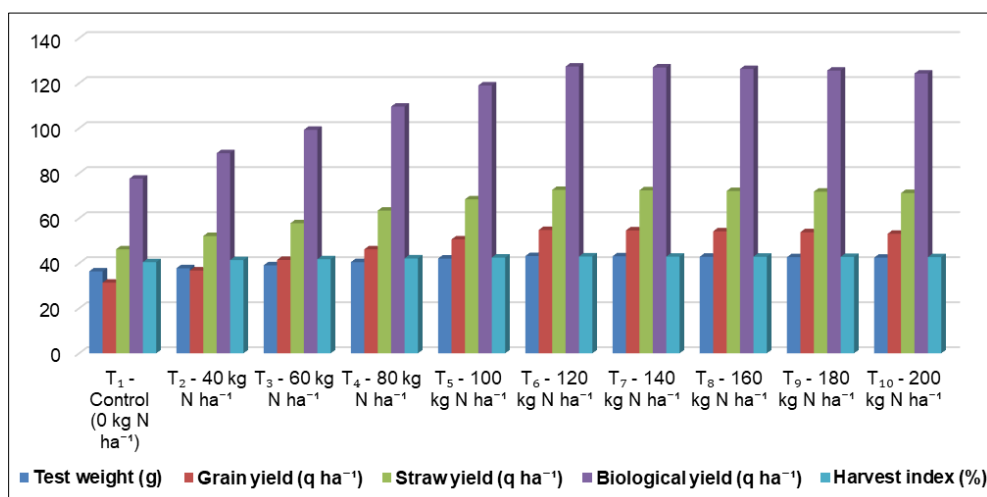


Fig 1: Effect of different levels of nitrogen on test weight and yield of wheat

Economics

The economic analysis indicated that profitability of wheat cultivation varied clearly with nitrogen level (Table 2). Cost of cultivation ranged from ₹46,200 ha⁻¹ under control to ₹54,800 ha⁻¹ under 200 kg N ha⁻¹. The increase in input cost at higher nitrogen doses reduced the marginal economic advantage, particularly when the additional yield response was small.

The highest gross return (₹1,20,560 ha⁻¹), net return (₹70,920 ha⁻¹) and benefit-cost ratio (2.43) were recorded with 120 kg N ha⁻¹. Although 140, 160, 180 and 200 kg N ha⁻¹ produced grain yields statistically at par with 120 kg N ha⁻¹, their net returns and benefit-cost ratios were lower due to higher cost of cultivation. The control treatment recorded the lowest gross return (₹69,080

ha⁻¹), net return (₹22,880 ha⁻¹) and benefit-cost ratio (1.50). The net return under 120 kg N ha⁻¹ was ₹48,040 ha⁻¹ higher than control, indicating a strong economic response to optimum nitrogen application.

The superiority of 120 kg N ha⁻¹ in terms of benefit-cost ratio shows that biological yield alone should not be the basis of fertilizer recommendation. The optimum nitrogen level produced the best balance between yield advantage and input cost. Similar economic responses to optimum nitrogen fertilization were reported by Kumar and Yadav (2019) [7], Saini *et al.* (2019) [13], Meena *et al.* (2021) [9] and Choudhary *et al.* (2023) [3], who observed that higher nitrogen levels beyond the economic optimum did not proportionately enhance net return.

Table 2: Effect of different levels of nitrogen on economics of wheat cultivation

Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	Benefit-cost ratio
T ₁ - Control (0 kg N ha ⁻¹)	46,200	69,080	22,880	1.50
T ₂ - 40 kg N ha ⁻¹	47,800	80,960	33,160	1.69
T ₃ - 60 kg N ha ⁻¹	48,600	91,300	42,700	1.88
T ₄ - 80 kg N ha ⁻¹	49,500	1,01,640	52,140	2.05
T ₅ - 100 kg N ha ⁻¹	50,400	1,11,320	60,920	2.21
T ₆ - 120 kg N ha ⁻¹	49,640	1,20,560	70,920	2.43
T ₇ - 140 kg N ha ⁻¹	50,440	1,20,120	69,680	2.38
T ₈ - 160 kg N ha ⁻¹	51,640	1,19,240	67,600	2.31
T ₉ - 180 kg N ha ⁻¹	53,200	1,18,360	65,160	2.22
T ₁₀ - 200 kg N ha ⁻¹	54,800	1,16,820	62,020	2.13

Gross return was calculated from grain yield using the prevailing wheat price; net return = gross return - cost of cultivation; benefit-cost ratio = gross return/cost of cultivation. Source data: thesis economics table.

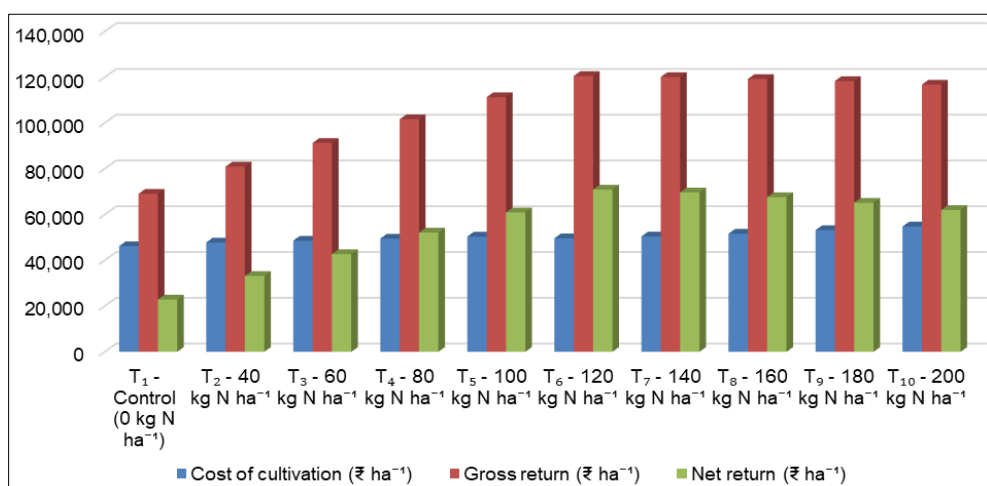


Fig 2: Effect of different levels of nitrogen on economics of wheat cultivation

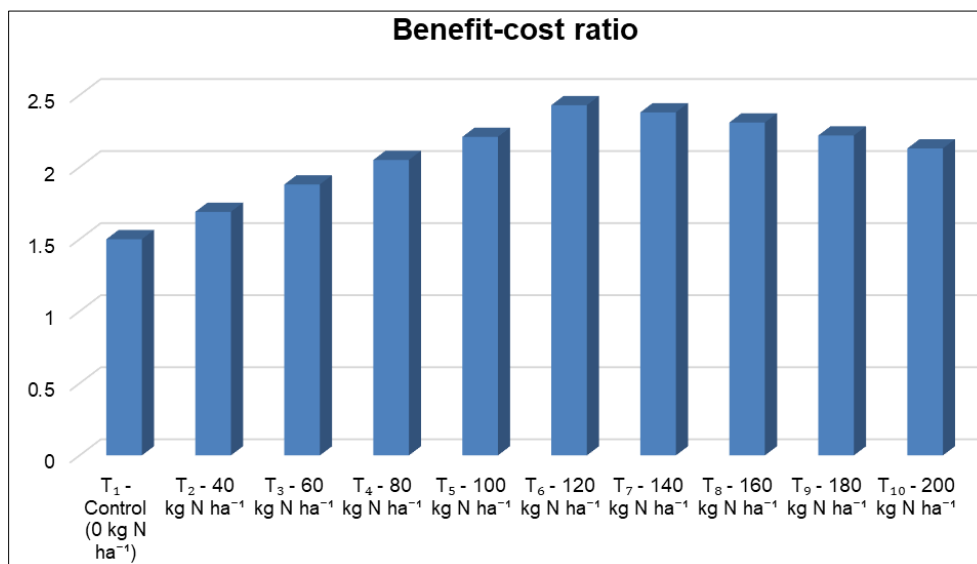


Fig 3: Effect of different levels of nitrogen on benefit-cost ratio of wheat cultivation

Conclusion

On the basis of the present investigation, application of 120 kg N ha⁻¹ was found most effective for improving yield and profitability of wheat under the semi-arid conditions of Gwalior. This treatment recorded the highest grain yield (54.8 q ha⁻¹), straw yield (72.6 q ha⁻¹), biological yield (127.4 q ha⁻¹), harvest index (43.01%), net return (₹70,920 ha⁻¹) and benefit-cost ratio (2.43). Increasing nitrogen beyond 120 kg ha⁻¹ did not provide a proportional yield or economic advantage. Therefore, 120 kg N ha⁻¹ may be recommended as an economically viable nitrogen level for wheat cultivation under similar soil and climatic conditions.

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