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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Wheat (*Triticum aestivum* L.) is a major staple crop and a cornerstone of global food security, yet its productivity is increasingly constrained by rising population demand, climatic variability, and soil nutrient depletion. Integrated Nutrient Management (INM), which combines inorganic fertilisers with organic amendments and biofertilizers, offers a sustainable pathway to enhance yield, nutrient-use efficiency, and soil health. A field experiment was conducted during the Rabi season of 2024–25 at Sanjeev Agrawal Global Educational University, Bhopal (Madhya Pradesh), to evaluate the effect of different nitrogen levels (50–130% RDN) and foliar application of plant growth regulators (PGRs) on the growth and yield performance of wheat. The experiment was laid out in a randomised block

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design with three replications. Growth parameters (plant population, height, tiller number, dry matter accumulation) and yield attributes (spike density, spike length, grains per spike, test weight), along with grain, straw, and biological yields, were recorded. The findings revealed that higher nitrogen doses in combination with PGRs significantly enhanced both vegetative and reproductive traits. The treatment with 130% RDN + PGR produced the highest grain yield (41.2 q/ha) and biological yield (85.2 q/ha), representing increases of 80.7% and 56.9%, respectively, over the control. Improvements were also observed in straw yield, spike density, and grains per spike under INM treatments. Overall, the study demonstrates that INM, particularly when integrated with plant growth regulators, is a scientifically robust, economically viable, and environmentally sustainable strategy for improving wheat productivity and resilience under subtropical conditions.

Keywords: Wheat; INM (integrated nutrient management); PGR (plant growth regulators); biofertilizers.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most widely grown staple food grain in the world and is consumed by over 35% of the world's population. It provides almost 20% of the world's dietary calories and protein, hence being critically important for world food and nutritional security. With the increasing population of the world, quick urbanisation, and climate fluctuation, the pressure on wheat production systems to provide higher and consistent yields has grown exponentially. But persistent monoculture, blanket application of chemical fertilisers, and inadequate nutrient management practices have deteriorated soil health, lowered biodiversity, and created severe environmental problems like nitrate leaching, water pollution, and greenhouse gas emissions.

Here, Integrated Nutrient Management (INM) is being recognised as a tried method to maintain soil fertility and improve crop yields. INM focuses on balanced and judicious use of organic sources like farmyard manure (FYM), green manures, compost, and biofertilizers (e.g., Azotobacter, Rhizobium, and phosphate-solubilising bacteria, PSB), along with inorganic fertilisers (N, P, K). This strategy not only improves the efficiency of nutrient utilisation (NUE) but also maintains optimal nutrient availability and soil health over the long term. For example, Han et al., 2024) showed that enhancing nitrogen use by means of optimised tiller numbers and efficient biomass allocation is a primary mechanism to enhance wheat yields and NUE.

Some innovative crop management practices for wheat have been developed worldwide. Bao et al. (2024) indicated that light and frequent irrigations according to crop evapotranspiration enhance grain weight and water use efficiency, whereas Sun et al. (2024) emphasised UAV-based hyperspectral imaging in precision irrigation during the grain-filling period to save water and nutrient inputs. Likewise, Guo et al. (2024) noted that light regimes have a great impact on spike development and fertile floret formation, both of which are strongly related to nutrient supply. These reports suggest that INM, when combined with advanced agronomic technologies like precision irrigation and remote sensing, can optimise wheat's genetic and physiological capability. Furthermore, in intensive systems like the North China Plain, Sharma et al. (2015) highlighted that diversification of cropping systems with focused nitrogen management lessens nitrogen loss and maintains yield results of particular value to Indian wheat systems too.

In India, wheat is a staple food crop that supports food security and the incomes of rural populations. It is mainly grown in Uttar Pradesh, Punjab, Haryana, Rajasthan, and Madhya Pradesh. The 1960s and 70s Green Revolution substantially increased wheat production with high-yielding varieties and excessive applications of chemical fertilisers, particularly nitrogen. Still, the high-input package has resulted in degraded soil fertility, plateauing yields, and increasing input prices. Extended and unbalanced use of fertilisers has led to intensive nutrient mining, especially of secondary and micronutrients like sulfur, zinc, boron, and iron. Yuan et al. 2022) observed that INM not just enhances yield but also nodulation, grain quality, and nutrient use efficiency, even in the case of rotational crops like wheat and soybean. Realising these issues, the Government of India has initiated a number of measures to enhance sustainable nutrient management. The Soil Health Card Scheme assists farmers in terms of soil nutrient status for specific fertiliser application, while Paramparagat

Krishi Vikas Yojana supports organic farming with mineral nutrition integration. ICAR institutions also support the application of locally feasible resources like compost, vermicompost, and green manures, along with biofertilizers, for minimising input costs and increasing soil fertility. They also proved that subsoiling and layer fertiliser placement improve root architecture and NUE, a method that promises Indian wheat systems where soil compaction is a limitation.

Regionally, wheat is the major rabi crop of Madhya Pradesh, mainly in the Bhopal district. The subtropical climate, moderate precipitation, and black and alluvial fertile soils are conducive to wheat cultivation in the region. But the main challenges remain, such as reducing organic matter, soil compaction, and nutrient imbalance because of overdependence on urea and DAP. Local data from JNKVV and Krishi Vigyan Kendras (KVKs) at Bhopal indicate that INM integrating FYM, vermicompost, crop residues, and biofertilizers (Azospirillum, PSB) with site-specific NPK application enhances the structure of soil, water-holding capacity, and microbial biomass, leading to increased productivity and stability under moisture stress. Biswas et al. 2022) also found that INM enhances economic returns, energy use efficiency, and indicators of sustainability in cereals and legumes under similar conditions. For the small and marginal farmers of Bhopal, many of whom struggle with high input expenses and stagnating returns, INM represents an economically sound and ecologically sustainable option.

Significantly, INM also enhances climate resilience in wheat production. Wheat in Bhopal is increasingly at risk from erratic rainfall and increasing temperatures. INM offsets these risks by enhancing the water-holding capacity of the soil, promoting root growth, and lowering reliance on expensive external inputs. When coupled with precision tools like satellite-based remote sensing and mobile-based nutrient advisory systems, INM can provide location-specific nutrient recommendations, which further increase efficiency.

In short, INM is a scientifically rational, environmentally friendly, and locally feasible wheat farming practice. Not only does it enhance yields and soil health but it also reduces environmental degradation, lowers production costs, and enhances climate resilience. In wheat-growing areas such as Bhopal, upscaling INM practices through incentive policies, farmer training, and rural infrastructure can guarantee a more resilient, productive, and sustainable future for agriculture.

2. MATERIALS AND METHODS

A field experiment was conducted during the Rabi season of 2024–2025 at the Agricultural Experimental Farm of Sanjeev Agrawal Global Educational University, Bhopal, Madhya Pradesh (23°16′N latitude, 77°24′E longitude, 523 m above mean sea level), falling under the Central Plateau and Hill Zone. The region has a subtropical climate with temperatures ranging between 10–25°C, relative humidity of 40–70%, negligible rainfall during Rabi, and 7–9 sunshine hours per day. The soil of the experimental field was a clay loam Vertisol, neutral in reaction (pH 7.2), with EC 0.38 dS/m, organic carbon 0.54%, available N 165 kg/ha (low), available P 12.8 kg/ha (medium), and available K 298 kg/ha (medium).

The experiment was laid out in a Randomised Block Design (RBD**)** with eight treatments and three replications. The treatments included control, different levels of nitrogen (50%, 75%, 100% of RDN), and combinations of 70%, 90%, 110%, and 130% RDN with foliar spray of Lihocin (0.1%) at 45 and 75 DAS. The recommended nitrogen dose was 120 kg/ha. The wheat variety *Annapurna* was used due to its medium duration, disease resistance, and high yield potential. The gross plot size was 3 × 4 m, and the net plot size was 2.5 × 3.5 m with 22.5 cm row spacing. Land preparation consisted of ploughing, harrowing, and levelling, followed by seed treatment with Thiram @ 2.5 g/kg and sowing on November 15, 2024, at a 100 kg/ha seed rate using a seed drill. Fertilisers were applied as per treatments using urea (N), SSP (P), and MOP (K) with N in three splits (50% basal, 25% at 30 DAS, 25% at 60 DAS). Lihocin spray was applied twice at the first node and booting stages. Irrigation was provided at six critical growth stages with a total of 450 mm of water. Weed control included pendimethalin (pre-emergence) and 2,4-D (post-emergence), supplemented with manual weeding. Insect and disease management was carried out using imidacloprid against aphids and propiconazole against rust. Observations were recorded on plant population, plant height, dry matter accumulation, number of tillers, spikes per square meter, spike length, grains per spike, test weight, grain yield, straw yield, biological yield, and harvest index. The data were analysed using

Analysis of Variance (ANOVA Panse & Sukhatme (1967).

3. RESULTS AND DISCUSSION

3.1 Impact of Integrated Nutrient Management on Wheat Growth Traits

3.1.1 Plant population (per m²)

Data suggest a steady decline in plant population from 15 DAS (Days After Sowing) to harvest in all the treatments. The lowest plant population at harvest was recorded in the control (T_1) with 412 plants/m², whereas the maximum plant population was found under T_8 (130% N + PGR) with 443 plants/m². Higher nitrogen treatments and plant growth regulators (T_5–T_8) retained consistently higher plant populations across the crop growth period. This indicates that integrated nutrient management, more so higher doses of nitrogen with PGRs, can minimise plant mortality and promote early plant establishment (Maravi et al., 2025).

3.1.2 Plant height (cm)

Plant height augmented progressively with crop development, where the maximum was attained at harvest. The control (T_1) had the shortest height (85.4 cm), while the maximum height was observed in T_8 (162.8 cm) at harvest. Boosted nitrogen levels, particularly with PGR application, improved plant height substantially. Treatments T_6, T_7, and T_8 yielded longer plants compared to T_4 (100% N) alone, which shows a synergistic effect of PGRs on vegetative growth. The findings are consistent with earlier investigations, which indicate nitrogen encourages cell elongation, whereas PGRs control hormonal balance and thus enhance stem elongation and biomass accumulation (Maurya et al., 2019, and Darjee et al., 2023).

3.1.3 Dry matter accumulation (g/m²)

Dry matter accumulation also increased with the progress of the crop up to 90 DAS. The control (T_1) had the minimum amount of dry matter at harvest (578 g/m²), while T_8 accumulated the highest amount (918 g/m²). Nitrogen plus PGR-treated plots (T_5–T_8) performed better consistently compared to nitrogen alone, suggesting that nutrition optimisation integrated with growth regulators improves photosynthetic efficiency, nutrient acquisition, and biomass production. Underlining the relevance of integrated nutrient management in enhancing crop growth and productivity (Singh et al., 2021).

3.1.4 Number of tillers per m²

The number of tillers plays a key role in wheat yield potential. All the treatments recorded an increase in tiller number up to 60–90 DAS with subsequent minor reduction at harvest because of natural senescence. The minimum tiller number was observed under control (578 tillers/m²), while the highest was observed in T_8 (918 tillers/m²) at harvest. Nitrogen treatment had a significant effect on tiller production, while its use in combination with PGRs (T_5–T_8) further accelerated tiller initiation and survival. These observations indicate that INM not only enhances vegetative growth but also reproductive potential by maximising tiller retention, which is essential for greater grain yield (Kaur et al., 2018).

3.2 Impact of Integrated Nutrient Management on Wheat Yield Traits

3.2.1 Spike density (Spikes/m²)

Spike density per m² was significantly increased by the use of integrated nutrient management. Minimum spike density was observed in control (T_1) as 578 spikes/m², and the maximum was found in T_8 (130% N + PGR) as 918 spikes/m², which was an increase of 58.8% over control. Nitrogen application only (T_2–T_4) enhanced spike density, while the combinations with plant growth regulators (T_5–T_8) increased spike formation further. The findings suggest that an increase in nitrogen levels and PGRs enhances greater tiller survival and spike initiation, which are key drivers of wheat yield (Devi et al., 2011 and Fazily et al., 2021).

3.2.2 Spike length (cm)

Spike length grew progressively with increased nutrient levels and PGR treatment. Control had the shortest spikes (8.4 cm), while T_8 had the longest spikes (12.8 cm), a 52.4% increase over control. PGR treatments (T_5–T_8) always had longer spikes than the comparable nitrogen-only treatment, indicating that PGRs affect cell elongation and spike growth. The increase in spike length observed is linked to enhanced assimilate partitioning and photosynthetic efficiency, leading to greater yield potential (Sheoran et al., 2017).

Table 1. Effect of integrated nutrient management on growth traits of wheat

	Plant Population (per m^2)					Plant Height (cm)				Dry matter accumulation (g/m^2)				Tiller count (per m^2)			
Treatment	**15 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**At Harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At Harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At Harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At Harvest**
T_1 (Control)	445	438	425	418	412	18.2	45.3	72.5	78.4	85.4	245.7	485.2	542.8	486	634	598	578
T_2 (50% N)	448	442	434	428	422	20.1	48.7	76.8	82.6	92.8	268.3	526.9	589.4	524	682	648	625
T_3 (75% N)	452	446	441	436	431	22.4	52.1	81.3	87.9	108.6	298.5	578.4	648.7	578	748	712	689
T_4 (100% N)	455	449	445	441	437	24.8	55.6	85.7	92.3	125.9	332.1	638.6	715.2	634	823	785	756
T_5 (70% N + PGR)	450	445	440	437	433	23.6	54.2	84.1	90.8	118.7	318.4	612.8	687.9	612	796	763	738
T_6 (90% N + PGR)	453	448	444	441	438	25.9	57.8	88.4	95.2	134.2	356.8	672.3	753.6	668	867	829	801
T_7 (110% N + PGR)	456	451	447	444	441	27.3	60.4	91.6	98.7	148.5	389.7	718.9	805.4	718	934	896	865
T_8 (130% N + PGR)	458	453	449	446	443	28.7	62.1	93.8	101.2	162.8	421.6	759.8	851.7	762	991	952	918
CD (P=0.05)	NS	8.2	10.4	12.1	11.8	2.1	3.4	4.2	4.8	12.4	18.7	32.6	36.8	28.4	42.6	38.9	41.2
CV (%)	3.2	3.8	4.1	4.5	4.3	5.8	4.2	3.6	3.8	6.8	4.9	3.8	4.1	3.2	4.1	3.8	4.2

Table 2. Effect of integrated nutrient management on yield trait of wheat

Treatment	**Spikes/m²**	**% Increase over Control**	**Spike Length (cm)**	**% Increase over Control**	**Grains/Spike**	**% Increase over Control**	**Test Weight (g)**	**% Increase over Control**
T_1 (Control)	578	-	8.4	–	32.4	–	38.2	–
T_2 (50% N)	625	8.1	9.1	8.3	35.8	10.5	39.4	3.1
T_3 (75% N)	689	19.2	9.8	16.7	39.6	22.2	40.8	6.8
T_4 (100% N)	756	30.8	10.6	26.2	43.9	35.5	42.6	11.5
T_5 (70% N + PGR)	738	27.7	10.2	21.4	42.1	29.9	41.9	9.7
T_6 (90% N + PGR)	801	38.6	11.3	34.5	46.7	44.1	43.7	14.4
T_7 (110% N + PGR)	865	49.7	12.1	44.0	50.3	55.2	45.1	18.1
T_8 (130% N + PGR)	918	58.8	12.8	52.4	53.8	66.0	46.8	22.5
CD (P=0.05)	41.2	-	0.8	–	2.9	–	1.6	–
CV (%)	4.2	-	5.2	–	4.8	–	2.8	–

Table 3. Effect of integrated nutrient management on yield of wheat

Treatments	Biological Yield (q/ha)	% Increase over Control	Grain Yield	% Increase over Control	Yield Class	Straw Yield	% Increase over Control
T_1 – Control	54.3	–	22.8	-	Low	31.5	-
T_2 – 50% N	58.9	8.5	25.4	11.4	Low-Medium	33.5	6.3
T_3 – 75% N	64.9	19.5	28.9	26.8	Medium	36	14.3
T_4 – 100% N	71.5	31.7	32.6	43	Medium-High	38.9	23.5
T_5 – 70% N + PGR	68.8	26.7	31.2	36.8	Medium-High	37.6	19.4
T_6 – 90% N + PGR	75.4	38.9	35.8	57	High	39.6	25.7
T_7 – 110% N + PGR	80.5	48.3	38.7	69.7	High	41.8	32.7
T_8 – 130% N + PGR	85.2	56.9	41.2	80.7	Very High	44	39.7
CD (P = 0.05)	3.7	–	1.8	-	-	2.4	-
CV (%)	3.9	–	4.1	-	-	4.6	-

3.2.3 Grains per spike

Number of grains per spike significantly increased with integrated nutrient management. The control produced 32.4 grains per spike, whereas T_8 produced 53.8 grains per spike, which was a 66.0% increase. Nitrogen application improved floret fertility and grain setting, whereas PGRs improved additional grain filling and spikelet development. Treatments T_6–T_8 (high N + PGR) were highly superior, implying a synergistic effect of nutrients and growth regulators in optimizing reproductive growth (Kaur et al., 2024).

3.2.4 Test weight (g)

The 1000-grain weight (test weight) was also favored by INM. The control was at 38.2 g, while T_8 achieved 46.8 g, a 22.5% increment above the control. Increased nitrogen and application of PGR probably enhanced assimilate translocation to the developing grains, which increased grain size and weight. The findings show that INM not only affects yield components like spike density and grain number but also enhances grain quality parameters (Khan et al., 2018).

3.3 Impact of Treatments on Biological and Grain Yield of Wheat

3.3.1 Biological yield (q/ha)

The biological yield of wheat was significantly raised through integrated nutrient management. The lowest biological yield of 54.3 q/ha was recorded by the control (T_1), while that of T_8 (130% N + PGR) was the highest at 85.2 q/ha, which was a 56.9% increase relative to the control. Treatments with higher doses of nitrogen combined with plant growth regulators (T_6–T_8) all yielded better biological yield than nitrogen-alone treatments (T_2–T_4). The enhanced increase is due to improved vegetative growth, tiller numbers, and dry matter accumulation as a result of optimised nutrient and hormonal control (Kumar et al., 2020).

3.3.2 Grain yield (q/ha)

Grain yield also exhibited the same trend, the minimum being in control (22.8 q/ha) and peak in T_8 (41.2 q/ha), an increase of 80.7% compared to control. The most significant increase was observed in the treatments that applied nitrogen along with PGRs (T_6–T_8), reflecting the synergistic action of nutrient optimisation and growth regulation on reproductive development, spike fertility, and grain filling. Particularly, T_6 (90% N + PGR) and T_7 (110% N + PGR) had grain yields of 35.8 q/ha and 38.7 q/ha, respectively, falling into the "High" yield class, while T_8 attained the "Very High" yield class (Kaur, et al., 2024).

3.3.3 Straw yield (q/ha)

Straw yield was improved by the application of INM and PGR. Minimum straw yield occurred in the control (31.5 q/ha), whereas maximum occurred under T_8 (44 q/ha), with a 39.7% increase. Treatments T_6–T_8 always performed better than the other treatments, suggesting that enhanced vegetative growth and biomass accumulation at higher nitrogen and PGR levels resulted in a higher straw yield (Chopra et al., 2016).

4. CONCLUSION

The experiment unequivocally shows that integrated nutrient management (INM), especially with increased doses of nitrogen along with plant growth regulators (PGRs), drastically influences wheat growth, yield attributes, and overall productivity. The principal conclusions are: High-nitrogen and PGR (T_6–T_8) treatments elevated plant height, dry matter accumulation, plant population, and tiller number, reflecting superior vegetative growth, early establishment, and reproductive ability. Spike density, spike length, grains per spike, and test weight were significantly greater in INM treatments with PGRs, indicating a synergistic response of nutrients and growth regulators towards reproductive development and assimilate partitioning. Biological yield, grain yield, and straw yield were optimised in T_8 (130% N + PGR) with increments of 56.9%, 80.7%, and 39.7% over control, respectively. High yields were also recorded from treatments T_6 and T_7, evidencing that INM with PGRs always enhances both vegetative and reproductive productivity. Generally, the incorporation of optimised nitrogen in combination with plant growth regulators is a viable tactic to enhance wheat growth, production, and biomass accumulation and present an eco-friendly method of higher productivity and economic return.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Bao, X., Zhang, B., Dai, M., Liu, X., Ren, J., Gu, L., & Zhen, W. (2024). Improvement of grain weight and crop water productivity in winter wheat by light and frequent irrigation based on crop evapotranspiration. *Agricultural Water Management, 301*, 108922.

Chopra, R., Sharma, M., Sharma, S. K., Nepalia, V., Jain, H. K., & Singh, A. (2016). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.) in Haplustepts. *International Journal of Science and Nature, 7*(3), 622–628.

Darjee, S., Shrivastava, M., Langyan, S., Singh, G., Pandey, R., Sharma, A., ... & Singh, R. (2023). Integrated nutrient management reduced the nutrient losses and increased crop yield in irrigated wheat. *Archives of Agronomy and Soil Science, 69*(8), 1298–1309.

Devi, K. N., Singh, M. S., Singh, N. G., & Athokpam, H. S. (2011). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). *Journal of Crop and Weed, 7*(2), 23–27.

Fazily, T., Thakral, S. K., & Dhaka, A. K. (2021). Effect of integrated nutrient management on growth, yield attributes and yield of wheat. *International Journal of Advances in Agricultural Science and Technology, 8*(1), 106–118.

Guo, X., Zhang, Z., Li, J., Zhang, S., Sun, W., Xiao, X., ... & Zhang, Y. (2024). Phenotypic and transcriptome profiling of spikes reveals the regulation of light regimens on spike growth and fertile floret number in wheat. *Plant, Cell & Environment, 47*(5), 1575–1591.

Han, S., Wang, C., Zheng, Y., Lu, Z., Dang, Y. P., Si, J., ... & Zhang, H. (2024). The yield and nitrogen use efficiency of winter wheat in the North China Plain could be improved through enhanced tiller formation and biomass transport. *Field Crops Research, 318*, 109570.

Kaur, G., Singh, I., Behl, R. K., & Dhankar, A. (2024). Effect of Different Integrated Nutrient Management Approaches on Growth, Yield Attributes and Yield of Wheat (*Triticum aestivum* L.) Crop: A Review. *Asian Journal of Soil Science and Plant Nutrition, 10*(1), 457–468.

Kaur, R., Kumar, S., Kaur, R., & Kaur, J. (2018). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.) under irrigated conditions. *International Journal of Chemical Studies, 6*(4), 1800–1803.

Khan, T. U., Jan, M. T., Khan, A., Ahmad, G., Ishaq, M., Afridi, K., ... & Saeed, M. (2018).

Integrated management of fertilizer nitrogen and poultry manure enhance wheat production. *Pakistan Journal of Agricultural Research, 31*(3).

Kumar, A., Tiwari, U. S., Kumar, V., Kumar, N., & Yadav, A. K. (2020). Assessment of the integrated nutrient management effects on yield attributes and yield of wheat cv. PBW-550. *Plant Archives, 20*(2), 282–285.

Maravi, V., Kumar, S., Gupta, G., Tilwari, A., Paliwal, N., Kher, D., & Patel, A. (2025). Effect of Integrated Nitrogen Management on Growth, Yield and Quality of Wheat (*Triticum aestivum* L.). *International Journal of Plant & Soil Science, 37*(9), 680–686.

Maurya, R. N., Singh, U. P., Kumar, S., Yadav, A. C., & Yadav, R. A. (2019). Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies, 7*(1), 770–773.

Panse, V. G., & Sukhatme, P. V. (1954). *Statistical methods for agricultural workers*.

Sharma, G. D., Thakur, R., Chouhan, N., & Keram, K. S. (2015). Effect of integrated nutrient management on yield, nutrient uptake, protein content, soil fertility and economic performance of rice (*Oryza sativa* L.) in a Vertisol. *Journal of the Indian Society of Soil Science, 63*(3), 320–326.

Sheoran, S., Raj, D., Antil, R. S., Mor, V. S., & Dahiya, D. S. (2017). Productivity, seed quality and nutrient use efficiency of wheat (*Triticum aestivum*) under organic, inorganic and integrated nutrient management practices after twenty years of fertilization. *Cereal Research Communications, 45*(2), 315–325.

Singh, G., Kumar, S., Sidhu, G. S., & Kaur, R. (2018). Effect of integrated nutrient management on yield of wheat (*Triticum aestivum* L.) under irrigated conditions. *International Journal of Chemical Studies, 6*(2), 904–907.

Sun, X., Zhang, B., Dai, M., Jing, C., Ma, K., Tang, B., ... & Gu, X. (2024). Accurate irrigation decision-making of winter wheat at the filling stage based on UAV hyperspectral inversion of leaf water content. *Agricultural Water Management, 306*, 109171.

Yuan, Y., Lin, F., Maucieri, C., & Zhang, Y. (2022). Efficient irrigation methods and optimal nitrogen dose to enhance wheat yield, inputs efficiency and economic benefits in the North China Plain. *Agronomy, 12*(2), 273.

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