

Growth characteristics, yield components and yield of wheat (*Triticum aestivum* L.) as affected by integrated nutrient management on under central plain zone of Uttar Pradesh

Abstract

Field experiments were carried out at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, to investigate the influence of integrated nutrient management on wheat growth metrics, yield components, and yield during the rabi seasons of 2021-22 and 2022-23. The trial included 11 treatment combinations in a randomised block design with three replications and each treatment combination likely involves different combinations of inorganic fertilizers, organic manure, and biofertilizers. Wheat variety HD-2967 was grown with the using prescribed agronomic practices. According to investigation results the maximum plant height at maturity is 99.85 cm and 102.79 cm, the maximum number of effective tillers is 101.45 cm and 104.83, and the maximum ear length is 11.29 cm and 11.76 cm are associated with the treatment T10 [100% NPK + S40 + Zn5 + Fe10 + Azotobacter + PSB + 5 tonne FYM] during both years of experimentation. Similarly, among the yield components and productivity parameters maximum values with regard to the number of spikelet ear-1 (22.64 and 22.95), grain ear-1 (43.11 and 46.03), 1000 grain wt. (41.17 and 42.13 gm), grain yield (48.60 and 49.93 q ha⁻¹) and straw yield (63.15 and 67.53 q ha⁻¹) have been observed in the treatment T10 [100% NPK + S40 + Zn5 + Fe10 + Azotobacter + PSB + 5 tonne FYM] during both the years of the experimentation.

Key Words: *Azotobacter*, FYM, PSB, Wheat, Yield and Zinc

Introduction

Wheat (*Triticum aestivum* L.) holds a prominent status as a staple crop and stands as the second most significant agricultural product, following rice, within the nation. This crop constitutes approximately one-third of the overall production of food grains. It falls within the *Poaceae* family, commonly referred to as the grass family or *Graminae*, and occupies a pivotal role in the agricultural landscape of the country.

Wheat, an energy-rich winter crop, contributes around 35% of the country's food grain basket. Wheat (*Triticum aestivum* L.) is farmed in 124 countries and covers an area of around 215 million hectares, producing 734.50 mt. of grain in 2019-20 (Anonymous, 2020). Since the onset of the green revolution in 1967, the area under wheat in India has expanded, as has

production and productivity. Wheat area grew from 12.8 million hectares in 1966-67 to 31.45 million hectares in 2019-20. During this time, output climbed from 11.4 to 107.59 mt, and productivity increased from 887 to 3421 kg ha⁻¹ (**Anonymous, 2020**).

In order to maintain or adjust soil fertility and plant nutrient supply to an appropriate level, integrated nutrient management (INM) encourages the use of balanced and prudent use of chemical fertilisers in conjunction with manures such as compost, farm yard manure, vermicomposting, green manures, fertilisers fortified with micronutrients and use of bio-fertilizers (phosphate solubilizing bacteria, *Azospirillum*, *Azotobacter*, *Rhizobium*. (**Rakshit et al. 2008; Parewa et al. 2014; Ullah., et al. 2021**). Using the proper ratio of organic and inorganic fertiliser is essential in this endeavour for preserving soil health and increasing productivity. Wheat, a key cereal crop, requires a substantial supply of minerals, especially nitrogen, for growth and production. It is possible to think about soil restoration using organic fertilisers as a helpful technique to increase the sustainability of agricultural systems. By preserving the soil's structure and using organic fertilisers, soil organic matter, and nutrients, you can promote the growth and activity of microorganisms while also giving your plants a healthy environment to flourish in. Increased biological activity enhances nutrients from organic sources, hazardous material breakdown, and nutrient exchange capability. (**Chew et al., 2019**).

Nitrogen is most important structural element of the cell. As a result, it is thought to be the most crucial nutrient for plant growth, which would be impossible without it. Without it, crop growth is significantly hindered, the foliage turns yellow, the grain shrivels, and the agricultural yield ultimately decreases **Andrews et al., 2004**. Phosphorus is the second most important mineral, making it essential for the growth of crops. According to Ziadi et al. (2008), phosphorus is crucial for improving seed maturity and seed development. Phosphorus is an important component of several essential processes, including photosynthesis, the conversion of sugar to starch, the generation of proteins and nucleic acids, the fixation of nitrogen, and the production of oil. Additionally, it is a component of all plant biochemical cycles (**Mehrvarz and Chaichi, 2008**). Potassium (K⁺) is of unusual significance because of its live role in biochemical functions of the plant like activating various enzymes, improvement of protein, carbohydrates and fat concentration, developing tolerance against drought and resistance to frost, lodging, pests and disease attack. (**Jabbar et al., 2009**). The baking properties of wheat and the biological value of

proteins can also be improved by increasing sulphur fertilization which has reported many times (Marschner, 1997; Jarvan *et al.*, 2006).

Because it is necessary for a vast number of enzymes and plays a crucial function in DNA transcription, zinc is regarded as an essential micronutrient for the growth of wheat. According to reports, pollen contains a significant amount of zinc, most of which is converted to seed only during seed formation. Applying zinc also reportedly enhances grain production. (Choudhary *et al.*, 2007).

The creation of antibiotics by biofertilizers, which can fix atmospheric nitrogen into a form that plants can use, has a positive impact on plant development. Most crops are grown with biofertilizers like Azotobacter (Yasari *et al.*, 2007). The N₂-fixing and phosphate-solubilizing abilities of Azotobacter as well as their potential to create compounds that promote growth may be responsible for an improvement in crop performance. (Salantur *et al.*, 2006). Azotobacter and graded doses of nitrogen increase phosphorus and potassium absorption by plants significantly (Agrawal *et al.*, 2004).

The solubilization of applied phosphates and fixed soil P by phosphate solubilizing bacteria (PSB) has been proven to increase crop yields (Panhwar *et al.*, 2014).

Method and Materials

Experimental Site

The study took place in the winter seasons of 2021-22 and 2022-23 at the Student's Instructional Farm, located within the premises of C.S.A. University of Agriculture and Technology in Kanpur Nagar, Uttar Pradesh. The experimental field was properly graded and watered using a tube well for irrigation. This farm is positioned within the main campus of the university, situated in the northwest region of Kanpur city. The geographical context falls under the sub-tropical zone within the fifth agroclimatic zone, specifically categorized as the central plain zone.

Experimental soils

Analytical data of the experimental soil and method employed in the estimation was given in the Table-1

Table No. 1: Analytical data of the experimental soil (pre-sowing)

S. No.	Soil characters	Value		Method employed
		2021-22	2022-23	

1.	pH (1:2.5 soil water suspension)	8.14	8.15	Glass electrode pH meter (Jackson, 1973)
2.	EC (dsm ⁻¹) (1:2.5 soil water suspension)	0.45	0.46	Conductivity bridge (Jackson, 1973)
3	Mechanical analysis			Hydrometer Method (Bouyoucos, 1962)
i	Sand (%)	60.92	60.40	
ii	Silt (%)	21.71	22.21	
iii	Clay (%)	17.37	17.29	
iv	Texture	Sandy loam	Sandy loam	
4.	Organic carbon (%)	0.35	0.36	Chromic acid digestion (Walkley and Black, 1934)
5.	Available N (kg ha ⁻¹)	178.16	180.56	Alkaline permanganate method (Subbiah and Asija, 1956)
6.	Available P (kg ha ⁻¹)	13.04	13.21	Olsen's calorimetrically method(Olsen et al., 1954)
7.	Available K (kg ha ⁻¹)	129.54	132.42	Flame photometer Ammonium acetate extract (Hanwey and Heidel, 1952)
8.	Available S (kg ha ⁻¹)	15.98	16.02	Turbidimetric (0.15 % CaCl ₂) method (Chensin and Yien, 1950)
9.	Available Zn (mg kg ⁻¹)	0.420	0.421	DTPA extraction (AAS) Lindsay and Norvell (1978)
10.	Available Fe (mg kg ⁻¹)	10.38	10.41	DTPA extraction (AAS) Lindsay and Norvell (1978)

Treatment details and design

The 11 treatments combination of nutrient management practices was laid out in randomized block design with three replications.

Table -2: detail of the treatment combinations:

S.No.	Symbols	Treatment combinations
1.	T ₁	Control

2.	T ₂	100% NPK
3.	T ₃	100 % NPK + 5 ton FYM
4.	T ₄	100 % NPK + PSB + Azotobacter
5.	T ₅	125 % NPK + PSB + Azotobacter + 5 ton FYM
6.	T ₆	100 % NPK + S ₄₀
7.	T ₇	100 % NPK + Zn ₅
8.	T ₈	100 % NPK + S ₄₀ + Zn ₅
9.	T ₉	100 % NPK + S ₄₀ + Zn ₅ + Fe ₁₀
10.	T ₁₀	100 % NPK + S ₄₀ + Zn ₅ + Fe ₁₀ + Azotobacter + PSB + 5 ton FYM
11.	T ₁₁	125 % NPK

Agronomic practices

In the experimental field, a pre-sowing irrigation (Paleva) was carried out with the goal of achieving the ideal moisture levels for achieving optimal germination. A tractor-drawn mould board plough was used for one ploughing at the proper tillage, followed by two cultivator plowings. At the time of planting, a half-dose of nitrogen and a full-dose each of phosphorus and potash were administered as a basal fertiliser in the forms of urea, DAP, and MOP, respectively. At 30 and 55 days after sowing (DAS), the remaining half dose of nitrogen was top dressed into two divided doses. To maintain a consistent plant population, the wheat cv. HD-2967 seeds were manually sown in lines at a depth of 2-3 cm of soil. The distance between the lines was 22.5 cm. To maintain a consistent plant population, the wheat cv. HD-2967 seeds were manually sown in lines at a depth of 2-3 cm of soil. The distance between the lines was 22.5 cm. FYM was applied, and the soil was treated with Azotobacter and PSB.

Harvesting and threshing: When the crop was fully grown, it was harvested and allowed to dry in the sun. Each plot received a unique bundle that was weighted. The harvest was manually threshed after drying.

Collection of data

Grain yield

Following threshing, the grain yield from each plot was individually weighed, converted to quintals per hectare, and recorded.

Straw yield

After deducting the total biological yield from the grain yield per plot. The yields were recorded after being converted into quintals per hectare.

Statistical analysis: The growth parameters and yields were measured and analysed in accordance with Gomez and Gomez (1984), and significant differences were detected using a 5% level of significance test.

Result and Discussion

Growth Parameters

Upon careful examination of the data presented in Table-3, it becomes evident that various growth parameters of wheat, including plant height upon reaching maturity, the maximum count of productive tillers, and the length of the ear, experience notable enhancements through the introduction of nitrogen, iron, zinc, sulphur, farmyard manure (FYM), Azotobacter, and phosphate-solubilizing bacteria (PSB). Over time, these growth parameters exhibit a progressive increase. The range for plant height at maturity spans from 57.41 to 101.32 cm, the spectrum of effective tillers extends from 55.82 to 103.14, and the ear's length varies between 8.57 to 11.63 cm when considering the combined data. In the second year of experimentation (2022-23), the treatment labelled as T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] is connected with the most significant outcomes in terms of growth parameters. This treatment yielded the highest plant height at maturity (102.79 cm), the greatest number of effective tillers (104.83), and the maximum ear length (11.76 cm). Conversely, during the initial year (2021-22) of the study, the treatment marked as T₁ [control] yielded the least favourable results, with the smallest plant height at maturity (54.10 cm), the lowest number of productive tillers (53.14), and the shortest spike length (8.52 cm). Similar findings were reported by Tejalben *et al.* (2017), Rathwa *et al.* (2018), Singh *et al.*, (2021), Kumar *et al.* (2022) and Choudhary *et al.* (2022)

Table-3: Effect of integrated nutrient management on growth characteristics of wheat crop

Treatments	Plant Height (cm) at Maturity stage	Number of effective tillers (mrl ⁻¹)	Ear length (cm)
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	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T₁	54.10	60.71	57.41	53.14	58.50	55.82	8.52	8.61	8.57
T₂	84.12	87.49	85.81	67.63	70.84	69.24	10.65	10.97	10.81
T₃	87.25	90.67	88.96	82.42	84.49	83.46	10.81	11.16	10.99
T₄	85.72	89.24	87.48	81.72	83.62	82.67	10.77	11.09	10.93
T₅	89.69	91.76	90.73	83.72	86.91	85.32	10.90	11.27	11.09
T₆	93.93	96.51	95.22	88.43	94.59	91.51	11.09	11.49	11.29
T₇	94.40	97.73	96.07	99.39	100.31	99.85	11.14	11.56	11.35
T₈	97.81	100.13	98.97	99.55	100.97	100.26	11.19	11.62	11.41
T₉	98.68	101.56	100.12	99.75	101.76	100.76	11.24	11.69	11.47
T₁₀	99.85	102.79	101.32	101.45	104.83	103.14	11.29	11.76	11.53
T₁₁	91.16	94.29	92.73	86.75	88.71	87.73	10.99	11.30	11.15
SE(m) ±	0.54	0.52	0.60	1.15	1.16	0.819	0.02	0.03	0.05
C.D. at 5 %	1.58	1.53	1.89	3.40	3.43	2.34	0.07	0.09	0.16

Yield Components

A rapid overview of the information presented in Table-4 reveals a distinct trend in the yield-related characteristics of wheat, including Spikelet ear⁻¹, grain ear⁻¹, and the weight of 1000 grains (in grams). This discernible enhancement in these yield-contributing factors emerges from the combined application of diverse nutrient sources. Notably elevated outcomes in terms of yield components are noted with the utilization of T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + *Azotobacter* + *PSB* + 5 ton FYM], surpassing the effects of other treatments. Upon amalgamating the data, it becomes apparent that the improvements in spikelet ear⁻¹, grain ear⁻¹, and 1000-grain weight range from 17.00 to 22.80, 35.65 to 44.57, and 34.25 to 41.65, respectively. These enhancements are notably influenced by the intervention of the T₁₀ treatment, which encompasses a comprehensive approach to nutrient management. The zenith of these yield attributing characters—spikelet ear⁻¹ (22.95), grain ear⁻¹ (46.03), and 1000-grain weight (42.13 grams)—is linked with the T₁₀ treatment during the second year of experimentation (2022-23). In contrast, the nadir of these attributes—Spikelet ear⁻¹ (16.10), Grain ear⁻¹ (34.70), and 1000-grain weight (33.41 grams)—aligns with the T₁ [Control] treatment during the inaugural year of the

study (2021-22)The results of the present investigation are also in agreement with the findings of **Tripathi et al. (2016), Patel et al. (2017), Hadis et al. (2018), Verma et al., (2022)and Kumar et al. (2022).**

Table-4: Effect of integrated management on yield attributes of wheat crop

Treatments	Spikelet ear ⁻¹			Grain ear ⁻¹			1000 Grain Weight (gm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T₁	16.10	17.89	17.00	34.70	36.60	35.65	33.41	35.09	34.25
T₂	17.98	19.35	18.67	39.76	42.99	41.38	35.40	35.97	35.69
T₃	18.84	19.22	19.03	40.23	43.42	41.83	35.93	36.84	36.39
T₄	18.43	19.10	18.77	40.13	43.15	41.64	35.53	36.24	35.89
T₅	19.29	19.67	19.48	40.63	44.09	42.36	36.98	37.16	37.07
T₆	19.86	20.27	20.07	41.93	44.30	43.12	38.19	38.36	38.28
T₇	20.21	20.59	20.40	42.30	44.77	43.54	38.31	39.46	38.89
T₈	20.53	20.77	20.65	42.67	45.11	43.89	39.86	40.12	39.99
T₉	21.12	21.64	21.38	42.82	45.26	44.04	40.42	41.65	41.04
T₁₀	22.64	22.95	22.80	43.11	46.03	44.57	41.17	42.13	41.65
T₁₁	19.59	19.97	19.78	40.80	44.21	42.51	37.71	37.99	37.85
SE(m) ±	0.14	0.16	0.25	0.11	0.10	0.25	0.19	0.21	0.25
C.D. at 5 %	0.43	0.46	0.78	0.34	0.30	0.80	0.57	0.62	0.78

Yield

An analysis of the data presented in Table-4 unmistakably reveals that within the realm of productivity parameters—namely grain yield (in quintals per hectare) and straw yield (in quintals per hectare)—notable improvements arise from the integrated application of diverse nutrient sources. Grain yield exhibited a range from 18.87 to 49.27 quintals per hectare, while straw yield displayed variation from 29.15 to 65.34 quintals per hectare. The pinnacle of both grain yield (49.93 quintals per hectare) and straw yield (67.53 quintals per hectare) aligns with the T₁₀

treatment [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + *Azotobacter* + *PSB* + 5 ton FYM] during the second year (2022-23) of experimentation. In contrast, the trough of grain yield (17.90 quintals per hectare) and straw yield (26.87 quintals per hectare) emerges from the T₁ treatment [control] during the first year (2021-22) of experimentation. The substantial upswing in both seed and straw yields, facilitated by sufficient nutrient provision, can be primarily attributed to the collective impact of an increased number of spikelet ear⁻¹, grains ear⁻¹, and a higher test weight. This is a consequence of improved movement of photosynthates from source to sink, ultimately resulting in amplified yields. The augmentation in grain yield is predominantly rooted in an abundant supply of nutrients, resulting in a heightened number of yield attributes and thus an increase in grain yield. Within this context, grain and straw yields of wheat experience significant increments due to the application of 270 kg ha⁻¹ of nitrogen and 10 t ha⁻¹ of farmyard manure (FYM), surpassing their respective controls. Furthermore, the introduction of *Azotobacter* and *PSB* inoculants further amplifies the grain and straw yields of wheat, outperforming conditions without inoculation. This can be attributed to the influence of soil treatment with bio-inoculants, which harness atmospheric nitrogen and augment nutrient supply to plants, ultimately contributing to the augmented grain and straw yields of wheat. These results also confirm the findings of *Maurya et al. (2019)*, *Singh et al., (2021)*, *Kumar et al. (2022)*, *Sirohiya et al. (2022)* and *Verma et al., (2022)*

Table-5: Effect of integrated nutrient management on yield of wheat crop

Treatments	Grain Yield (q ha ⁻¹)			Straw Yield (q ha ⁻¹)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁	17.90	19.84	18.87	26.87	31.43	29.15
T ₂	38.90	39.75	39.32	55.24	60.88	58.06
T ₃	42.23	42.29	42.26	58.06	62.63	60.35
T ₄	40.96	41.89	41.43	57.17	61.21	59.19
T ₅	42.31	42.98	42.65	59.68	63.56	61.62
T ₆	42.58	43.56	43.07	61.88	64.76	63.32
T ₇	42.95	45.08	44.02	61.96	65.01	63.49
T ₈	44.35	45.19	44.77	62.01	65.53	63.77

T₉	45.90	47.16	46.53	62.86	66.63	64.75
T₁₀	48.60	49.93	49.27	63.15	67.53	65.34
T₁₁	42.49	43.36	42.93	59.79	63.61	61.70
SE(m) ±	0.31	0.34	0.39	0.27	0.23	0.39
C.D. at 5 %	0.93	1.00	1.24	0.80	0.68	1.22

Conclusion

The present investigation underscores the advantages gained from the individual application of nitrogen, zinc, sulfur, farmyard manure (FYM), Azotobacter, and phosphate-solubilizing bacteria (PSB), alongside the recommended levels of nitrogen and potassium (N, K), in achieving enhanced growth parameters and heightened productivity in wheat cultivation. The incorporation of nitrogen, zinc, iron, sulfur, FYM, Azotobacter, and PSB has demonstrated its potential to elevate both the attributes contributing to yield and the overall yield of the wheat crop. In culmination, the study decisively supports the notion that treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] emerges as the optimal choice for augmenting the productivity of wheat cultivation. This comprehensive treatment package showcases its efficacy in promoting the growth, yield attributes, and overall yield of the wheat crop

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