

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 conducted to study the effect of integrated nutrient management on growth parameters, yield components and yield of wheat during rabi season of 2021 and 2022 at students instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The experiment consisted of 11 treatment combinations in randomized block design with three replications. The treatments consisted of different combinations of inorganic fertilizer, organic manure and biofertilizer. Wheat variety HD-2967 was grown with the recommended agronomic practices. On the basis of results emanated from investigation it can be concluded that among the growth parameters maximum plant height at maturity is 99.85 cm and 102.79 cm, maximum number of effective tillers is 101.45 and 104.83 and 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 ton FYM] during the both years of experimentation. Similarly, among the yield components and productivity parameters maximum values in relation to 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) were found in the treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] during both the years of the experimentation.

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

Introduction

Wheat (*Triticum aestivum* L.) is most staple and second most important crop after rice of the country which contribute nearly one third of total food grain production. It belongs to grass family *Poaceae* (*Graminae*).

Wheat being an energy rich winter cereal contributes around 35 % to the food grain basket of the country. Globally wheat (*Triticum aestivum* L.) is grown in 124 countries and occupied an area of about 215 million hectares with a production of 734.50 [mt.](#) of grain during 2019-20 (Anonymous, 2020). In India the area under wheat increased since the start of green revolution

Comment [GZ1]: What is your justification/gab for this research, and final recommendation (should be comprehensive)

Comment [GZ2]: What does it mean?

in 1967 and the production and productivity also increased. The area under wheat increased from 12.8 mha. In 1966-67 to 31.45 mha. in 2019-20. In this period production has also increased from 11.4 to 107.59 mt. and the productivity was increased from 887 to 3421 kg ha⁻¹(Anonymous, 2020).

Comment [GZ3]: Mha in...

Integrated Nutrient Management (INM) promotes the use of balanced and judicious use of chemical fertilizers in conjunction with manures like compost, farm yard manure, vermicomposting, green manures and use of fertilizers fortified with micro-nutrients, use of bio-fertilizers (*phosphate solubilizing bacteria, Azospirillum, Azotobacter, Rhizobium, and Potash mobilizing bio-fertilizers*) in order to maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity (Rakshit *et al.* 2008; Parewa *et al.* 2014; Ullah., *et al.* 2021). In this quest, using the right proportion of organic and inorganic fertilizer is crucial for maintaining soil health as well as enhancing output. For growth and productivity, wheat, a significant cereal crop, needs a strong supply of nutrients, particularly nitrogen. Soil remediation using organic fertilizers can be considered a useful way to improve the sustainability of agricultural systems. The use of organic fertilizers, soil organic matter and nutrients increase the growth and activity of microorganisms and by maintaining the structure of the soil provides a good substrate for growth, and helps keep the plant healthy. Increasing biological activity improves nutrients from chemicals, organics sources and decomposition of toxic substances and nutrient exchange capacity (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 critical mineral for plants which is necessary for crop production. Phosphorus is essential for enhancing seed maturity and seed development (Ziadi *et al.* 2008). Phosphorus plays a significant role in several vital functions such as photosynthesis, transformation of sugar to starch, protein information, nucleic acid production, nitrogen fixation and formation of oil. It is also, the part of all biochemical cycles in plants (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.*,

Comment [GZ4]: decreases (Andrews *et al.*, 2004

Comment [GZ5]: do you mean by protein formation??

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).

Zinc is also reported as an important micronutrient for wheat production because it is required in a large number of enzymes and plays an essential role in DNA transcription. It is reported that high amount of zinc is contained in pollen and mostly zinc is inverted to seed only during seed formation and an application of zinc improves grain formation (Choudhary *et al.*, 2007).

Biofertilizer are able to fix atmospheric nitrogen in the available form for plant and have beneficial effect upon plant growth by production of antibiotic. Azotobacter is used as biofertilizer in the cultivation of most crop (Yasari *et al.*, 2007). An improvement in crop performance might be attributed to the N₂-fixing and phosphate solubilising capacity of *Azotobacter* as well as the ability of these microorganisms to produce growth promoting substances (Salantur *et al.*, 2006). *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly (Agrawal *et al.*, 2004).

Phosphate solubilizing bacteria (PSB) as bio-fertilizers have been found effective in solubilizing the fixed soil P and applied phosphates resulting in higher crop yields (Panhwar *et al.*, 2014).

Resources and Methods

Experimental Site

The experiment was conducted during *rabi* season of 2021 and 2022 at student's Instructional farm, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). The field was well leveled and irrigated by tube well. The farm is situated at main campus of the university, in the west northern part of Kanpur city under sub-tropical zone in vth agroclimatic zone (central plain zone).

Edaphic Condition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 8.14 and 8.15 (1:2.5 soil: water suspension method given by Jackson, 1973), electrical conductivity 0.45 and 0.46 dSm⁻¹ (1:2.5 soil: water suspension method given by Jackson, 1973), Organic carbon percentage in soil is 0.35 and 0.36 per cent (Walkley and Black's rapid titration method

Comment [GZ6]: What about Fe??

Comment [GZ7]: In your introduction part, you have to justify the reason for doing the research eg soil fertility problem? yield gap to be fulfilled by your research findings

Comment [GZ8]: Geographic location, map(sudy site, elevation, RF, Temp...)

given by **Walkley and Black, 1934**), with available nitrogen 178.16 and 180.56 kg ha⁻¹ (Alkaline permanganate method given by **Subbiah and Asija, 1956**), available phosphorus as sodium bicarbonate-extractable P was 13.04 and 13.21 kg ha⁻¹ (Olsen's calorimetrically method, **Olsen et al., 1954**) available potassium was 129.54 and 132.42kg ha⁻¹ (Flame photometer method given by **Hanwey and Heidel, 1952**), available sulphur was 15.98 and 16.02kg ha⁻¹ (Turbidimetric method given by **Chensin and Yien, 1951**) and available zinc was 0.420 and 0.421 ppm (DTPA extraction method given by (**Lindsay and Norvell, 1978**) and available iron was 12.38 and 12.45 ppm (DTPA extraction method given by (**Lindsay and Norvell, 1978**)).

Comment [GZ9]: Categorical/classification description (high or low nutrient status for your site...)

Detail of treatments and design

The 11 treatments combination of nutrient management practices of inorganic fertilizer (Urea, **DAP, MOP**, Elemental sulphur, Zinc oxide and Iron oxide), Organic manure (FYM) and Biofertilizer (*Azotobacter* and PSB). Experiment was laid out in randomized block design with three replications.

Comment [GZ10]: What does it mean (make it full)

Table -1: 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

Crop Husbandry

A pre-sowing irrigation (Paleva) was done in the experimental field with an object to get optimum moisture conditions for attaining good germination. At proper tilth, one ploughing with tractor drawn mould board plough was done followed by two ploughings by cultivator. Half dose of Nitrogen together with full dose of Phosphorus, Potash were applied as basal at the time of sowing in the form of Urea, DAP and MOP respectively. Remaining half dose of nitrogen was top dressed in two split doses at 30 and 55 days after sowing (DAS). The sowing of seeds of wheat cv. HD-2967 was done by line sowing by hand at 2-3 cm depth of soil and with line to line spacing of 22.5 cm to maintain uniform plant population. Application of FYM and Soil treatment with *Azotobacter* and *PSB* was done.

Comment [GZ11]: Make it full

Comment [GZ12]: What does it mean?

Comment [GZ13]: What about the application of micronutrients (Fe, Zn...) should be incorporated here

Harvesting and threshing: the crop was harvested at maturity and was allowed to dry in sun. Separate bundles were made for each plot and weighted. The after drying harvest was threshed manually.

Data Collection

Grain yield

After threshing the grain yield from each plot was separately weighed and recorded after converting into quintals per hectare.

Comment [GZ14]: Needs rewrite or rephrase it

Straw yield

After subtracting the grain yield per plot from the total biological yield. After converting the yields into quintals per hectare, yields were recorded.

Comment [GZ15]: Needs rephrase delete one of the word 'after'

Statistical analysis: The growth parameters and yields were recorded and analyzed as per Gomez and Gomez (1984) the tested at 5% level of significance to interpret the significant differences.

Comment [GZ16]: what software did you use here??? Eg SAS, GMP...

Comment [GZ17]: Please Rephrase it and make it to give sense

Result and Discussion

Growth Parameters

A critical perusal of the data given in Table-2 clearly shows that among the growth parameters of wheat such as plant height (cm) at maturity, maximum number of effective tillers¹ and ear length significantly increase due to the application of nitrogen, Iron, Zinc, Sulphur, FYM, *Azotobacter* and *PSB*. Growth parameters also increased with lapse of time. Plant height at maturity varied from 57.41-101.32 cm, maximum number of effective tillers varied from 55.82-103.14 and ear

Comment [GZ18]: .

length varied from 8.57-11.63 cm on pooled basis. Maximum plant height (102.79cm) at maturity, maximum number of effective tillers(104.83) and maximum ear length (11.76 cm) was associated with the treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] during the second year (2022-23) of experimentation. Minimum plant height (54.10 cm) at maturity, minimum number of effective tiller¹(53.14) and spike length (8.52 cm) was associated with the treatment T₁ [control] during the first year (2021-22) of experimentation. The growth parameters of wheat might be increased due to integrated use of organic, inorganic and biofertilizers. Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers. *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly. The consequences of the current investigation are additionally in concurrence with the investigation of *Tejalben et al. (2017), Rathwa et al. (2018), Singh et al., (2021), Kumar et al. (2022) and Choudhary et al. (2022)*

Comment [GZ19]: Repeatable word (varied)???

Comment [GZ20]: Describe their findings here

Table-2: Effect of different treatment combination on growth parameters of wheat

Treatments	Plant Height (cm) at Maturity			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

Yield Components

At a glance over the data given in the Table-3 clearly shows that among the yield attributing characters of wheat such as Spikelet ear⁻¹, Grain ear⁻¹ and 100 grain weight (gm) significantly increase due to integrated use of different nutrient sources. Significantly higher response on yield components was recorded with T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] over other treatments. The Spikelet ear⁻¹, Grain ear⁻¹ and 100 grain weight (gm) increased to the magnitude of 17.00 to 22.80, 35.65 to 44.57 and 34.25 to 41.65 respectively, on pooled basis. Maximum number of spikelet ear⁻¹ (22.95), number of grain ear⁻¹ (46.03) and 100 grain weight (42.13gm) was associated with the treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] during the second year (2022-23) of experimentation. Minimum number of Spikelet ear⁻¹ (16.10), number of grain ear⁻¹ (34.70) and 100 grain weight (33.41gm) was associated with the treatment T₁ [Control] during the first year (2021-22) of experimentation. 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).

Comment [GZ21]: Best if described by %

Comment [GZ22]: What they said/found, describe it, it looks general or blind

Table-3: Effect of different treatment combinations on yield components of wheat

Treatments	Spikelet ear ⁻¹			Grain ear ⁻¹			100 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

Productivity Parameters

It is visualized from the data given in Table-4 clearly indicate that among the productivity parameters viz. grain yield (q ha⁻¹) and straw yield (q ha⁻¹) significantly increase due to the integrated use of different nutrient sources. Grain yield varied from 18.87 to 49.27 q ha⁻¹, straw yield varied from 29.15 to 65.34q ha⁻¹. The maximum grain yield (49.93 q ha⁻¹), straw yield (67.53q ha⁻¹) was associated with the treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] during the second year (2022-23) of experimentation. The minimum grain yield (17.90 q ha⁻¹), straw yield (26.87 q ha⁻¹) was found under the treatment T₁ [control] during the first year (2021-22) of experimentation. The surge in seed and straw yields under adequate nutrients supply might be attributed to mainly to the collective effect of a greater number of spikelet ear⁻¹, grains ear⁻¹ and higher test weight, which was the result of improved translocation of photosynthates from source to sink ultimately yield is increased. The increase in grain yield under adequate nutrients supply mainly due to more yield attributes ultimately resulted more grain yield. Grain and straw yield of wheat significantly increased due to nitrogen 270 (kg ha⁻¹) and FYM(10t ha⁻¹) over their controls. Inoculation of Azotobacter and PSB further increased grain & straw yield of wheat significantly over without inoculation. It may due to treatment of soil with bio-inoculant which fix atmospheric nitrogen and increased the supply of other nutrients to plants and ultimately increased grain and strawyield of wheat. These results also confirms 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-4: Effect of different treatment combinations on productivity parameters of wheat

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	41.78	40.34	55.24	60.88	58.06
T ₃	42.23	42.29	42.26	58.06	62.63	60.35

Comment [GZ23]: What about the residual effect of the 1st year on the 2nd year (did you mean you never apply any fertilizer in the 2nd year or? this comment is for all tables or research results

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

Conclusion

The current study demonstrate the benefit of nitrogen, Zinc, Sulphur, FYM, Azotobacter and PSB alone with recommended N, K for achieving higher growth parameters and productivity by wheat crop. Application of nitrogen, Zinc, Iron, Sulphur, FYM, Azotobacter and PSB increased yield attributes and yield of wheat crop. Finally it can be concluded that the treatment T₁₀ [100 % NPK + S₄₀ + Zn₅ + Fe₁₀ + Azotobacter + PSB + 5 ton FYM] is a best option for improving productivity of wheat crop.

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Comment [GZ24]: 1. It very shallow and without any recommendation
2. no cost benefit analysis here (you have to go for analyses of return against all your treatments)
3. what about the effect of treatments on soil nutrient status after harvest??) and final remarks of your research

Comment [GZ25]: Best if your references are from all corners of the glob to be comprehensive

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Comment [GZ26]: Finally, you have to check for consistency of using language and rephrase it to be suitable for readers