



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(2): 323-328
Received: 17-11-2025
Accepted: 22-12-2025

Abhishek Tiwari
SAAST, Chhatrapati Shahu Ji
Maharaj University, Kanpur,
Uttar Pradesh, India

Shubham Bajpai
SAAST, Chhatrapati Shahu Ji
Maharaj University, Kanpur,
Uttar Pradesh, India

Saurabh Raj Pandey
Department of Agronomy, IAS,
Banaras Hindu University,
Varanasi, Uttar Pradesh, India

Pawan Kumar Verma
Department of Agronomy, IAS,
Banaras Hindu University,
Varanasi, Uttar Pradesh, India

Ambikesh Tripathi
Department of Agronomy, IAS,
Banaras Hindu University,
Varanasi, Uttar Pradesh, India

Sumit Kumar
Department of Soil Science and
Agricultural Chemistry,
CSAUA&T, Kanpur, Uttar
Pradesh, India

Kaushik Bajpai
SAAST, Chhatrapati Shahu Ji
Maharaj University, Kanpur,
Uttar Pradesh, India

Corresponding Author:
Abhishek Tiwari
SAAST, Chhatrapati Shahu Ji
Maharaj University, Kanpur,
Uttar Pradesh, India

Effect of integrated nutrients management on yield and economics of wheat (*Triticum aestivum* L.) crop in central plain zone of Uttar Pradesh

Abhishek Tiwari, Shubham Bajpai, Saurabh Raj Pandey, Pawan Kumar Verma, Ambikesh Tripathi, Sumit Kumar and Kaushik Bajpai

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i2e.4873>

Abstract

Nutrient management continues to be one of the most critical challenges in wheat-producing regions, as improper or imbalanced nutrient application often leads to poor soil health and suboptimal grain quality, ultimately affecting crop productivity and profitability. In order to address these issues, a comprehensive field experiment was conducted over two consecutive Rabi seasons, namely 2021-22 and 2022-23, at the Student Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The primary objective of this study was to evaluate the influence of integrated nutrient sources on the physico-chemical properties of soil as well as on the qualitative attributes of wheat, using pooled data from both years to ensure consistency and reliability of the results. The experiment was laid out following a randomized block design, comprising three distinct nutrient management treatments with three replications to minimize experimental error and enhance statistical validity. The findings of the study clearly indicated that the integrated application of 100% recommended doses of NPK fertilizers in combination with sulphur (40 kg ha⁻¹), zinc (5 kg ha⁻¹), iron (10 kg ha⁻¹), biofertilizers such as *Azotobacter* and phosphate-solubilizing bacteria (PSB), along with farmyard manure at the rate of 5 tonnes ha⁻¹, significantly improved wheat growth, yield attributes, grain yield, and overall economic returns. This integrated nutrient management approach proved to be superior to other treatments by enhancing nutrient availability, improving soil fertility status, and promoting sustainable wheat production across both years of experimentation.

Keywords: Wheat, zinc, iron, biofertilizers, yield and economics

Introduction

Wheat (*Triticum aestivum* L.) is the most widely consumed staple food crop of the world and ranks second after rice in India in terms of importance. It contributes nearly one-third of the total food grain production of the country and belongs to the family Poaceae (Gramineae). Globally, wheat serves as the primary food source for about two billion people, representing nearly 36% of the world's population. Wheat occupies a leading position among cereal crops worldwide with an average productivity of about 2.98 t ha⁻¹ and is consumed by nearly one-third of the global population. Globally, wheat is cultivated over an area of about 220.29 million hectares, producing nearly 780.59 million tonnes with an average productivity of 3390 kg ha⁻¹. The European Union is the largest wheat producer, followed by China, India, and the United States of America. Over the past 15 years, wheat consumption has increased continuously due to rapid population growth. Major wheat-producing countries include China, India, USA, Russia, Canada, and Australia. In India, wheat is grown on a large scale, occupying a prominent position with a production of about 109.52 million tonnes and a productivity of 3464 kg ha⁻¹, ranking second globally after China (Anonymous, 2022-23a) ^[1]. Among Indian states, Uttar Pradesh leads both in area and production of wheat, contributing approximately 30 million tonnes, followed by Punjab (16.4 million tonnes) and Haryana (11.6 million tonnes), cultivated over areas of 9.75, 3.59, and 2.52 million hectares, respectively. Despite its dominance in area and production, the productivity of wheat in Uttar Pradesh (2661 kg ha⁻¹) remains lower than the national average (Anonymous, 2022-23b) ^[1].

Wheat is nutritionally rich and serves as an excellent supplement to the human diet. It contains 8.0-15.0% protein, 60-68% starch, 1.5-2.0% fat, 2.0-2.5% cellulose, and 1.5-2.0% minerals along with vitamins, particularly B-complex and vitamin E. It is utilized both as human food and animal feed (Rueda-Ayala *et al.*, 2011) ^[9]. Wheat can be successfully cultivated across diverse soil types and climatic conditions, ranging between latitudes 30°-60° N and 27°-40° S, from sea level up to an altitude of 3658 m. In India, wheat is grown in almost all states except Kerala, with major production concentrated in Haryana, Punjab, Madhya Pradesh, and Uttar Pradesh.

Excessive and continuous use of chemical fertilizers has led to soil contamination, posing a serious threat to sustainable agricultural production. In contrast, bio-organic fertilizers are environmentally friendly and do not contribute to soil pollution (Sarker *et al.*, 2020) ^[11]. Balanced plant nutrition through organic fertilizers plays a vital role in sustainable agriculture by enhancing soil fertility, crop quality, and productivity. Growing environmental concerns and increasing demand for pesticide-free and organic food have further intensified interest in eco-friendly crop production systems (Sivakumar, 2014) ^[12]. It is well recognized that neither chemical fertilizers nor organic manures alone can sustain crop productivity under intensive agriculture due to high nutrient removal and soil degradation.

This realization has led to the adoption of Integrated Nutrient Management (INM), which involves the judicious and balanced use of chemical fertilizers along with organic manures such as farmyard manure, compost, vermicompost, green manures, micronutrient-enriched fertilizers, and bio-fertilizers including *Azotobacter*, *Azospirillum*, phosphate-solubilizing bacteria (PSB), *Rhizobium*, and potassium-mobilizing microorganisms. INM aims to maintain soil fertility and ensure optimum nutrient supply for sustained crop productivity (Ullah *et al.*, 2021) ^[13]. Wheat being a nutrient-exhaustive crop, requires a substantial supply of nutrients, particularly nitrogen, for optimum growth and yield. The combined use of organic and inorganic fertilizers improves soil organic matter, enhances microbial activity, maintains soil structure, and increases nutrient availability, ultimately promoting plant health and sustainability of the production system. Enhanced biological activity improves nutrient transformation, detoxification of harmful substances, and nutrient exchange capacity in soil (Chew *et al.*, 2019) ^[2].

Nitrogen is the most critical nutrient influencing wheat yield and quality. Efficient nitrogen management, including appropriate rate, source, and timing of application, is essential to maximize yield while minimizing fertilizer losses. Adequate nitrogen increases chlorophyll content, carbohydrate synthesis, and protein accumulation in grains. Nitrogen deficiency leads to stunted growth, yellowing of leaves, shriveled grains, and reduced yield due to poor vegetative growth and inadequate flowering. Phosphorus plays a key role in energy transfer, photosynthesis, carbohydrate metabolism, protein synthesis, nucleic acid formation, and nitrogen fixation. It enhances root growth, seed development, and maturity and strengthens stems, thereby reducing lodging. Phosphorus is often referred to as the “bottleneck of world hunger” due to its critical role in crop productivity (Kumar *et al.*, 2022) ^[4]. Potassium is essential for activating enzymes, regulating water balance, improving photosynthesis, and enhancing tolerance to drought, frost, pests, and diseases. It improves grain quality and facilitates translocation of assimilates from leaves to grains, earning its recognition as a “quality element” in crop production. Therefore, balanced application of NPK fertilizers is crucial for achieving higher wheat productivity (Jabbar *et al.*, 2009) ^[3].

Although cereals require relatively lower sulphur, sulphur deficiency has become increasingly common. Adequate sulphur nutrition improves protein quality and baking properties of wheat. Hence, balanced fertilization including sulphur is necessary to achieve higher yields. Zinc is an essential micronutrient involved in enzyme activation, DNA transcription, and grain development. Zinc application improves pollen viability, seed formation, and grain yield in wheat. Similarly, iron is vital for chlorophyll synthesis, photosynthesis, nutrient uptake, stress tolerance, and grain quality. Iron deficiency adversely affects wheat productivity and economic returns, making its balanced application essential (Saquee *et al.*, 2023) ^[10].

Biofertilizers such as *Azotobacter* and phosphate-solubilizing bacteria play a significant role in sustainable agriculture by fixing atmospheric nitrogen, solubilizing soil phosphorus, producing growth-promoting substances like indole acetic acid and gibberellins, and enhancing nutrient uptake. Seed or soil inoculation with efficient microbial strains improves root growth, nutrient use efficiency, and crop performance (Panhwar *et al.*, 2014) ^[8]. Therefore, an integrated nutrient supply system combining chemical fertilizers, organic manures, and biofertilizers is essential for sustaining wheat productivity and maintaining soil health.

Materials and Methods

The present investigation was carried out at the Student Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, during the Rabi seasons of 2021-22 and 2022-23. The experiment consisted of eleven nutrient management treatments, namely T₁ (control), T₂ (100% recommended NPK), T₃ (100% NPK + farmyard manure @ 5 t ha⁻¹), T₄ (100% NPK + phosphate-solubilizing bacteria and *Azotobacter*), T₅ (125% NPK + PSB + *Azotobacter* + FYM @ 5 t ha⁻¹), T₆ (100% NPK + sulphur @ 40 kg ha⁻¹), T₇ (100% NPK + zinc @ 5 kg ha⁻¹), T₈ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹), T₉ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹), T₁₀ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹ along with *Azotobacter*, PSB, and FYM @ 5 t ha⁻¹), and T₁₁ (125% recommended NPK). The treatments were arranged in a randomized block design with three replications to ensure precision and reduce experimental error. Prior to the initiation of the experiment, the soil of the experimental field was sandy loam in texture with an alkaline reaction, low organic carbon content, and was deficient in available nitrogen, phosphorus, and potassium at the 0-15 cm soil depth. In wheat, grain yield refers to the economic yield obtained as harvested grains from a unit area after threshing and drying, while straw yield includes stems, leaves, and chaff excluding grains; biological yield represents the total above-ground dry matter production of the crop and is calculated as the sum of grain yield and straw yield. Straw yield is obtained by subtracting grain yield from biological yield. The harvest index (HI) expresses the efficiency of the crop in converting total biomass into economic yield and is calculated as the ratio of grain yield to biological yield multiplied by 100.

$$HI (\%) = (\text{Grain yield} / \text{Biological yield}) \times 100.$$

In wheat cultivation, economic analysis is done by calculating the cost of cultivation, gross return, net return, and benefit-cost (B:C) ratio. The cost of cultivation (₹ ha⁻¹) includes all expenses incurred on land preparation, seed, fertilizers, manures, labour, irrigation, plant protection, harvesting, and threshing. Gross

return (₹ ha⁻¹) is calculated by multiplying grain yield and straw yield with their respective market prices and then summing both values. Net return (₹ ha⁻¹) is obtained by subtracting the total cost of cultivation from the gross return. The benefit-cost ratio (B:C) indicates profitability and is calculated by dividing gross return by cost of cultivation.

B:C ratio = Gross return / Cost of cultivation.

Results and Discussion

Grain Yield

The grain yield of wheat exhibited considerable variation, ranging from 17.90 to 48.60 q ha⁻¹ during the first year and from 19.84 to 49.93 q ha⁻¹ in the second year of experimentation. All nutrient management treatments recorded significantly higher grain yields compared to the control in both years of the study. Among the different treatment combinations, T₁₀ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹ along with *Azotobacter*, PSB, and farmyard manure @ 5 t ha⁻¹) emerged as the most effective treatment in terms of grain yield during both years, followed closely by T₉ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹), when compared with the control. The substantial improvement in grain yield clearly highlighted the significance of the combined application of organic manures, inorganic fertilizers, and biofertilizers. Greater variation in grain yield was observed

between the first and second years, indicating a pronounced residual effect of applied nutrients during the second year over the first, irrespective of the fertilizer treatments. However, the overall trend of treatment responses remained consistent across both years of experimentation (Kumar *et al.*, 2024) ^[5].

Straw Yield

The straw yield of wheat showed wide variation, ranging from 26.87 to 63.15 q ha⁻¹ during the first year and from 31.43 to 67.53 q ha⁻¹ in the second year of the study. All nutrient management treatments produced significantly higher straw yields than the control during both years of experimentation. Among the different treatment combinations, T₁₀ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹ along with *Azotobacter*, PSB, and farmyard manure @ 5 t ha⁻¹) recorded the highest straw yield in both years, followed closely by T₉ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹), when compared with the control treatment. The substantial enhancement in straw yield clearly demonstrated the importance of the integrated application of organic manures, inorganic fertilizers, and biofertilizers. Greater variation in straw yield was observed between the first and second years, indicating a positive residual effect of applied nutrients during the second year irrespective of fertilizer treatments. However, the overall response pattern of treatments remained similar across both years of investigation (Kumar *et al.*, 2024) ^[5].

Table 1: Effect of integrated nutrients management on grain yield (q ha⁻¹)

Treatment Symbol	Treatment Combination	Grain yield (q ha ⁻¹)		
		2021-22	2022-23	Pooled
T ₁	CONTROL	17.90	19.84	18.87
T ₂	100% NPK	38.90	39.75	39.32
T ₃	100% NPK + 5 ton FYM	42.23	42.29	42.26
T ₄	100% NPK + PSB + <i>Azotobacter</i>	40.96	41.89	41.43
T ₅	125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	42.31	42.98	42.65
T ₆	100% NPK+ S ₄₀	42.58	43.56	43.07
T ₇	100% NPK + Zn ₅	42.95	45.08	44.02
T ₈	100% NPK + S ₄₀ + Zn ₅	44.35	45.19	44.77
T ₉	100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	45.90	47.16	46.53
T ₁₀	100% NPK+ S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	48.60	49.93	49.27
T ₁₁	125% NPK	42.49	43.36	42.93
	S.E. (m) (±)	0.31	0.34	0.39
	C.D. (p = 0.05)	0.93	1.00	1.24

Biological Yield

The biological yield of wheat increased significantly under all nutrient management treatments compared to the control during both years of the study. The highest biological yield, amounting to 111.75 and 146.0 q ha⁻¹ in the first and second years, respectively, was recorded with the integrated application of 100% NPK along with sulphur @ 40 kg ha⁻¹, zinc @ 5 kg ha⁻¹, iron @ 10 kg ha⁻¹, *Azotobacter*, phosphate-solubilizing bacteria, and farmyard manure @ 5 t ha⁻¹. This treatment was closely followed by the application of 100% NPK combined with sulphur, zinc, and iron (T₉), while the lowest biological yield was observed under the control treatment. The integration of sulphur, zinc, iron, biofertilizers, and farmyard manure along

with the recommended dose of NPK resulted in a significant improvement in biological yield during both years of experimentation. Overall, all treatments were significantly superior to the control; however, the treatment combination T₁₀ (100% NPK + S₄₀ + Zn₅ + Fe₁₀ + *Azotobacter* + PSB + FYM @ 5 t ha⁻¹) proved to be the most effective in enhancing biological yield, followed by T₉ (100% NPK + S₄₀ + Zn₅ + Fe₁₀), across both years. The significant increase in biological yield clearly demonstrated the importance of the integrated use of organic manures, inorganic fertilizers, and biofertilizers. Considerable variation in biological yield was observed between the first and second years, reflecting the cumulative and residual effects of applied nutrients (Pal *et al.*, 2024) ^[7].

Table 2: Effect of integrated nutrients management on straw yield (q ha⁻¹)

Treatment Symbol	Treatment Combination	Straw yield (q ha ⁻¹)		
		2021-22	2022-23	Pooled
T ₁	CONTROL	26.87	31.43	29.15
T ₂	100% NPK	55.24	60.88	58.06
T ₃	100% NPK + 5 ton FYM	58.06	62.63	60.35
T ₄	100% NPK + PSB + <i>Azotobacter</i>	57.17	61.21	59.19
T ₅	125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	59.68	63.56	61.62
T ₆	100% NPK+ S ₄₀	61.88	64.76	63.32
T ₇	100% NPK + Zn ₅	61.96	65.01	63.49
T ₈	100% NPK + S ₄₀ + Zn ₅	62.01	65.53	63.77
T ₉	100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	62.86	66.63	64.75
T ₁₀	100% NPK+ S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	63.15	67.53	65.34
T ₁₁	125% NPK	59.79	63.61	61.70
	S.E. (m) (±)	0.27	0.23	0.39
	C.D. (p = 0.05)	0.80	0.68	1.22

Table 3: Effect of integrated nutrients management on biological yield (q ha⁻¹)

Treatment Symbol	Treatment Combination	Biological yield (q ha ⁻¹)		
		2021-22	2022-23	Pooled
T ₁	Control	44.77	51.27	48.02
T ₂	100% NPK	94.14	100.63	97.38
T ₃	100% NPK + 5 ton FYM	100.29	104.92	102.61
T ₄	100% NPK + PSB + <i>Azotobacter</i>	98.13	103.10	100.62
T ₅	125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	101.99	106.54	104.27
T ₆	100% NPK+ S ₄₀	104.46	108.32	106.39
T ₇	100% NPK + Zn ₅	104.91	110.09	107.50
T ₈	100% NPK + S ₄₀ + Zn ₅	106.36	110.72	108.54
T ₉	100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	108.76	113.79	111.28
T ₁₀	100% NPK+ S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	111.75	117.46	114.61
T ₁₁	125% NPK	102.28	106.97	104.63
	S.E. (m) (±)	0.58	0.57	0.64
	C.D. (p = 0.05)	1.73	1.67	2.02

Harvest Index

The harvest index of wheat was influenced by different nutrient management treatments and showed improvement over the control in both years of experimentation. The application of 100% NPK in combination with sulphur @ 40 kg ha⁻¹, zinc @ 5 kg ha⁻¹, iron @ 10 kg ha⁻¹ along with *Azotobacter*, PSB, and farmyard manure @ 5 t ha⁻¹ resulted in a slight but consistent increase in harvest index during both the first and second years.

The variation in harvest index between the treatments receiving 100% NPK + S₄₀ + Zn₅ + Fe₁₀ + biofertilizers + FYM and 100% NPK + S₄₀ + Zn₅ + Fe₁₀ alone was narrow yet statistically significant across both years. Overall, the harvest index values ranged from 48.02 to 114.61, indicating differential partitioning of total biomass into economic yield under various nutrient management practices (Kumar *et al.*, 2023) ^[6].

Table 4: Effect of integrated nutrients management on harvest index (%)

Treatment Symbol	Treatment Combination	Harvest Index (%)		
		2021-22	2022-23	Pooled
T ₁	Control	39.98	38.69	39.34
T ₂	100% NPK	41.32	39.50	40.41
T ₃	100% NPK + 5 ton FYM	42.11	40.31	41.21
T ₄	100% NPK + PSB + <i>Azotobacter</i>	41.74	40.63	41.18
T ₅	125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	41.48	40.34	40.91
T ₆	100% NPK+ S ₄₀	40.76	40.21	40.49
T ₇	100% NPK + Zn ₅	40.94	40.95	40.94
T ₈	100% NPK + S ₄₀ + Zn ₅	41.70	40.81	41.26
T ₉	100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	42.20	41.44	41.82
T ₁₀	100% NPK+ S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	43.49	42.51	43.00
T ₁₁	125% NPK	41.54	40.53	41.04
	S.E. (m) (±)	0.08	0.12	0.23
	C.D. (p = 0.05)	0.24	0.34	0.73

Economics

Cost of cultivation

The cost of cultivation (₹ ha⁻¹) was computed separately for each treatment. The basic or common cost of cultivation remained uniform across all treatments, as operations such as land preparation, sowing, irrigation, and plant protection measures

were carried out equally in all plots. Accordingly, the common cost amounted to ₹ 30,651 ha⁻¹ during the first year of experimentation. In contrast, the treatment cost, which included expenses incurred on nitrogen, phosphorus, potassium, sulphur, zinc, and iron fertilizers, farmyard manure, and biofertilizers such as PSB and *Azotobacter*, varied among the treatments,

while it was nil in the control treatment. The treatment cost ranged from ₹ 7,253 to ₹ 23,154 ha⁻¹, with the highest expenditure recorded under the treatment receiving 100% NPK along with sulphur @ 40 kg ha⁻¹, zinc @ 5 kg ha⁻¹, iron @ 10 kg ha⁻¹, *Azotobacter*, PSB, and FYM @ 5 t ha⁻¹ during the first year. During the second year, the common cost of cultivation increased to ₹ 33,405 ha⁻¹ across all treatments. The variable treatment cost ranged from ₹ 7,253 to ₹ 23,911 ha⁻¹, and the overall trend in cost variation among treatments remained similar to that observed during the first year.

Gross Return

The gross return (₹ ha⁻¹) was calculated by multiplying the grain and straw yields per hectare with their respective minimum support prices (MSP) as announced by the Ministry of Agriculture and Farmers' Welfare, Government of India, and subsequently summing the returns from both produce components. The gross return ranged from ₹ 54,162 to ₹ 1,40,190 ha⁻¹ during the first year and from ₹ 65,122 to ₹ 1,54,632 ha⁻¹ in the second year of experimentation. The highest gross return was recorded under treatment T₁₀ (100% NPK + sulphur @ 40 kg ha⁻¹ + zinc @ 5 kg ha⁻¹ + iron @ 10 kg ha⁻¹ along with *Azotobacter*, PSB, and FYM @ 5 t ha⁻¹), followed by treatment T₉ (100% NPK + S₄₀ + Zn₅ + Fe₁₀) throughout the study period. In contrast, the lowest gross return was obtained from the control treatment (T₁).

Net return

The net return was computed by subtracting the total cost of

cultivation incurred under each treatment from the corresponding gross return. The net return recorded under the control treatment amounted to ₹ 23,511 and ₹ 31,717 during the first and second years, respectively, which represented the lowest values among all treatments. In contrast, the highest net return of ₹ 89,209 in the first year and ₹ 99,375 in the second year was obtained with the application of 100% NPK in combination with sulphur @ 40 kg ha⁻¹, zinc @ 5 kg ha⁻¹, and iron @ 10 kg ha⁻¹. Treatments involving organic manures and biofertilizers exhibited comparatively lower net returns, as nutrients supplied through organic sources are not fully available to the crop in a single season but contribute to improved soil fertility and nutrient availability for subsequent crops.

B:C ratio

The benefit-cost (B:C) ratio data were summarized and presented in the table. During the first year of experimentation, the B:C ratio ranged from 0.76 under the control treatment to a maximum of 2.26 with the application of 100% NPK + zinc, closely followed by the 125% NPK treatment. In the second year, the B:C ratio varied from 0.94 to 2.31 across different treatments. Treatments receiving farmyard manure, *Azotobacter*, and phosphate-solubilizing bacteria recorded comparatively lower B:C ratios due to the higher cost of organic inputs and the gradual release and utilization of nutrients, which are not fully available to the crop within a single growing season. However, the residual effect of organic amendments contributes to improved soil fertility, enhanced soil biological activity, and long-term benefits for subsequent crops.

Table 5: Economic study of wheat as affected by different treatment combinations

Treatment	Cost of cultivation (Rs. ha ⁻¹)			Cost of cultivation (Rs. ha ⁻¹)			Pooled
	Common Cost	Treatment cost	Total cost	Common Cost	Treatment cost	Total Cost	
	2021-22	2021-22	2021-22	2022-23	2022-23	2022-23	
T ₁ : Control	30651	0	30651	33405	0	33405	32028
T ₂ : 100% NPK	30651	7253	37904	33405	7253	40658	39281
T ₃ : 100% NPK + 5 ton FYM	30651	14753	45404	33405	14753	48158	46718
T ₄ : 100% NPK + PSB + <i>Azotobacter</i>	30651	8113	38764	33405	8113	41518	40141
T ₅ : 125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	30651	17427	48078	33405	17427	50832	49455
T ₆ : 100% NPK + S ₄₀	30651	11953	42604	33405	12517	45922	44263
T ₇ : 100% NPK + Zn ₅	30651	8664	39315	33405	8727	42132	40724
T ₈ : 100% NPK + S ₄₀ + Zn ₅	30651	13364	44015	33405	13991	47396	45706
T ₉ : 100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	30651	14794	45445	33405	15551	48956	47201
T ₁₀ : 100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	30651	23154	53805	33405	23911	57316	55661
T ₁₁ : 125% NPK	30651	9067	39718	33405	9067	42472	41095

Table 6: Economic study of wheat as affected by different treatment combinations

Treatment	Gross Return (Rs. ha ⁻¹)			Net return (Rs. ha ⁻¹)			B:C ratio		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Control	54162	65122	59642	23511	31717	27614	0.76	0.94	0.85
T ₂ : 100% NPK	115495	125756	120626	77587	85098	81343	2.04	2.09	2.06
T ₃ : 100% NPK + 5 ton FYM	124046	135318	129682	78642	87160	82901	1.73	1.80	1.76
T ₄ : 100% NPK + PSB + <i>Azotobacter</i>	120915	133376	127146	82151	91858	87005	2.11	2.21	2.16
T ₅ : 125% NPK + PSB + <i>Azotobacter</i> + 5 ton FYM	125338	137452	131395	77260	86620	81940	1.60	1.61	1.58
T ₆ : 100% NPK + S ₄₀	127271	139581	133426	84667	93659	89163	1.98	2.03	2.05
T ₇ : 100% NPK + Zn ₅	128198	139595	133897	88883	97463	93173	2.26	2.31	2.28
T ₈ : 100% NPK + S ₄₀ + Zn ₅	130998	143481	137240	86983	96085	91534	1.97	2.02	1.99
T ₉ : 100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀	134654	148331	141493	89209	99375	94292	1.96	2.04	2.0
T ₁₀ : 100% NPK + S ₄₀ + Zn ₅ + Fe ₁₀ + <i>Azotobacter</i> + PSB + 5 ton FYM	140190	154632	147411	86385	97316	91850	1.61	1.69	1.65
T ₁₁ : 125% NPK	125771	138258	132015	85954	95786	90870	2.16	2.25	2.20

Conclusion

The study conclusively demonstrated that integrated nutrient management plays a pivotal role in enhancing soil health, wheat productivity, and profitability. Based on pooled data from two consecutive Rabi seasons (2021-22 and 2022-23), the combined application of 100% recommended NPK along with sulphur (40 kg ha⁻¹), zinc (5 kg ha⁻¹), iron (10 kg ha⁻¹), biofertilizers (*Azotobacter* and PSB), and farmyard manure (5 t ha⁻¹) proved to be the most effective nutrient management strategy. This integrated approach significantly improved soil physico-chemical properties, growth and yield attributes, grain yield, and economic returns of wheat compared to other treatments. The results highlight that balanced use of inorganic fertilizers supplemented with organic and biological sources enhances nutrient availability, sustains soil fertility, and supports environmentally sustainable wheat production under the agro-climatic conditions of central Uttar Pradesh.

References

1. Anonymous. Annual report 2022-23. New Delhi: Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture, Government of India; 2022-23.
2. Chew KW, Chia SR, Yen HW, Nomanbhay S, Ho YC, Show PL. Transformation of biomass waste into sustainable organic fertilizers. *Sustainability*. 2019;11(8):2266.
3. Jabbar A, Aziz T, Bhatti IH, Virk ZA, Khan MM. Effect of potassium application on yield and protein contents of late sown wheat (*Triticum aestivum* L.) under field conditions. *Soil & Environment*. 2009;28:193-196.
4. Kumar D, Kumar R, Pandey AK, Yadav A, Singh V, Sachan R, *et al.* Interaction effect of phosphorous and zinc on yield attributes, yield and quality characteristics of chickpea under the central plain zone of Uttar Pradesh. *Int J Plant Soil Sci*. 2022;34(24):81-89.
5. Kumar N, Bahadur R, Yadav SK, Singh SP, Singh A, Baheliya AK, *et al.* Productivity and profitability of rice (*Oryza sativa*) influenced by customized fertilizers under rice-wheat cropping system. *Indian Journal of Agronomy*. 2024;69(1):11-16.
6. Kumar N, Singh AK, Bahadur R, Kumar R, Arora S, Mehta V, *et al.* Influence of long-term integrated nutrient management on soil properties, nutrient balance and productivity of rice–wheat cropping system in Central Indo-Gangetic plains. *Journal of Soil and Water Conservation*. 2023;22(3):291-302.
7. Pal SK, Kumar N, Ram CN, Kumar D, Maurya S, Singh A, *et al.* Effect of organic, inorganic and biofertilizers on soil characteristics and potato tuber yield (*Solanum tuberosum* L.). *Journal of Scientific Research and Reports*. 2024;30(11):494-500.
8. Panhwar QA, Jusop S, Naher UA, Othman R, Razi MI. Application of potential phosphate-solubilizing bacteria and organic acids on phosphate solubilization from phosphate rock in aerobic rice. *Scientific World Journal*. 2013;2013:272409-272410.
9. Rueda-Ayala VP, Rasmussen J, Gerhards R, Fournaise NE. The influence of post-emergence weed harrowing on selectivity, crop recovery and crop yield in different growth stages of winter wheat. *Weed Research*. 2011;51:478-488.
10. Saquee FS, Diakite S, Kavhiza NJ, Pakina E, Zargar M. The efficacy of micronutrient fertilizers on the yield formulation and quality of wheat grains. *Agronomy*. 2023;13(2):566.
11. Sarker M, Choudhury S, Islam N, Zeb T, Zeb B, Mahmood Q. The effects of climatic change mediated water stress on growth and yield of tomato. *Central Asian Journal of Environmental Science and Technology Innovation*. 2020;1(2):85-92.
12. Sivakumar T. Review on Panchagavya. *International Journal of Advanced Research in Biological Sciences*. 2014;1(8):130-154.
13. Ullah S, Zhao Q, Wu K, Ali I, Liang H, Iqbal A, *et al.* Biochar application to rice with 15N-labelled fertilizers enhanced leaf nitrogen concentration and assimilation by improving morphophysiological traits and soil quality. *Saudi Journal of Biological Sciences*. 2021;28(6):3399-3413.