International Journal of Plant & Soil Science

Volume 35, Issue 18, Page 2015-2022, 2023; Article no.IJPSS.104710
ISSN: 2320-7035

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

Abhishek Tiwari [a*], Anil Kumar [a], R. K. Pathak [a], Ravindra Kumar [a], Ravindra Sachan [a], Suryabhan [b] and Himani Verma [c++]

[a] Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.)-208002, India.
[b] Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.)-208002, India.
[c] Soil and Land Use Survey of India, Ministry of Agriculture and Farmer Welfare, Noida (U.P.)–201301, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2023/v35i183557

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104710

Original Research Article

Received: 05/06/2023
Accepted: 09/08/2023
Published: 10/08/2023

[++] *Assistant field Officer;*
**Corresponding author: E-mail: abhishektiwari208002@gmail.com;*

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 T_{10} [100 % NPK + S_{40} + Zn_5 + Fe_{10} + *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 T_{10} [100 % NPK + S_{40} + Zn_5 + Fe_{10} + *Azotobacter* + *PSB* + 5 tonne FYM] during both the years of the experimentation. The objective of the study to understand how different combinations of inorganic fertilizers, organic manure, and biofertilizers affect the growth and productivity of wheat, specifically the HD-2967 variety, when grown using recommended agronomic practices.

Keywords: Azotobacter; FYM; PSB; wheat; yield; zinc.

1. 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 metric tons. of grain in 2019-20 [1]. 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 metric tons, and productivity increased from 887 to 3421 kg ha^{-1} [1].

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 [2,3,4]. 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 [5].

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. [6]. Phosphorus is the second most important mineral, making it essential for the growth of crops. According to Ziadi et al. [7], 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 [8]. 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 [9]. The baking properties of wheat and the biological value of proteins can also be improved by increasing sulphur fertilization which has reported many times [10,11].

Availability of iron plays a critical role in wheat crop productivity and economics. Ensuring an adequate supply of iron to wheat plants is essential for chlorophyll formation, photosynthesis, nutrient uptake, stress resistance, grain development, and overall yield. Iron deficiency can lead to decreased yield, lower grain quality, and additional costs associated with corrective measures. Balancing the costs of iron fertilizer application with the potential economic benefits of improved yield and grain quality is an important consideration for wheat farmers [12].

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* [13]. 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 [14]. *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium absorption by plants significantly [15].

The solubilization of applied phosphates and fixed soil P by phosphate solubilizing bacteria (PSB) has been proven to increase crop yields [16].

2. METHODS AND MATERIALS

2.1 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.

2.2 Experimental soils

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

2.3 Treatment Details and Design

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

2.4 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 bold plough was used for one ploughing at the proper tilth, followed by two cultivator ploughings. 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, Di Ammonium Phosphate, and Muriate of Potash, respectively. At 30 and 55 days after sowing (DAS), the remaining half dose of nitrogen was top dressed into two divided doses. Full dose of zinc and iron were incorporated as a basal dose in the forms of zinc oxide and iron oxide. 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.

Table 1. Analytical data of the experimental soil (pre-sowing)

S. No.	Soil characters	Value		Category	Method employed
		2021-22	2022-23		
1.	pH (1:2.5 soil water suspension)	8.14	8.15	Alkaline	Glass electrode pH meter [17]
2.	EC (dsm^{-1}) (1:2.5 soil water suspension)	0.45	0.46	Low concentration of dissolved ions	Conductivity bridge [17]
3	Mechanical analysis			Good drainage and aeration status	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	Low	Chromic acid digestion [18]
5.	Available N (kg ha^{-1})	178.16	180.56	Low	Alkaline permanganate method [19]
6.	Available P (kg ha^{-1})	13.04	13.21	Medium	Olsen's calorimetrically method [20]
7.	Available K (kg ha^{-1})	129.54	132.42	Low	Flame photometer Ammonium acetate extract [21]
8.	Available S (kg ha^{-1})	15.98	16.02	Low	Turbidimetric (0.15% $CaCl_2$) method (Chensin and Yien, 1950)
9.	Available Zn (mg kg^{-1})	0.420	0.421	Low	DTPA extraction (AAS) Lindsay and Norvell [22]
10.	Available Fe (mg kg^{-1})	10.38	10.41	Low	DTPA extraction (AAS) Lindsay and Norvell [22]

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

2.5 Collection of Data

2.5.1 Grain yield

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

2.5.2 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 [23], and significant differences were detected using a 5% level of significance test.

3. RESULTS AND DISCUSSION

3.1 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 T_{10} [100 % NPK + S_{40} + Zn_5 + Fe_{10} + *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 T_1 [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. [24], Rathwa et al. [25], Singh et al. [26,27], Kumar et al. [28,29] and Choudhary et al. [30].

3.2 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 T_{10} [100 % NPK + S_{40} + Zn_5 + Fe_{10} + *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 T_{10} 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 T_{10} 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 T_1 [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. [31], Patel et al. [32], Hadis et al. [33], Verma et al. [34,35] and Kumar et al. [28,29].

3.3 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 T_{10} treatment [100 % NPK + S_{40} + Zn_5 + Fe_{10} + *Azotobacter* + *PSB* + 5 ton FYM] during the second year (2022-23) of experimentation. In contrast, the trough of grain yield (17.90 quintals

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)		
	2021-22	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
T_1	54.10	60.71	57.41	53.14	58.50	55.82	8.52	8.61	8.57
T_2	84.12	87.49	85.81	67.63	70.84	69.24	10.65	10.97	10.81
T_3	87.25	90.67	88.96	82.42	84.49	83.46	10.81	11.16	10.99
T_4	85.72	89.24	87.48	81.72	83.62	82.67	10.77	11.09	10.93
T_5	89.69	91.76	90.73	83.72	86.91	85.32	10.90	11.27	11.09
T_6	93.93	96.51	95.22	88.43	94.59	91.51	11.09	11.49	11.29
T_7	94.40	97.73	96.07	99.39	100.31	99.85	11.14	11.56	11.35
T_8	97.81	100.13	98.97	99.55	100.97	100.26	11.19	11.62	11.41
T_9	98.68	101.56	100.12	99.75	101.76	100.76	11.24	11.69	11.47
T_{10}	99.85	102.79	101.32	101.45	104.83	103.14	11.29	11.76	11.53
T_{11}	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**

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
T_1	16.10	17.89	17.00	34.70	36.60	35.65	33.41	35.09	34.25
T_2	17.98	19.35	18.67	39.76	42.99	41.38	35.40	35.97	35.69
T_3	18.84	19.22	19.03	40.23	43.42	41.83	35.93	36.84	36.39
T_4	18.43	19.10	18.77	40.13	43.15	41.64	35.53	36.24	35.89
T_5	19.29	19.67	19.48	40.63	44.09	42.36	36.98	37.16	37.07
T_6	19.86	20.27	20.07	41.93	44.30	43.12	38.19	38.36	38.28
T_7	20.21	20.59	20.40	42.30	44.77	43.54	38.31	39.46	38.89
T_8	20.53	20.77	20.65	42.67	45.11	43.89	39.86	40.12	39.99
T_9	21.12	21.64	21.38	42.82	45.26	44.04	40.42	41.65	41.04
T_{10}	22.64	22.95	22.80	43.11	46.03	44.57	41.17	42.13	41.65
T_{11}	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**

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
T_9	45.90	47.16	46.53	62.86	66.63	64.75
T_{10}	48.60	49.93	49.27	63.15	67.53	65.34
T_{11}	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**

per hectare) and straw yield (26.87 quintals per hectare) emerges from the T_1 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. This might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favourable increase in yield attributing characters which ultimately led towards an increase in economic yield Singh et al. [26,27]. These results also confirms the findings of Maurya et al. [36], Kumar et al. [28,29], Sirohiya et al. [37] and Verma et al. [34,35], [38-41].

4. 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 T_{10} [100% NPK + S_{40} + Zn_5 + Fe_{10} + *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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Agricultural statistics at a glance 2020. Directorate of economics & statistics, department of agriculture, cooperation and farmers welfare. New Delhi: Ministry of Agriculture & Farmers Welfare, Govt of India. 2020;63.
2. Rakshit A, Sarkar NC, Sen D. Influence of organic manures on productivity of two varieties of rice. J Cent Eur Agric. 2008;9(4):629-34.
3. Parewa HP, Yadav J, Rakshit A. Effect of fertilizer levels, FYM and bioinoculants on soil properties in inceptisol of Varanasi, Uttar Pradesh, India. Int J Agric Environ Biotechnol. 2014;7(3):517-25.
4. Ullah N, Ditta A, Imtiaz M, Li X, Jan AU, Mehmood S, et al. Appraisal for organic amendments and plant growth-promoting rhizobacteria to enhance crop productivity under drought stress: A review. J Agron Crop Sci. 2021;207(5):783-802.
5. 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.
6. Andrews M, Lea PJ, Raven JA, Lindsey K. Can genetic manipulation of plant nitrogen assimilation enzymes result in increased crop yield and greater N-use efficiency. An assessment. Ann Appl Biol. 2004;145(1):25-40.
7. Ziadi N, Bélanger G, Cambouris AN, Tremblay N, Nolin MC, Claessens A. Relationship between phosphorus and nitrogen concentrations in spring wheat. Agron J. 2008;100(1):80-6.
8. Mehrvarz S, Chaichi MR. Effect of phosphate solubilizing microorganisms and phosphorus chemical fertilizer on forage and grain quality of barely (*Hordeum vulgare* L.). Am-euros. J Agric Environ Sci. 2008;3(6):855-60.
9. Jabbar AT, Aziz IH, Bhatti ZA, Virk MM. Khan and Wasl-u-Din. Soil Environ. Effect of potassium application on yield and protein contents of late sown wheat (*Triticum aestivum* L.) under field conditions. 2009;28(2):193-6.
10. Marschner H. Sulfur supply, plant growth, and plant composition. In mineral nutrition of higher plants. Cambridge: Academic press. 1997;261-5.
11. Järvan ML, Lukme, Akk A. The effect of sulphur on biological quality of protein and baking properties of winter wheat. Trans ERIA. 2006;71:123-8.
12. 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.
13. Yasari E, Patwardhan AM. Effects of Azotobacter and Azospirillum inoculations and chemical fertilizers on growth and productivity of Canola. Asian J Plant Sci. 2007;6:77-82.
14. Salantur A, Ozturk A, Akten S. Growth and yield response of spring wheat (*Triticum aestivum* L.) to inoculation with rhizobacteria. Plant Soil Environ. 2006;52(3):111-8.
15. Agrawal N, Singh HP, Savita US. Effect of Azotobacter inoculation and graded doses of nitrogen on the content, uptake and yield of wheat in a mollisol. Indian J Agric Res. 2004;38:288-92.
16. Panhwar QA, Naher UA, Shamshuddin J, Othman R, Latif MA, Ismail MR. Biochemical and molecular characterization of potential phosphate-solubilizing bacteria in acid sulfate soils and their beneficial effects on rice growth. PLOS ONE. 2014;9(10):e97241.
17. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd; 1973.
18. Walkley A, Black IA. Old piper, S.S. soil and plant analysis. Soil Sci. 1934;37(1):29-38.
19. Subbiah BV, Asija CL. A rapid procedure for the estimation of available N in Soil. Curr Sci. 1956;25:259-60.
20. Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. USDA Cric. 1954;930:19-23.
21. Hanway JJ, Heidel H. Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. Iowa Agric. 1952;54:1-31.
22. Lindsay WL, Norvell W. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci Soc Am J. 1978;42(3):421-8.
23. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley & Sons; 1984.

24. Tejalben P, Patel KC, Patel VN. Effect of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.). Int J Chem Stud. 2017;5(4):1366-9.
25. Rathwa PG, Mevada KD, Ombase KC, Dodiya CJ, Bhadu V, Purabiya VS et al. Integrated nitrogen management through different sources on growth and yield of wheat (*Triticum aestivum* L.). J Pure Appl Microbiol. 2018;12(2):905-11.
26. Singh AP, Yadav DD, Pyare R, Kumar A, Naresh R, Sachan R, et al. Impact of methods of sowing, FYM and seed treatment on growth, yield attributes, grain yield and quality of late sown wheat (Triticum aestivum L.). The Pharm Innov J. 2021;10(11):373-6.
27. Singh AP, Yadav DD, Siddiqui MZ, Kumar S, Singh V, Chandel RS, et al. Effect of FYM, methods of sowing and seed treatment on growth, yield attributes, yield and net return of late sown wheat (Triticum aestivum L.). The Pharm Innov J. 2021;10(11):458-60.
28. Kumar A, Dimree S, Sachan R, Shekhar C, Gangwar K, Kumar M. Effect of FYM and zinc on growth, yield attributes and productivity parameters of wheat (*Triticum aestivum* L.). Asian J Microbiol Biotechnol Environ Sci. 2022;24, No. (4):20-3 ISSN-0972-3005.
29. Kumar P, Dubey SD, Sachan R, Rawat CL, Kumar V. Effect of organic manure, inorganic fertilizers and biofertilizers on nutrient content of maize (*Zea mays* L.) and their residual effect on succeeding wheat (*Triticum aestivum* L.) crop. International Journal of Plant & amp. Soil Sci. 2022;34(20):817-27:Article no.IJPSS.89229ISSN: 2320-7035.
30. Choudhary L, Singh KN, Gangwar K, Sachan R. Effect of FYM and Inorganic fertilizers on growth performance, yield components and yield of wheat (*Triticum aestivum* L.) under Indo-gangetic plain of Uttar Pradesh. The Pharm Innov J. 2022;11(4):1476-9.
31. Tripathi SC, Chander S, Meena RP. Maximizing wheat yield through integrated use of farmyard manure and fertilizers. SAARC J Agric. 2016;14(1):103-10.
32. Patel TG, Patel KC, Patel VN. Effect of integrated nutrient management on yield attributes and yield of wheat (*Triticum aestivum* L.). Int J Chem Stud. 2017;5(4):1366-9.
33. Hadis M, Meteke G, Haile W. Response of bread wheat to integrated application of vermicompost and NPK fertilizers. Afr J Agric Res. 2018;13(1):14-20.
34. Verma H, Pathak RK, Kumar A, Sachan R, Pandey HP, Tiwari A et al. Effect of integrated nutrient management on growth parameters, yield components and yield of wheat (*Triticum aestivum* L.) under central plain zone of Uttar Pradesh. Int J Plant Soil Sci. 2022;34(23):1050-7.
35. Verma H, Pathak RK, Kumar A, Sachan R, Pandey HP, Tiwari A et al. Effect of inorganic fertilizers, organic manure and bioinoculant on production and economics of wheat (*Triticum aestivum* L.). Int J Environ Clim Change. 2022;12(11):3716-24.
36. Maurya RN, Singh UP, Kumar S, Yadav AC, Yadav RA. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). Int J Chem Stud. 2019;7(1):770-3.
37. Sirohiya A, Kumar A, Pathak RK, Sachan R, Tiwari A, Nema S et al. Effect on organic manure and inorganic fertilizers on productivity parameters and quality traits of wheat (*Triticum aestivum* L.) under central plain zone of Uttar Pradesh. Int J Environ Clim Change. 2022;12(11):1197-202:Article no.IJECC.90083 ISSN: 2581-8627.
38. Chaudhary SK, Thakur SK, Pandey AK. Response of wetland rice to nitrogen and zinc. Oryza. 2007;44(1):31-4.
39. Chensin L, Yien CH. Turbidimetric determination of available sulphates. Soil Sci Soc Am Proc. 1951;15:149-51.
40. Patyal A, Shekhar C, Sachan R, Kumar D, Yadav A, Kumar G. Effect of integrated nutrient management (INM) on growth parameters and yield of wheat (*Triticum aestivum* L.). Int J Plant Soil Sci. 2022; 34(22):962-7.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104710