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Yield attributes and yield formation of wheat (*Triticum aestivum* L.) as influenced by tillage, hydrogel and integrated nutrient management (INM)

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ABSTRACT

Triticum aestivum L. is a hexaploid species that evolved through natural hybridization involving diploid and tetraploid ancestors (Dubcovsky & Dvorak, 2007). In India, the Government of India (GoI) estimates wheat production at approximately 117-118 million tonnes during the agricultural year 2024-25. Tillage, hydrogel and Integrated Nutrient Management (INM) are important agronomic interventions that can influence the yield potential of wheat (*Triticum aestivum* L.) by modifying the soil-water-nutrient environment. The combined optimization of these practices can promote yield-attributing traits and yield formation of wheat (*Triticum aestivum* L.). The field experiment was conducted at the Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (208002), Uttar Pradesh, India. The experiment was carried out during two consecutive Rabi seasons of 2024-25 and 2025-26, for which, Wheat variety "DBW-187" (Karan Vandana) is used with Split Plot Design, comprising four main plot factors i.e., Tillage practices (T): Conventional Tillage (15 cm) (T_1), Deep Tillage (25 cm) (T_2), Conventional Tillage (15 cm) + Pusa Hydrogel 5 kg ha⁻¹ (T_3) and, Deep Tillage (25 cm) + Pusa Hydrogel 5 kg ha⁻¹ (T_4) and six sub-plot factors i.e., Integrated Nutrient Management (N): 100% Recommended dose of NPK (120:60:40 kg ha⁻¹) (N_1), 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ (N_2), 100% Recommended dose of NPK + Farm Yard Manure @ 20 t ha⁻¹ (N_3), 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ + FYM @ 20 t ha⁻¹ (N_4), 75% Recommended dose of NPK + Farm Yard Manure @ 20 t ha⁻¹ (N_5) and 75% Recommended dose of NPK + FYM @ 20 t ha⁻¹ + Vermicompost @ 8 t ha⁻¹ (N_6) making total combination of twenty-four treatments which replicated thrice. Study was conducted considering, Length of Spikes (cm), Number of Spikes (m⁻²), Number of Grains (Spike⁻¹), Weight of Spike (m⁻²) and Test Weight (g), yield attributing characters. Result indicates that, Deep tillage (25 cm) + Pusa Hydrogel 5 kg ha⁻¹ (T_4) generally recorded the highest yield attributes and grain yield, whereas, Conventional Tillage (15 cm) (T_1) recorded the lowest. INM treatments showed variable responses, with 75% Recommended dose of NPK + FYM @ 20 t ha⁻¹ + Vermicompost @ 8 t ha⁻¹ (N_6) and 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ + FYM @ 20 t ha⁻¹ (N_4) performing better for several yield attributing traits.

Keywords: Wheat, Tillage, Hydrogel, INM, Yield Attributes and Yield Formation

1. Introduction

Triticum aestivum L. is a hexaploid species that evolved through natural hybridization involving diploid and tetraploid ancestors (Dubcovsky *et al.*, 2007) [1]. It is an annual herbaceous plant characterized by hollow stems (culms), narrow leaves, and a terminal spike composed of spikelets. Each spikelet contains several florets that develop into grains (Bonjean *et al.*, 2001) [2]. Global wheat production has shown an increasing trend in recent years. According to estimates by the Food and Agriculture Organization (FAO, 2025) [3] and the International Grains Council (IGC, 2025) [4], world wheat production in 2025 is projected at 796-810 million tonnes, compared with approximately 787 million tonnes in 2024. In India, the Government of India (GoI) estimates wheat production at approximately 117-118 million tonnes during the agricultural year 2024-25.

Tillage is a fundamental agronomic practice that alters the physical environment of the soil and consequently influences crop establishment, root system development and subsequent crop growth. Variations in tillage depth and intensity can modify soil structure, bulk density, porosity, aeration, water infiltration and soil moisture distribution, thereby regulating the availability of water and nutrients within the rhizosphere. Appropriate tillage practices facilitate favorable soil conditions for root proliferation, crop establishment, tiller initiation and dry matter accumulation, ultimately contributing to improved growth and development of wheat. Hydrogel is a superabsorbent polymer capable of absorbing, storing and gradually releasing water within the soil, thereby enhancing soil moisture availability in the crop root zone. Its incorporation into soil can improve soil water retention and reduce fluctuations in moisture content, creating a more favorable wa

ter regime for crop growth. Enhanced water availability may promote root growth and activity, nutrient acquisition, plant height, tiller formation, leaf development and dry matter production. Therefore, hydrogel application has considerable potential to improve wheat growth and development, particularly under conditions of inadequate or erratic water supply. Integrated Nutrient Management (INM) refers to the balanced and efficient integration of inorganic fertilizers with organic nutrient sources such as farmyard manure (FYM) and vermicompost to maintain soil fertility and meet crop nutrient requirements. The combined application of organic and inorganic nutrient sources can enhance nutrient availability, improve soil fertility and nutrient-use efficiency, and support sustained crop productivity. Appropriate INM practices can consequently promote vegetative growth, tiller production, leaf development and dry matter accumulation, thereby improving the overall growth dynamics and productivity of wheat. Tillage, hydrogel and Integrated Nutrient Management (INM) are important agronomic interventions that can influence the yield potential of wheat (*Triticum aestivum* L.) by modifying the soil-water-nutrient environment. Appropriate tillage facilitates favorable soil physical conditions and root development, while hydrogel enhances soil water retention and moisture availability in the rhizosphere. INM ensures a balanced supply of nutrients through the integration of inorganic fertilizers with organic sources, thereby improving nutrient availability and use efficiency. The combined optimization of these practices can promote yield attributing traits and yield formation of wheat (*Triticum aestivum* L.).

2. Materials and methods

2.1. Experimental site

The field experiment was conducted at the Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (208002), Uttar Pradesh, India. The experimental site is located at 26.49° North latitude and 80.29° East longitude, with an altitude of approximately 125.9 m above mean sea level. The region falls under the Central Plain Zone (Agro-climatic zone- III) of Uttar Pradesh and is characterized by a subtropical climate with hot summers and cool winters.

2.2. Treatment details and experimental design

The experiment was carried out during two consecutive *Rabi* seasons of 2024-25 and 2025-26, for which, Wheat variety "DBW-187" (Karan Vandana) is used with Split Plot Design as described by Gomez *et al.* (1984) [5], comprising four main plot factors i.e., Tillage practices (T): Conventional Tillage (15 cm) (T₁), Deep Tillage (25 cm) (T₂), Conventional Tillage (15 cm) + Pusa Hydrogel 5 kg ha⁻¹ (T₃) and, Deep Tillage (25 cm) + Pusa Hydrogel 5 kg ha⁻¹ (T₄) and six sub-plot factors i.e., Integrated Nutrient Management (N): 100% Recommended dose of NPK (120:60:40 kg ha⁻¹) (N₁), 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ (N₂), 100% Recommended dose of NPK + Farm Yard Manure @ 20 t ha⁻¹ (N₃), 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ + FYM @ 20 t ha⁻¹ (N₄), 75% Recommended dose of NPK + Farm Yard Manure @ 20 t ha⁻¹ (N₅) and 75% Recommended dose of NPK + FYM @ 20 t ha⁻¹ + Vermicompost @ 8 t ha⁻¹ (N₆) making total combination of twenty-four treatments which replicated thrice.

2.3. Yield attributing characters

2.3.1. Length of spikes (cm)

Five plants were randomly selected and tagged from each plot for recording spike length. At physiological maturity, spike length was measured in centimetres from the base to the tip of the spike using a metre scale.

2.3.2. Number of spikes (m⁻²)

The number of effective spikes was determined by counting all spikes within a 1 m² area of each plot at maturity. The observations were expressed as number of spikes m⁻².

2.3.3. Number of grains (spike⁻¹)

Five spikes were randomly selected from each plot at maturity, and the number of grains per spike was determined manually after threshing. The mean value was expressed as number of grains spike⁻¹.

2.3.4. Weight of spike (m⁻²)

Spike weight was determined by harvesting all spikes from a 1 m² area of each plot at maturity and weighing them using a digital balance. The observations were expressed as gm⁻².

2.3.5. Test weight (g)

Test weight was determined by randomly selecting and counting 1000 grains from each plot at harvest, followed by weighing them on a digital balance. The test weight was expressed in grams (g).

3. Result and discussion

3.1. Length of spikes (cm)

The data presented in Table 01. and Fig. 01. represents that, at harvest, spike length during 2024-25 was highest under T₄ (13.77) and lowest under T₁ (10.78), with tillage having a significant effect. Among INM treatments, N₆ recorded the highest spike length (12.75), while N₄ and N₅ recorded the lowest (12.23); however, the INM effect and Tillage × INM interaction were non-significant. In 2025-26, spike length was highest under T₄ (13.94) and lowest under T₁ (10.86), with a significant tillage effect. Among INM treatments, N₂ recorded the highest value (12.98) and N₄ the lowest (12.35), while the effects of INM and Tillage × INM interaction remained non-significant.

3.2. Number of spikes (m⁻²)

The data presented in Table 01. and Fig. 01. represents that, at harvest, the number of spikes during 2024-25 was highest under T₄ (458.39) and lowest under T₁ (375.72), with a significant effect of tillage. Among INM treatments, N₃ recorded the highest number of spikes (433.67) and N₄ the lowest (407.83); however, the INM effect and Tillage × INM interaction were non-significant. In 2025-26, T₄ recorded the highest number of spikes (470.94) and T₁ the lowest (381.72), with tillage having a significant effect. Among INM treatments, N₃ recorded the highest value (448.42) and N₄ the lowest (419.17), while the effects of INM and Tillage × INM interaction remained non-significant.

3.3. Number of grains (spike⁻¹)

The data presented in Table 01. and Fig. 01. represents that, at harvest, the number of grains per spike during 2024-25 was highest under T₄ (58.28) and lowest under T₁ (45.83), with a significant effect of tillage. Among INM treatments, N₂ recorded the highest value (54.08) and N₄ the lowest (51.50); however, the INM effect and Tillage × INM interaction were non-significant. In 2025-26, T₄ recorded the highest number of grains per spike (60.67) and T₁ the lowest (47.94), with a significant tillage effect. Among INM treatments, N₂ recorded the highest value (56.67) and N₆ the lowest (53.25), the INM effect was non-significant, whereas the Tillage × INM interaction was found to be significant, which was represented in interaction Table 03.

3.4. Weight of spike (m⁻²)

The data presented in Table 02. and Fig. 01. represents that, at harvest, spike weight during 2024-25 was highest under T₄ (406.33) and lowest under T₁ (318.17), with a significant effect of tillage. Among INM treatments, N₆ recorded the highest spike weight (374.67) and N₁ the lowest (350.00); however, the INM effect and Tillage × INM interaction were non-significant. In 2025-26, T₄ recorded the highest spike weight (409.06) and T₁ the lowest (317.56), with a significant tillage effect. Among INM treatments, N₆ recorded the highest value

(374.42) and N₁ the lowest (350.00), while the effects of INM and Tillage × INM interaction remained non-significant.

3.5. Test weight (g)

The data presented in Table 02. and Fig. 01. represents that, at harvest, test weight during 2024-25 was highest under T₄ (49.14) and lowest under T₁ (42.88), with a significant effect of tillage. Among

INM treatments, N₆ recorded the highest test weight (46.91) and N₁ the lowest (45.25); however, the INM effect and Tillage × INM interaction were non-significant. In 2025-26, T₄ recorded the highest test weight (49.75) and T₁ the lowest (43.30), with a significant tillage effect. Among INM treatments, N₆ recorded the highest value (47.36) and N₁ the lowest (45.59); the INM effect was significant, whereas the Tillage × INM interaction was non-significant.

Table 01. Yield attributing characters (At harvest) in wheat as influenced by tillage practices and integrated nutrient management (INM) during *rabi* 2024-25 and 2025-26

Treatments	Yield Attributing Characters (At harvest)								
	Length of spikes (cm)			Number of spikes (m ⁻²)			Number of grains (spike ⁻¹)		
	2024-25	2025-26	Mean	2024-25	2025-26	Mean	2024-25	2025-26	Mean
Tillage practices (T)									
T ₁	10.78	10.86	10.82	375.72	381.72	378.72	45.83	47.94	46.89
T ₂	12.14	12.47	12.31	397.56	405.67	401.62	51.06	52.67	51.87
T ₃	13.40	13.63	13.52	446.89	457.39	452.14	55.11	57.33	56.22
T ₄	13.77	13.94	13.86	458.39	470.94	464.67	58.28	60.67	59.48
S.Ed. ±	0.24	0.22	0.23	5.29	14.29	9.79	1.02	1.00	1.01
C.D. (P = 0.05)	0.81	0.77	0.79	18.32	49.46	33.89	3.54	3.44	3.49
Integrated Nutrient Management (N)									
N ₁	12.69	12.79	12.74	425.50	432.75	429.13	52.17	53.75	52.96
N ₂	12.61	12.98	12.80	418.25	422.83	420.54	54.08	56.67	55.38
N ₃	12.63	12.80	12.72	433.67	448.42	441.05	53.00	55.58	54.29
N ₄	12.23	12.35	12.29	407.83	419.17	413.50	51.50	53.75	52.63
N ₅	12.23	12.48	12.36	416.08	426.67	421.38	53.08	54.92	54.00
N ₆	12.75	12.97	12.86	416.50	423.75	420.13	51.58	53.25	52.42
S.Ed. ±	0.31	0.35	0.33	9.37	7.89	8.63	1.87	1.09	1.48
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T × N)									
S.Ed. ±	0.61	0.70	0.66	18.73	15.78	17.26	3.75	2.18	2.97
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	6.22	NS

Table 02. Yield attributing characters (At harvest) in wheat as influenced by tillage practices and integrated nutrient management (INM) during *rabi* 2024-25 and 2025-26

Treatments	Yield Attributing Characters (At harvest)					
	Weight of spike (m ⁻²)			Test Weight (g)		
	2024-25	2025-26	Mean	2024-25	2025-26	Mean
Tillage practices (T)						
T ₁	318.17	317.56	317.87	42.88	43.30	43.09
T ₂	346.61	347.33	346.97	44.94	45.49	45.22
T ₃	377.78	376.67	377.23	47.15	47.73	47.44
T ₄	406.33	409.06	407.70	49.14	49.75	49.45
S.Ed. ±	10.21	13.31	11.76	1.00	0.37	0.69
C.D. (P = 0.05)	35.34	46.04	40.69	3.45	1.28	2.37
Integrated Nutrient Management (N)						
N ₁	350.00	350.00	350.00	45.25	45.59	45.42
N ₂	354.25	355.08	354.67	45.44	46.14	45.79
N ₃	359.00	360.17	359.59	45.80	46.48	46.14
N ₄	367.58	365.75	366.67	46.27	46.80	46.54
N ₅	367.83	370.50	369.17	46.50	47.04	46.77
N ₆	374.67	374.42	374.55	46.91	47.36	47.14
S.Ed. ±	9.96	18.21	14.09	0.78	0.30	0.54
C.D. (P = 0.05)	NS	NS	NS	NS	0.87	NS
Interaction (T × N)						
S.Ed. ±	19.92	36.41	28.17	1.56	0.61	1.09
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS

(continued on next page)

Table 03. Interaction effect of tillage practices and integrated nutrient management (INM) on number of grains (spike⁻¹) at harvest during 2025-26

Treatment	No. of grains (spike ⁻¹)						Mean
	N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	
T ₁	46.66	51.33	47.33	46	49.66	46.66	47.94
T ₂	54.66	50.33	56.00	54.33	50.33	50.33	52.67
T ₃	53.66	61.00	55.66	60.00	55.33	58.33	57.33
T ₄	60.00	64.00	63.33	54.66	64.33	57.66	60.67
Mean	53.75	56.67	55.58	53.75	54.92	53.25	
Treatments	S.Ed. ± C.D. (P = 0.05)						
Tillage Practices (T)	1.00 3.44						
INM (N)	1.09 NS						
Interaction of T × N	2.18 6.22						

4. Conclusion

The study on yield attributes and yield formation of wheat (*Triticum aestivum* L.) variety DBW-187 as influenced by tillage, hydrogel and integrated nutrient management revealed that, Deep tillage (25 cm) + *Pusa* Hydrogel 5 kg ha⁻¹ (T₄) generally recorded the highest yield attributes and grain yield, whereas, Conventional Tillage (15 cm) (T₁) recorded the lowest. INM treatments showed variable responses, with 75% Recommended dose of NPK + FYM @ 20 t ha⁻¹ + Vermicompost @ 8 t ha⁻¹ (N₆) and 100% Recommended dose of NPK + Vermicompost @ 8 t ha⁻¹ + FYM @ 20 t ha⁻¹ (N₄) performing better for several yield attributing traits.

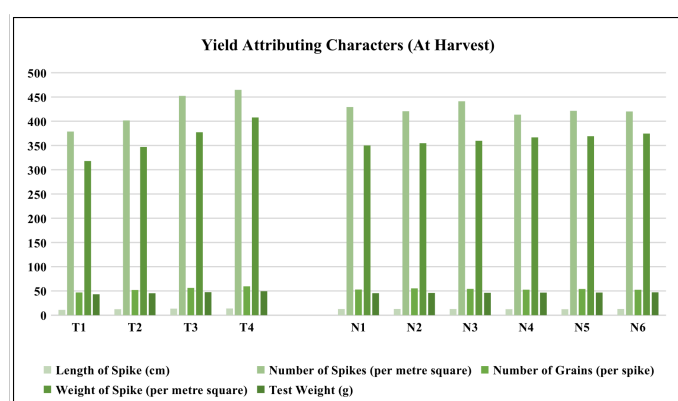


Figure 01. Yield attributing characters (At harvest) in wheat as influenced by tillage practices and integrated nutrient management (INM) during *rabi* 2024-25 and 2025-26

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