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Harish Kumar

Ph.D. Scholar (Soil Science) College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Kiranpreet Kaur

M.Sc. (Soil Science and Agriculture Chemistry), College of Agriculture, Punjabi University Patiala, Punjab, India

Ajaypal

Ph.D. Scholar (Soil Science) College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Avinesh Kumar

Ph.D. Scholar (Agronomy) College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Aaradhana Verma

Ph.D. Scholar (Soil Science) College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Corresponding Author:

Harish Kumar

Ph.D. Scholar (Soil Science) College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Influence of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.)

Harish Kumar, Kiranpreet Kaur, Ajaypal, Avinesh Kumar and Aaradhana Verma

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Abstract

Wheat is world's one of the most important cereal crops, yet its production greatly threatened by soil degradation, nutrient loss and climate change. To study the influence of INM practices on growth, yield, soil properties, nutrient uptake and content of wheat (*Triticum aestivum* L.) under alluvial clay loam soil, a field experiment was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab during Rabi season of 2022-23. The experiment was laid out using a Randomized Block Design (RBD) with 3 replications and 11 treatments on wheat var. DBW-187. The result revealed that amongst the treatments INM treatment T₁₁- RDF (100%) + VC @5 t ha⁻¹ + FYM @10 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ recorded superior growth attributes viz. plant height (104.17 cm), dry matter accumulation (669.89 g) and leaf area index (7.67), yield attributes viz. spike length (14.45 cm), effective tillers (379.67 m⁻²), no. of grains spike⁻¹ (49.61) and test weight (44.71 g) and yields viz grain yield (52.97 q ha⁻¹), straw yield (79.89 q ha⁻¹), biological yield (132.89 q ha⁻¹) and harvest Index (41.25%) over all treatments. However, on yield basis T₇- RDF (75%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ recorded higher yield over T₃- RDF (100%), highlights the potential of INM in reducing dependency on synthetic fertilizers.

Keywords: Integrated nutrient management, azotobacter, FYM, vermicompost and wheat

Introduction

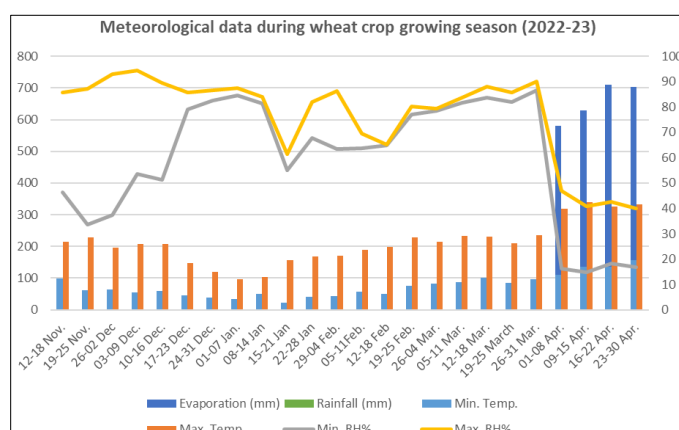
Wheat (*Triticum aestivum* L.) is one of the major staple crops of India, contributing approximately 35% to the country's food basket (Singh *et al.* 2023) [13]. Belonging to the family Poaceae, wheat is widely used in bakery products such as bread, flour, pasta, biscuits, cakes, porridge, halwa, and most commonly, chapattis. Its high protein content, primarily gluten, makes it essential for baking and earns it the title "king of cereals." A key challenge in wheat production is enhancing grain yield while maintaining protein quality.

India is second globally in wheat output, producing the crop on 31.8 million hectares and yielding 95 million metric tons (Bahaudin *et al.* 2022) [2]. Wheat is cultivated over more than 3.5 million hectares in Punjab. Uttar Pradesh ranks first in cultivated area, succeeded by Madhya Pradesh and Punjab, although Punjab excels in production (4531 kg ha⁻¹), followed by Haryana (4066 kg ha⁻¹) (Gulati, 2021) [4]. Wheat is as a functional source of energy and nutrients for around 55% of the global population. It is cultivated as bread wheat, durum, and dicoccum, contingent upon climatic circumstances and demographic requirements. Macronutrients, including N, P, and K, together with secondary nutrients such as S, Ca, Mg, and micronutrients like Zn and B, are vital for wheat yield and quality. Wheat grains include 12% protein, 2.7% minerals, 2% fiber, 1.7% fat, and 60–70% carbohydrates, yielding 327 kcal per 100 g, along with vital elements including dietary fiber, manganese, phosphorus, and niacin (Yadav *et al.* 2022) [14]. INM i.e. organic, inorganic, and biofertilizer sources to augment soil fertility, crop productivity, and environmental sustainability. INM enhances fertility of soil, alleviates nutrient inadequacies, and augments nutrient and water utilization efficiency. Integrating farmyard manure (FYM) with chemical fertilizers improves dry matter productivity, grain output, and straw yield (Lamichhane *et al.* 2022) [9]. Biofertilizers, such as nitrogen-fixing bacteria i.e. *Azotobacter* (AZB) promote plant development, and boost soil health. AZB can fix 20–30 kg of nitrogen per hectare, improving effective tillers, grain count per ear, ear length, and total yield (Aasfar *et al.* 2021) [1]. FYM enhances soil fertility and growth

attributes of plant resulting in augmented nutrient absorption and productivity (Bashir *et al.* 2021) [3]. Vermicompost (VC), generated via the bio-oxidation of organic matter by earthworms and microorganisms, enriches soil with nutrients and beneficial bacteria, hence increasing wheat yield (Lirikum *et al.* 2022) [10]. The prudent use of organic and inorganic fertilizers within INM mitigates the drawbacks of exclusive chemical fertilizer application and fosters sustainable wheat cultivation. The current research was examined the effect of INM on plant growth, yield attributes and yields of wheat.

Materials and Methods

During Rabi season of 2022-23, a field experiment was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab. The study aimed to evaluate the influence of INM practices on soil properties, plant growth, and yield performance of wheat (*Triticum aestivum* L.) under alluvial clay loam soil. The experiment was laid out using a Randomized Block Design (RBD) with 3 replications on wheat var. DBW-187. A total of 11 treatments were evaluated, namely: T₁ (Control), T₂ (RDF 75%), T₃ (RDF 100%), T₄ (RDF 75% + FYM 10 t ha⁻¹), T₅ (RDF 75% + VC 5 t ha⁻¹), T₆ (RDF 100% + VC 5 t ha⁻¹ + *Azotobacter* 6 kg ha⁻¹), T₇ (RDF 75% + VC 5 t ha⁻¹ + *Azotobacter* 6 kg ha⁻¹), T₈ (RDF 50% + VC 5 t ha⁻¹ + *Azotobacter* 6 kg ha⁻¹), T₉ (RDF 50% + FYM 10 t ha⁻¹), T₁₀ (RDF 75% + *Azotobacter* 6 kg ha⁻¹), and T₁₁ (RDF 100% + VC 5 t ha⁻¹ + FYM 10 t ha⁻¹ + *Azotobacter* 6 kg ha⁻¹). The experimental soil was moderate fertile had pH (8.13), organic carbon (0.63%), EC (0.78 dS m⁻¹), available nitrogen (295.85 kg ha⁻¹), available phosphorus (295.85 kg ha⁻¹) and available potash (295.85 kg ha⁻¹). The climate of Fatehgarh Sahib is warm and temperate type, the meteorological data recorded at the meteorological observatory of the Mata Gujri College, Fatehgarh Sahib, Punjab during the crop growing season (November-April). The area enjoyed the total rainfall (40.05 mm), minimum temperature (16.38 °C), maximum temperature (37.59 °C), maximum RH (40.1 to 94.4%) and minimum RH (14.7 to 86.6%). The seeds were sown at the rate of 90 kg ha⁻¹ using line sowing, ensuring a depth of 4-5 cm keeping inter row spacing 22.5cm. The recorded data statically analysed by using MS-Excel and OPSTAT. The treatment means was subjected to analysis of variance as described by Panse and Sukhatme (2000) for Randomised Block Design and critical difference (CD) was work out at 0.05 level of significance for comparison.



Results and Discussion

Growth attributes

The data presented in Table 1 revealed that the maximum plant height (104.17 cm) was recorded in T₁₁ - RDF (100%) + VC @ 5

t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ which was at par with T₆- RDF (100%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ i.e. 101.57 cm. The minimum plant height (79.67 cm) was recorded in T₁-control plot. The maximum dry matter accumulation (669.89 g) was recorded in T₁₁- RDF (100%) + VC @5 t ha⁻¹ + FYM @10 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ which was at par with the application of T₆ - RDF (100%) + VC @5 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ i.e. 661.81 g. The minimum dry matter accumulation (198.49 g) was recorded in T₁- control. Similarly, the maximum leaf area index (7.67) was recorded in T₁₁- RDF (100%) + VC @5 t ha⁻¹ + FYM @10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ which was at par with T₆-RDF (100%) + VC @5 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ i.e. 7.11. The minimum leaf area index (3.01) was recorded in T₁- control. These results might be due to application of inorganic fertilizers along with organic sources increases nutrient supply and rapid conversion of carbohydrates in to protein which is turn elaborated in to protoplasm. Also, readily available nitrogen and other essential nutrients produced taller plants and a greater number of effective tillers plant⁻¹ produced more dry matter. Moreover, organic manure and *Azotobacter* delivered more nutrients, plants may have taken up and moved them better. It greatly increased plant growth and nutrient usage. Nutrients improve growth and yield These results are in close conformity with the findings of Reddi and Patil (2003) [12], Rathwa *et al.*, (2018) [11] Hadis *et al.*, (2018) [6] and Gupta *et al.*, (2023) [5].

Yield attributes and yields

The data presented in Table 2 showed that the maximum length of spike (14.45 cm) was recorded in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ and minimum length of spike (9.13 cm) was recorded in T₁-control. The maximum number of effective tillers (379.67 m⁻²) are produced in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ which was at par with T₆-RDF (100%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ i.e. 373.57 m⁻². The minimum number of effective tillers (308.33 m⁻²) was recorded in T₁-control treatment. the maximum number of grains spike⁻¹ (49.61) was recorded in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ which was at par with T₆-RDF (100%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ i.e. 47.93. The minimum number of grains spike⁻¹ (32.23) was recorded in T₁-control. Similarly, the maximum test weight (47.71 g) was recorded in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ and the minimum test weight (20.23 g) was recorded in T₁-control.

The data presented in Table 3 showed that all the integrated nutrient management treatment significantly influenced the yields as compared to control except harvest index. Maximum grain yield (52.97 q ha⁻¹) was recorded in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹, which was statistically at par with T₆- RDF (100%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ i.e. 50.03 q ha⁻¹ and minimum grain yield (20.15 q ha⁻¹) was recorded in T₁-control. However, in case of maximum straw yield (79.89 q ha) was recorded in T₁₁- RDF (100%) + VC @5 t ha⁻¹ + FYM @10 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ which was statistically at par with T₆ - RDF (100%) + VC @5 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ i.e. 71.25 q ha⁻¹ and minimum straw yield (47.43 q ha⁻¹) was recorded in T₁-control. Maximum biological yield (132.89 q ha⁻¹) was recorded in T₁₁- RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹, which was statistically at par with T₆-RDF (100%) + VC @ 5 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ i.e.121.29 q ha⁻¹ and minimum biological yield (75.59 q ha⁻¹) was recorded in T₁-control.

Similarly, maximum harvest index (41.25%) was recorded in T₁₁-RDF (100%) + VC @ 5 t ha⁻¹ + FYM @ 10 t ha⁻¹ + *Azotobacter* @ 6 kg ha⁻¹ and minimum harvest index (37.23%) was recorded in T₁-control. The higher yield attributes and yields is maybe due to additional supply of nutrients through FYM, vermicompost and *Azotobacter* which might have increased nutrient uptake and better translocation of nutrients. The minimum yields were recorded under control treatment (T₁) which was attributed due to fewer nutrients available to crop plants and poor yield attributing characters. In cereal cultivation, Khayat, (2021) [8] found that chemical fertilizers with vermicompost, FYM, and AZB boosted

grain and biological yields Nitrogen role in the plant body may explain the growth character increase. N's main job is to help cells divide, develop, and become different tissues. When N is sufficient, plants grow taller, develop more tillers, and produce more dry weight per hectare. Because nitrate reductase is a key component of amino acids, which form protein molecules, increased N concentrations may make it difficult to synthesize protein in seeds. These results are in close conformity with the findings of Reddi and Patil (2003) [12], Gupta *et al.*, (2023) [5], Kaur *et al.*, (2019) [7].

Table 1: Influence of integrated nutrient management on growth attributes

	Treatments	Plant height at harvest	Dry matter accumulation at harvest	Leaf area index at harvest
T ₁	Control	79.67	198.49	3.01
T ₂	RDF (75%)	91.23	424.07	3.97
T ₃	RDF (100%)	98.23	630.55	6.03
T ₄	RDF (75%) + FYM @ 10 t ha ⁻¹	92.93	493.09	4.33
T ₅	RDF (75%) + VC @ 5 t ha ⁻¹	96.83	601.13	5.43
T ₆	RDF (100%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	101.57	661.81	7.11
T ₇	RDF (75%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	99.85	645.97	6.53
T ₈	RDF (50%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	89.27	332.85	3.61
T ₉	RDF (50%) + FYM @ 10 t ha ⁻¹	87.87	249.07	3.23
T ₁₀	RDF (75%) + <i>Azotobacter</i> @ 6 kg ha ⁻¹	94.11	555.81	4.75
T ₁₁	RDF (100%) + VC @ 5 t ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	104.17	669.89	7.67
	SE (m)±	1.10	7.83	0.36
	CD (0.05)	3.25	23.11	1.07

Table 2: Influence of integrated nutrient management on yield attributes

	Treatments	Length of spike (cm)	Effective tillers m ⁻²	No. of grains spike ⁻¹	Test weight (g)
T ₁	Control	9.13	308.33	32.23	40.23
T ₂	RDF (75%)	10.99	334.17	39.05	42.93
T ₃	RDF (100%)	12.95	361.13	44.59	44.31
T ₄	RDF (75%) + FYM @ 10 t ha ⁻¹	11.53	340.11	40.49	43.61
T ₅	RDF (75%) + VC @ 5 t ha ⁻¹	12.39	354.27	43.09	44.03
T ₆	RDF (100%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	13.87	373.57	47.93	44.63
T ₇	RDF (75%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	13.51	367.21	45.97	44.33
T ₈	RDF (50%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	10.57	327.87	37.89	42.57
T ₉	RDF (50%) + FYM @ 10 t ha ⁻¹	9.97	322.07	36.73	42.01
T ₁₀	RDF (75%) + <i>Azotobacter</i> @ 6 kg ha ⁻¹	11.93	346.83	41.67	43.87
T ₁₁	RDF (100%) + VC @ 5 t ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	14.45	379.67	49.61	44.71
	SE (m)±	1.12	3.43	0.79	0.60
	CD (0.05)	NS	10.11	2.34	NS

Table 3: Influence of integrated nutrient management on yields

	Treatments	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest Index (%)
T ₁	Control	28.15	47.43	75.59	37.23
T ₂	RDF (75%)	38.31	60.01	99.23	38.60
T ₃	RDF (100%)	46.27	67.97	114.23	40.50
T ₄	RDF (75%) + FYM @ 10 t ha ⁻¹	39.59	60.95	101.19	39.10
T ₅	RDF (75%) + VC @ 5 t ha ⁻¹	44.35	66.11	110.45	40.16
T ₆	RDF (100%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	50.03	71.25	121.29	40.93
T ₇	RDF (75%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	48.21	69.93	118.13	40.83
T ₈	RDF (50%) + VC @ 5 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	37.07	58.91	96.05	38.56
T ₉	RDF (50%) + FYM @ 10 t ha ⁻¹	35.23	56.99	92.19	38.21
T ₁₀	RDF (75%) + <i>Azotobacter</i> @ 6 kg ha ⁻¹	41.69	61.59	101.71	39.87
T ₁₁	RDF (100%) + VC @ 5 t ha ⁻¹ + FYM @ 10 t ha ⁻¹ + <i>Azotobacter</i> @ 6 kg ha ⁻¹	52.97	79.89	132.89	41.25
	SE (m)±	0.98	1.17	1.59	0.92
	CD (0.05)	2.90	3.45	4.68	NS

Conclusion

From the above result it can be conclude that amongst the

treatments INM treatment T₁₁- RDF (100%) + VC @5 t ha⁻¹ + FYM @10 t ha⁻¹ + *Azotobacter* @6 kg ha⁻¹ recorded superior

growth attributes viz. plant height (104.17 cm), dry matter accumulation (669.89 g) and leaf area index (7.67), yield attributes viz. spike length (14.45 cm), effective tillers (379.67m^{-2}), no. of grains spike⁻¹ (49.61) and test weight (44.71 g) and yields viz grain yield (52.97 q ha^{-1}), straw yield (79.89 q ha^{-1}), biological yield (132.89 q ha^{-1}) and harvest Index (41.25%) over all treatments. However, on yield basis T₇- RDF (75%) + VC @ 5 t ha^{-1} + *Azotobacter* @ 6 kg ha^{-1} recorded higher yield over T₃-RDF (100%), highlights the potential of INM in reducing dependency on synthetic fertilizers.

Conflict of Interest

All the author declares that there is no conflict of interest related to this article.

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