



Effect of Integrated Nutrient Management on Growth Parameters, Yield Components and Yield of Wheat (*Triticum aestivum* L.) under Central Plain Zone of Uttar Pradesh

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Authors' contributions

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

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ABSTRACT

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 2020-21 and 2021-22 at students instructional farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The experiment consisted of 10 treatment combinations in randomized block design with three replications consisted of different combination 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 was 109.25 cm and 110.12, maximum number of effective tillers is 352.67 and 355.72 and maximum spike length is 13.55 cm and 13.79 cm are associated with the treatment T₁₀ [100%NPK + FYM + S₃₀+ Zn₅ +Azotobacter + PSB] during the both years of experimentation. Similarly, among the yield components and productivity parameters maximum values in relation to number of spikelet ear⁻¹, grain ear⁻¹, 1000 grain wt. (gm), grain yield (q ha⁻¹) and straw yield (q ha⁻¹) were found in the treatment T₁₀ [100%NPK+FYM+S₃₀+Zn₅+Azotobacter+PSB].

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1. INTRODUCTION

“Wheat being an energy rich winter cereal contributes around 35% to the food grain basket of the India. 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” [1]. “In India the area under wheat increased since the start of green revolution in 1967 and the production and productivity also increased. 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” [2]. “Wheat (*Triticum aestivum* L.) is one of the major cereal crops with a unique protein, which is consumed by humans and is grown around the world in different environments” [3]. “Wheat is foremost among cereals as a main source of carbohydrates and protein for both human beings and animals; contains starch (60-90%), protein (11-16.5%), fat (1.5-2%), inorganic ions(1.2-2%) and vitamins (B complex and vitamin E)” [4].

There are many reasons of low productivity of wheat out of which imbalance and excess fertilizer application is major one and changes in physico-chemical composition of the soil, a depletion and diminution in bioavailability of soil nutrients, a scarcity of good groundwater, buildup of pests and attack of various diseases of wheat greatly affected its yield and quality. “Injudicious application of chemical fertilizers not only harms the biological power of soil but also decreases the soil fertility and crop productivity” [5,6]. “Thus, integrated nutrient management advocates balanced and conjoint use of inorganic fertilizer, organic manure, and bio-inoculants in order to maintenance or adjustment of soil fertility and plant nutrient supply to an optimum level for sustaining desired crop productivity” [7,6].

“Nitrogen (N) is major factor for yield of wheat. The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield. Wheat is an important cereal crop and requires a good supply of nutrients especially nitrogen for its growth and yield” [8]. “Nitrogen rate, type of nitrogen, and timing of its application are important factors to increase wheat yield” [9]. “Some studies showed that N fertilization increases the total quantity of flour

proteins, resulting in an increase in both gliadins and glutenin” [10].

“Phosphorus is essential for enhancing seed maturity and seed development” [11]. “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” [12].

“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. Therefore, potassium known as "quality element" and it was considered as a key factor in crop production” [13].

“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” [14].

“Generally, crops needs less sulphur like cereals, still start suffering more and more from sulphur deficiency even there are some crops which need more sulphur as well” [15]. The baking properties of wheat and the biological value of proteins can also be improved by increasing sulphur fertilization which has reported many times [16].

“Judicious use of FYM with chemical fertilizers improves soil physical, chemical and biological properties and improves the crop productivity” [17]. “Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers” [18].

“The need of the hour is to evolve an integrated plant nutrient supply system, comprising balanced use of chemical fertilizer, organic manures and bio-fertilizers. 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" [19]. "Azotobacter and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly" [20]. "Wheat poses problem for the establishment of Azotobacter in its rhizosphere. The inoculation of crop plants with bacterial preparation is recommended because a selective and compatible strain is supposed to accelerate plant growth" [21]. "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" [22].

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted during *rabi* season of 2020-21 and 2021-22 at student's Instructional farm, Chandra Shekhar Azad 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 central plain zone of Uttar Pradesh.

2.2 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 8.13 (1:2.5 soil: water suspension method given by [23]), electrical conductivity 0.45 and 0.44 dSm⁻¹ (1:2.5 soil: water suspension method given by Jackson, [23]), Organic carbon percentage in soil is 0.42 and 0.43 per cent (Walkley and Black's rapid titration method given by Walkley and Black, [24]), with available nitrogen 193.0 and 195.0 kg ha⁻¹ (Alkaline

permanganate method given by Subbiah and Asija, [25]), available phosphorus as sodium bicarbonate-extractable P was 12.84 and 12.86 kg ha⁻¹ (Olsen's calorimetrically method, Olsen et al., [26]) available potassium was 146.76 and 148.52 kg ha⁻¹ (Flame photometer method given by Hanwey and Heidel, [27]), available sulphur was 8.5 and 8.6 kg ha⁻¹ (Turbidimetric method given by Chensin and Yien, [28]) and available zinc was 0.53 and 0.54 ppm (DTPA extraction method given by [29]).

2.3 Detail of Treatments and Design

The 10 treatments combination of nutrient management practices of inorganic fertilizer (Urea, Diammonium phosphate and Murate of potash), Organic manure (FYM) and Biofertilizer (*Azotobacter* and PSB). Experiment was laid out in randomized block design with three replications.

2.4 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 bold 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 into 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.

Table 1. Detail of the treatment combinations

S. No.	Symbols	Treatment combinations
1.	T ₁	CONTROL
2.	T ₂	50%NPK OF R.D.F.
3.	T ₃	75%NPK OF R.D.F.
4.	T ₄	100% NPK OF R.D.F.
5.	T ₅	125% NPK OF R.D.F.
6.	T ₆	100%NPK+FYM
7.	T ₇	100%NPK+FYM+S ₃₀
8.	T ₈	100%NPK+FYM+S ₃₀ +Zn ₅
9.	T ₉	100%NPK+FYM+S ₃₀ +Zn ₅ + <i>Azotobacter</i>
10.	T ₁₀	100%NPK+FYM+S ₃₀ +Zn ₅ + <i>Azotobacter</i> + PSB

R.D.F. - Recommended dose of fertilizer; FYM- Farm yard manure; PSB- Phosphate solubilizing bacteria

2.4.1 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.

2.5 Data Collection

2.5.1 Plant height

The observation for plant height (cm) was registered on at harvest. Five plants were selected and tagged randomly in each plot and the periodical plant height was recorded from them. The height was measured from the soil surface to the tip of tallest leaf before emergence of ear and up to tip of the spike excluding awns after heading.

2.5.2 Number of tiller plant⁻¹

The total number of tillers from each of one metre length from each net plot were counted. The average number of tillers metre⁻¹ row length were computed by dividing number of tillers excluding the main shoot by the number of main tillers recorded at harvest.

2.5.3 Spike length (cm)

The length of panicle was measured from basal to tip of the panicle excluding awns from five randomly selected plants. The mean length of panicle was worked out in cm.

2.5.4 Grain yield

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

2.5.5 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.

2.6 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.

3. RESULTS AND DISCUSSION

3.1 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 tiller¹ and spike length significantly increase due to the application of nitrogen, Zinc, Sulphur, FYM, *Azotobacter* and PSB. Growth parameters also increased with lapse of time. Plant height at maturity varied from 91.19-109.68 cm maximum number of effective tillers varied from 284.61-354.10 and spike length varied from 9.52-13.67 cm on pooled basis. Maximum plant height (110.12 cm) at maturity, maximum number of effective tillers (355.72) and maximum spike length (13.79 cm) was associated with the treatment T₁₀ [100% NPK + FYM + S₃₀+ Zn₅ +*Azotobacter* + PSB] during the second year (2021-22) of experimentation. Minimum plant height (91.12 cm) at maturity, minimum number of effective tiller¹ (283.58) and spike length (9.40 cm) was associated with the treatment T₁ [control] during the first year (2020-21) of experimentation. The growth parameters of wheat might be increased due to Nitrogen (N) is major factor for yield of wheat. The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield 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 .The baking properties of wheat and the biological value of proteins can also be improved by increasing sulphur fertilization which has reported many times application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers. Organic materials, such FYM and their continuous use have a strong influence on soil productivity and N dynamics in the soil-plant system. *Azotobacter* and graded doses of nitrogen increase phosphorus and potassium uptake by plants significantly. Wheat poses problem for the establishment of *Azotobacter* in its rhizosphere. 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. The consequences of the current investigation are additionally in concurrence with the investigation of Agrawal et al. [20], Jarvan et al. [16], Choudhary et al. [30], Panhwar et al. [22] and Choudhary et al. [14].

3.2 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 the application of Nitrogen, Zinc, Sulphur, FYM, *Azotobacter* and PSB. Significantly response on yield components was recorded with T₁₀ [100%NPK + FYM + S₃₀+ Zn₅ +*Azotobacter* + PSB] over other treatments. The Spikelet ear⁻¹, Grain ear⁻¹ and 100 grain weight (gm) increased to the magnitude of 36.97 to 45.56, 4.36 to 6.6 and 59.4 to 67.65 respectively, on pooled basis. Maximum number of spikelet ear⁻¹ (22.93), number of grain ear⁻¹ (3.32) and 100 grain weight (33.91 gm) was associated with the treatment T₁₀ [100%NPK + FYM + S₃₀+ Zn₅ +*Azotobacter* + PSB] during the second year (2021-22) of experimentation. Minimum number of Spikelet ear⁻¹ (18.34), number of grain ear⁻¹ (2.17) and 100 grain weight (29.51 gm) was associated with the treatment T₁ [Control] during the first year (2020-21) of experimentation. The results of the present investigation are also in agreement with the findings of Shaharoona et al. [31], Prasad et al. [32], Mahato and Kafle [33], Yadav et al. [34], Rathwa et al. [35], Maurya et al. [36] and Kumar et al. [37].

3.3 Productivity Parameters

It was 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 application of Nitrogen, Zinc, Sulphur, FYM,

Azotobacter and PSB. Grain yield varied from 30.31 to 54.21 q ha⁻¹, straw yield varied from 45.51 to 76.86 q ha⁻¹. The maximum grain yield (50.94 q ha⁻¹), straw yield (76.86 q ha⁻¹) was associated with the treatment T₁₀ [100%NPK + FYM + S₃₀+ Zn₅ +*Azotobacter* + PSB] during the second year (2021-22) of experimentation. The minimum grain yield (30.31 q ha⁻¹), straw yield (45.51 q ha⁻¹) was found under the treatment T₁ [control] during the first year (2020-21) of experimentation during the second 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 and FYM (10 t 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 straw yield of wheat. These results also confirms the findings of Kumar et al. [38], Yadav et al. [34], Yadav et al. [38], Kumar et al. [40], and Sirohiya et al. [41].

Table 2. Effect of different treatment combination on growth parameters of wheat

Treatments	Plant Height (cm) at Maturity			Number of effective tillers			Spike length (cm)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T ₁	91.12	91.25	91.19	283.58	285.63	284.61	9.40	9.65	9.52
T ₂	93.46	93.57	93.52	288.65	291.47	290.06	10.25	10.56	10.41
T ₃	95.52	95.64	95.58	292.71	295.56	294.14	10.65	10.92	10.79
T ₄	97.87	97.98	97.93	298.62	301.24	299.93	11.12	11.32	11.22
T ₅	99.74	99.86	99.80	315.26	318.69	316.98	11.96	12.10	12.03
T ₆	98.42	98.55	98.49	305.39	307.42	306.41	11.52	11.98	11.75
T ₇	101.45	101.52	101.49	322.48	325.54	324.01	12.13	12.56	12.35
T ₈	103.76	103.84	103.80	335.47	337.67	336.57	12.68	12.92	12.80
T ₉	106.48	106.62	106.55	343.19	346.96	345.08	13.16	13.62	13.39
T ₁₀	109.25	110.12	109.68	352.67	355.72	354.10	13.55	13.79	13.67
SE(m) ±	1.31	0.73	0.86	3.02	4.82	5.80	0.21	0.21	0.21
C.D. at 5 %	3.93	2.17	2.57	9.04	14.43	17.38	0.64	0.64	0.62

Table 3. Effect of different treatment combinations on yield components of wheat

Treatments	Spikelet ear ⁻¹			Grain ear ⁻¹			100 Grain Weight (gm)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T ₁	18.34	18.63	36.97	2.17	2.19	4.36	29.51	29.89	59.4
T ₂	18.62	18.86	37.48	2.38	2.40	4.78	30.12	30.45	60.57
T ₃	18.91	19.11	38.02	2.73	2.76	5.49	30.65	30.89	61.54
T ₄	19.19	19.63	38.82	2.89	2.92	5.81	31.10	31.35	62.45
T ₅	19.56	19.89	39.45	2.95	2.98	5.93	31.64	31.93	63.57
T ₆	19.82	20.16	39.98	2.98	3.07	6.05	32.15	32.42	64.57
T ₇	20.19	20.56	40.75	3.05	3.09	6.14	32.68	32.80	65.48
T ₈	20.52	20.75	41.27	3.14	3.18	6.32	32.00	33.12	65.12
T ₉	21.11	21.63	42.74	3.22	3.26	6.48	33.45	33.65	67.1
T ₁₀	22.63	22.93	45.56	3.28	3.32	6.6	33.74	33.91	67.65
SE(m) ±	0.21	0.37	0.37	0.39	0.40	0.22	0.46	0.51	0.48
C.D. at 5 %	0.63	1.10	1.11	1.17	1.19	0.67	1.39	1.51	1.44

Table 4. Effect of different treatment combinations on productivity parameters of wheat

Treatments	Grain Yield (q ha ⁻¹)			Straw Yield (q ha ⁻¹)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T ₁	30.31	31.15	30.73	45.51	46.45	45.98
T ₂	33.23	33.79	33.51	50.21	51.65	50.93
T ₃	36.12	36.95	36.15	53.13	54.19	53.66
T ₄	40.32	40.51	36.54	55.18	56.91	56.05
T ₅	42.15	42.46	40.42	59.23	60.25	59.74
T ₆	46.20	46.66	42.31	62.52	63.96	63.24
T ₇	47.82	48.21	46.43	65.25	66.56	65.91
T ₈	48.33	48.85	48.02	72.52	73.21	72.87
T ₉	50.13	50.94	48.59	75.85	76.86	76.36
T ₁₀	53.79	54.21	50.54	80.76	81.35	81.06
SE(m) ±	0.57	0.63	0.67	0.61	1.02	1.05
C.D. at 5 %	1.71	1.87	2.01	1.83	3.05	3.15

4. 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, Sulphur, FYM, *Azotobacter* and PSB increased yield attributes and yield of wheat crop. Finally it can be concluded that the treatment T₁₀ [100%NPK + FYM + S₃₀+ Zn₅ +*Azotobacter* + PSB] is a best option for improving productivity of wheat crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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