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Response of wheat to split applications of nitrogen fertilizer, and seed rates

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Abstract

A field experiment on “Response of Wheat to Split Application of Nitrogen Fertilizer and Seed Rates” was conducted during *Rabi* 2021-2022 at the Research farm of department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). A Factorial randomized block design consisted two factors whereas four levels of nitrogen and three seed rates of wheat variety and replicated for three times. The wheat varieties were tested for this experiment along with these treatments. The treatments were N₀-0 kg N/ha, N₁- 120 kg/ha (60 kg basal + 30 kg/ha CRI + 30 kg/ha PI), N₂- (60 kg/ha basal + 45 kg/ha CRI +35 kg/ha PI) and N₃- (60 kg/ha basal + 45 kg/ha CRI +20 kg/ha jointing stage + 35 kg/ha PI stage), while three seed rates of wheat were tested are S₁-100 kg/ha, S₂-110 kg/ha and S₃- 120 kg/ha. The gross and net plot size was 5 m x 3 m, respectively. The fertilizers grades were applied as per treatments. Based on this experiment, it is concluded that the application of a higher nitrogen level at 160 kg/ha in four splits 60 kg/ha basal, 45 kg/ha at CRI stage, 20 kg/ha at jointing, and 35 kg/ha at PI stage combined with a seed rate of 100 kg/ha, resulted in the maximum seed yield of 4.27 t/ha, with a total cultivation cost of Rs. 27,073.04. This treatment also recorded the highest and significantly superior net monetary returns of Rs. 101,466.96 per hectare and a benefit-cost ratio of 3.75:1. Therefore, this treatment combination is recommended for adoption in the Eastern Plateau and Hills region of Madhya Pradesh. However, these findings are preliminary and warrant further validation through additional experiments before final recommendations can be made to farmers.

Keywords: Wheat, split application of nitrogen, seed rate, wheat yield, benefit-cost ratio

Introduction

Wheat is the second staple food crop of India after rice. India has a total production of 95.91 million tonnes which is 12% of the world food production from 31.34 million hectares of land with productivity of 30.61 q/ha during rabi 2012-13 (Anonymous, 2014). It is cultivated mainly in the states of Uttar Pradesh, Madhaya Pradesh, Punjab and Haryana. Among the different states of India, Uttar Pradesh rank first in both area and production, while Punjab ranks first in productivity. It contains about 70% carbohydrate, 12% protein, 1.7% fats, 2.7% minerals and 2% fiber (Sharma and Jain, 2004). Madhya Pradesh is an equally important wheat growing states of India. The recent data shows that Madhaya Pradesh occupied more than 5000 thousand hectares under wheat in 2014-15 with total production was more than 13000 thousand tonnes and average yield was about 26.00 quintal per hectare (Anonymous, 2013).

Nitrogen is one of the most important factors for the growth and development of plants. However, nitrogen is prone to various types of losses such as denitrification, volatilization, and leaching, which not only reduce its efficiency but also pose environmental threats. The Normalized Difference Vegetation Index (NDVI) is a useful tool to improve Nitrogen Use Efficiency (NUE). Globally, the NUE for cereal production, including wheat, is approximately 33% (Raun and Johnson, 1999). The low NUE in wheat is largely attributed to nitrogen losses through volatilization, denitrification, and leaching (Prasad Rao and Prasad, 1980) [2, 56, 1, 51, 49]. Another contributing factor to low NUE is the inefficient splitting of nitrogen doses and application of nitrogen beyond the actual crop requirement. Therefore, the application of NDVI-based techniques is essential for optimizing nitrogen use, enhancing fertilizer efficiency, and ultimately increasing crop yield.

To improve NUE, top dressing and split application of nitrogen fertilizers at critical growth stages of wheat are being recommended (Singh, 1988). The availability of nitrogen at different stages of wheat growth plays a crucial role in determining both the yield and grain quality (Zende *et al.*, 2005). Split application is one of the effective methods to increase nitrogen utilization by the crop and minimize nutrient losses due to leaching, denitrification, runoff, and volatilization. The timing and rate of nitrogen application are key agronomic practices that directly affect the growth and yield of wheat (Pali and Sharma, 1992)^[60, 80].

To minimize nitrogen losses, different fertilizer application strategies have been developed to ensure a continuous and regulated supply of nitrogen throughout the crop lifecycle. Split application of nitrogen has been shown to increase crop yield and NUE by synchronizing fertilizer supply with plant demand, reducing losses, and improving nitrogen uptake. Thus, optimizing the timing and amount of nitrogen applied at various crop stages is a vital strategy for achieving higher yields in wheat.

Among various crop production factors, planting pattern and seed rate are of significant importance as they determine proper crop stand establishment. Using an optimum seed rate is essential to maximize yield. An excessively high seed rate can lead to overcrowding, causing competition among plants for light, water, and nutrients, resulting in poor growth and lower yields. On the other hand, a low seed rate results in fewer plants per unit area, also reducing yield (Singh and Uttam, 1994). An optimum seed rate helps achieve a greater number of tillers per unit area, suppresses weed growth through smothering, and enhances the effective utilization of resources. Seeding rate has a significant impact on wheat tillering and final grain yield, and an appropriate seed rate can contribute greatly to the efficient use of natural resources (Naveen *et al.*, 2017)^[61, 39].

Materials and methods

The present investigation entitled “Response of wheat (*Triticum aestivum* L.) to split application of nitrogen fertilizer and seed rates” was conducted during the Rabi season of 2021-2022 at the Research Farm of the Department of Agronomy, School of Agriculture Science, Technology and Research, Sardar Patel University. The experiment was laid out in a Factorial Randomized Block Design with three replications comprising four nitrogen split application treatments and three seed rates using wheat variety Lok-1. The nitrogen treatments included N0-0 kg N/ha, N1-120 kg N/ha (60 kg basal + 30 kg at CRI + 30 kg at PI stage), N2-140 kg N/ha (60 kg basal + 45 kg at CRI + 35 kg at PI stage) and N3-160 kg N/ha (60 kg basal + 45 kg at CRI + 20 kg at jointing stage + 35 kg at PI stage), while seed rates were S1-100 kg/ha, S2-110 kg/ha and S3-120 kg/ha. The soil of the experimental field was clay loam in texture, neutral in reaction (pH 7.5), medium in organic carbon and nitrogen, high in phosphorus and medium in potassium. The crop was sown manually on 15 November 2021 with spacing of 22.5 cm × 15 cm. Recommended doses of phosphorus and potassium were applied uniformly through single super phosphate and muriate of potash, while nitrogen was applied through urea as per treatment schedules. Standard agronomic practices including irrigation, weed management and harvesting were followed uniformly for all treatments. Observations on growth parameters, yield attributes, grain and straw yield, quality characters and economics were recorded at different growth stages. The experimental data were statistically analyzed using analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1985) to determine the significance of treatment effects^[47].

Results and discussion

The results of the present investigation clearly indicated that growth, yield attributes, yield, quality and economics of wheat were significantly influenced by split application of nitrogen fertilizer and seed rates. The experimental soil was clay loam in texture, slightly alkaline in reaction and medium in available nutrients, which provided favorable conditions for wheat cultivation during the Rabi season of 2021-2022. Weather conditions prevailing during the crop growth period were also congenial for satisfactory crop growth and development. The findings demonstrated that proper nutrient management, particularly nitrogen scheduling through split application, played a vital role in improving crop performance and sustaining productivity under the Eastern Plateau and Hills region of Madhya Pradesh.

Among the growth parameters, higher nitrogen application at 160 kg/ha applied in four splits (60 kg basal + 45 kg at CRI stage + 20 kg at jointing stage + 35 kg at PI stage) significantly increased plant height, number of leaves, effective tillers, fresh weight and dry weight of wheat plants. The beneficial effect of split nitrogen application may be attributed to continuous nitrogen availability during critical crop growth stages, resulting in enhanced photosynthetic activity, cell division and nutrient uptake. Nitrogen, being an essential component of chlorophyll and proteins, promoted vigorous vegetative growth and improved physiological activities within the plant. Similar findings were also reported by Meena (2010), Kumar *et al.* (2010), Jat *et al.* (2014c) and Usman *et al.* (2014), who observed better growth performance under higher nitrogen doses applied in splits^[39, 47, 34].

Yield attributing characters such as spike length, number of grains per spike, test weight and effective tillers were also markedly improved with higher nitrogen levels and optimum seed rate. The treatment receiving 160 kg N/ha in four splits along with a seed rate of 100 kg/ha recorded the highest values for these characters. Adequate and timely nitrogen supply improved dry matter accumulation, source-sink relationship and translocation of photosynthates towards reproductive organs, thereby enhancing grain formation and grain filling. Lower seed rate of 100 kg/ha proved superior due to reduced inter-plant competition for nutrients, moisture, space and light, which facilitated better tillering and spike development. These findings corroborate the reports of Pandey *et al.* (2007), Kumar and Dhar (2010), Singh *et al.* (2015) and Tripathi *et al.* (2015)^[46, 25, 75].

The maximum grain yield, straw yield and biological yield were recorded under the treatment combination of 160 kg N/ha applied in four splits with seed rate of 100 kg/ha. Higher nitrogen availability throughout the crop growth period enhanced nutrient uptake, photosynthetic efficiency and assimilate translocation, ultimately resulting in higher productivity. Protein content in grain was also significantly increased under higher nitrogen levels, particularly under split application schedules, due to increased nitrogen assimilation and protein synthesis in grains. Split nitrogen application reduced nitrogen losses and synchronized nutrient availability with crop demand, thereby improving both yield and grain quality. Similar observations were reported by Chibsa *et al.* (2016), Kaur *et al.* (2010a), Jat *et al.* (2014) and Kharub and Chander (2010)^[11, 20, 17, 22].

Economic analysis further revealed that the treatment receiving 160 kg N/ha in four splits combined with seed rate of 100 kg/ha generated the highest net monetary return and benefit-cost ratio compared to all other treatments. Although this treatment involved comparatively higher cultivation cost due to increased fertilizer input, the substantial increase in grain and straw yield

resulted in greater profitability. Therefore, the study concluded that application of 160 kg nitrogen per hectare in four splits along with a seed rate of 100 kg/ha is economically viable and agronomically beneficial for wheat cultivation under the Eastern

Plateau and Hills region of Madhya Pradesh. However, further multi-location and multi-season trials are needed before making broad recommendations to farmers.

Table 1: Response of wheat to split applications of nitrogen fertilizer, and seed rates

Treatment	Plant height at 90 DAS (cm)	Leaves plant ⁻¹ at 90 DAS	Effective tillers m ⁻¹ row length at 90 DAS	Spike length (cm)	Grains spike ⁻¹	Test weight (g)	Grain yield plant ⁻¹ (g)	Grain yield plot ⁻¹ (kg)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Protein content (%)	Gross monetary return (Rs/ha)	Net monetary return (Rs/ha)	B:C ratio
N ₀ S ₁	64.2	29.8	35.3	7.13	42.8	39.8	13.63	2.8	1.86	4.22	30.59	9.94	62520	37360	1.48
N ₁ S ₁	70	35.33	41.66	12.28	50	40.67	18	5.25	3.5	5.98	36.92	10.59	105880	79285.22	2.98
N ₂ S ₁	72.1	37.93	44	12.93	51.47	40.9	18.07	5.82	3.88	6.57	37.13	11.21	117020	90186.09	3.36
N ₃ S ₁	73.9	41.87	44.69	13.45	53	41.03	18.63	6.41	4.27	7.19	37.26	11.33	128540	101467	3.75
N ₀ S ₂	63.3	27.1	34.7	6.75	42	39.77	12.67	2.43	1.62	3.98	28.93	9.89	56280	30670	1.2
N ₁ S ₂	69.17	33.47	39.66	11.75	48.73	40.37	17.23	5.16	3.43	5.64	37.82	10.46	102440	75873.48	2.86
N ₂ S ₂	71.37	35.87	42.33	12.27	50.53	40.37	17.5	5.33	3.55	5.74	38.21	10.63	105440	78395.22	2.9
N ₃ S ₂	72.73	39.67	42.67	12.66	51.27	40.53	17.97	5.81	3.87	6.24	38.28	11.2	114840	87556.09	3.21
N ₀ S ₃	62.5	26.5	34	6.55	41.2	39.03	12.23	2.27	1.51	3.82	28.33	9.81	53120	27060	1.04
N ₁ S ₃	68.43	31.53	39	11.75	48.67	39.57	16.67	4.64	3.09	5.28	36.92	10.54	93480	66463.48	2.46
N ₂ S ₃	70.3	33.47	41.66	12.14	50.07	39.87	17	5.03	3.35	5.63	37.31	10.68	100780	73285.22	2.67
N ₃ S ₃	71.9	37.4	42	12.81	50.8	40.3	17.7	5.3	3.53	6.31	35.87	10.73	108460	80726.09	2.91
SEm±	0.24	0.41	0.56	0.13	0.47	0.39	0.26	0.191	0.127	0.226	1.19	0.072	—	—	—
CD (P=0.05)	0.69	1.2	1.64	0.4	1.39	1.15	0.77	0.559	0.372	0.662	3.48	0.213	—	—	—

Conclusion

Based on this experiment, it is concluded that the application of a higher nitrogen level at 160 kg/ha in four splits 60 kg/ha basal, 45 kg/ha at CRI stage, 20 kg/ha at jointing, and 35 kg/ha at PI stage combined with a seed rate of 100 kg/ha, resulted in the maximum seed yield of 4.27 t/ha, with a total cultivation cost of Rs. 27,073.04. This treatment also recorded the highest and significantly superior net monetary returns of Rs. 101,466.96 per hectare and a benefit-cost ratio of 3.75:1. Therefore, this treatment combination is recommended for adoption in the Eastern Plateau and Hills region of Madhya Pradesh. However, these findings are preliminary and warrant further validation through additional experiments before final recommendations can be made to farmers.

However, these findings are preliminary and warrant further validation through multi-location trials and long-term studies to confirm consistency and adaptability before final recommendations can be made to farmers.

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