



Effect of plant growth promoters and micronutrients on growth and productivity of wheat (*Triticum aestivum*) varieties

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Wheat (*Triticum aestivum* L.) is considered as a staple food crop in many parts of the world, especially in regions like North America, Europe, Asia and parts of Africa (Yamini *et al.* 2025). It's a primary source of calories and nutrition for billions of people (Singh *et al.* 2023). It plays a crucial role in ensuring food security, providing essential nutrients and contributing to the cultural and economic tapestry of society's worldwide. It is often referred to as the "staff of life" (Kumar *et al.* 2024). However, to feed the current-growing population, wheat production must be doubled by 2050. The wheat production in various ecologies presents a myriad of challenges, encompassing issues such as nutrient imbalance, micronutrient deficiencies, low-quality seeds, salinity, waterlogging and inadequate use of fertilizers (Kumar *et al.* 2023). Nevertheless, micronutrient deficiencies frequently manifest in Indian soils, primarily due to intensive agricultural practices in the scenario of climate change, notably within calcareous soils of arid and semi-arid regions. This deficiency poses a serious threat to global food production. The micronutrients, viz. zinc (Zn), iron (Fe), boron (B) and copper (Cu), have been found to have significant effects on the growth, yield and uptake of nutrient in wheat under aberrant situations (Joshi *et al.* 2020, Rawat *et al.* 2023). Seaweed extracts, containing trace elements and plant growth-promoting substances, enhance plant resistance and yield (Kumar *et al.* 2019). When applied in various forms, these support the growth of cereals, pulses, and flowering plants. Gibberellic acid (GA₃) contributes to plant growth and defense against stresses. Nitrobenzene, derived from seaweed extract, acts as a flower stimulant and yield booster, addressing challenges in wheat production by improving productivity and nutrient uptake (Kumar *et al.* 2019). The objective of the experiment was to assess

the effect of plant growth promoters and micronutrient on growth attributes and productivity of wheat varieties.

An experiment was conducted during winter (*rabi*) season of 2021–22 at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh to study the effect of plant growth promoters (GA₃, Nitrobenzene Seaweed extract) and micronutrients (Zn, Fe, Mn, Cu) on performance of wheat (*Triticum aestivum* L.) varieties. The soil of experimental field was sandy clay loam, low organic carbon (0.49), available NPK (148.20, 20.6 and 215.5 kg/ha respectively), having pH 7.7. The annual average rainfall of the region is approximately 885.6 mm, of which 88.70% is received during rainy season (July to September). The experiment was laid out in split plot design (SPD) with three replications, comprising three wheat varieties in main plot, viz. DBW-187 (V₁), K-1006 (V₂) and K-607(V₃) and six plant growth promoters options (PGP), viz. Control (G₀), Nitrobenzene @3 ml/L (G₁), Gibberellic acid @2000 ppm (G₂), Seaweed extract solid @25 kg/ha (G₃), Seaweed extract liquid @625 ml/ha (G₄), mixture of micronutrients (Zn, Fe, B, Cu) @0.5% (G₅) were applied in sub-plots. The field operations included leveling and inverting the soil by ploughing (Disc) followed by two cross harrowing to ensure proper germination and establishment. The sowing (29 Nov 2021) was done manually, under appropriate moisture for good germination, with a uniform seed rate of 100 kg/ha with 22.5 cm row to row spacing. Fertilizers were applied to each plot uniformly based on recommended dose of wheat NPK (kg/ha), viz. 120 N, 60 P₂O₅ and 40 K₂O. The PGPs were applied to specific plots and growth stages like nitrobenzene, gibberellic acid, liquid seaweed extract and, mixture of micronutrients (Zn, Fe, Cu and B) were applied through foliar spray at maximum tillering stage and solid seaweed extract was at sowing time as basal application. Clodinafop-propargyl (Topik) @60 g a.i./ha and metsulfuron-methyl @4 g a.i./ha were applied at 30 days after sowing (DAS) uniformly in each plot to control broad and narrow leaf weeds. The five irrigation (including pre-sowing), were given to the fulfillment of the crop water

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requirements based on critical stage of crop such as Crown Root Initiation stage (CRI), early jointing, flowering and milking Stage. The plant height (cm) was recorded for 5 tagged plants at tillering, flowering and harvest stages in each plot. Dry matter accumulation of crop was recorded by cutting plants from a 50 cm row length, 1–2 days sun-drying followed by oven-drying at $65 \pm 5^\circ\text{C}$ for 48 h, after which dry weight was recorded. Effective tillers/m² was counted using 1 m × 1 m quadrates at different growth stages. The crop was harvested (24-April-2022) manually from the net plot area (3 m × 2 m) based on harvest maturity marked by golden-yellow ear heads and fully dried leaves and stems. The obtained data were subjected to appropriate statistical analysis with analysis of variance (ANOVA) for split plot design using the method outlined by Gomez and Gomez (1984) to determine any differences among the treatment means. The evaluation of critical difference (CD) was done at 5% level of significance.

Growth and yield parameters: Height of plant is an important growth parameter directly linked with the productive potential of plants in terms of biomass production and productivity. The significantly ($p < 0.05$) maximum plant height, was recorded in DBW-187 (63.45, 80.59 and 85.70 cm at maximum tillering, flowering and harvest stage, respectively) variety followed by K-1006 (82.72 cm) and minimum plant height was recorded in K-607 variety (Table 1). Among plant growth promoters, significantly ($p < 0.05$) higher plant height (64.47, 81.22 and 86.41 cm at maximum tillering, flowering and harvest stage,

respectively) was recorded in mixture micronutrients (Zn, Fe, B, Cu) @0.5% followed by Gibberellic acid @2000 ppm, Seaweed extract (liquid) @625 ml/ha and minimum (80.42 cm) under control (Kumar *et al.* 2019). Yield is contingent on dry matter production and tillers, making increased total dry matter a key factor for higher yield (Table 1). Dry matter accumulation (DMA) in wheat varieties showed no significant difference at initial stage, but a notable increase in plant DMA at subsequent growth was observed. Wheat variety DBW-187 exhibited the maximum DMA (43.62, 168.20, 284.57 g/m row length at maximum tillering, flowering and harvest stage, respectively), followed by K-1006, while K-607 recording minimum DMA. Among plant growth promoters, micronutrients @0.5% resulted in the highest DMA (44.09, 178.71, 305.70 g/m row length at maximum tillering, flowering and harvest, respectively), followed by seaweed extract and GA₃ showing statistically similar results and minimum in control treatment. The micronutrient mixture likely enhanced wheat plant metabolic processes, leading to better growth compared to other growth substances. Micronutrient application improved soil nutritional status, stimulated root growth, enhanced nutrient (NPK) and water use efficiency, increased shoot growth and ultimately improved grain yield (Dawlatzai *et al.* 2017, Anwar *et al.* 2021).

The number of tillers in wheat is influenced by varieties and plant growth promoter. The maximum number of tillers is reached at flowering, but it decreases in subsequent stages and the productive tillers contribute

Table 1 Effect of plant growth promoters and micronutrient on height, dry weight, tillers and harvest index of wheat cultivars

Treatments	Plant height (cm)			Dry matter accumulation (g/m row length)			Number of tillers (m ²)			Harvest index (%)
	Maximum tillering stage	Flowering stage	Harvest stage	Maximum tillering stage	Flowering stage	Harvest stage	Maximum tillering stage	Flowering stage	Harvest stage	
Varieties										
V ₁	63.45	80.59	85.70	43.62	168.20	284.57	382.16	451.75	429.29	41.2
V ₂	62.54	77.51	82.72	43.04	165.33	281.60	362.21	440.70	420.13	38.5
V ₃	61.71	76.86	81.98	38.57	162.24	278.14	362.08	428.65	414.83	38.4
SE(d)±	0.443	0.567	0.428	0.418	1.439	1.409	2.469	5.182	3.141	0.260
LSD ($p=0.05$)	1.263	1.615	1.219	1.191	4.103	4.017	7.038	14.772	8.954	0.750
Plant Growth Promoters										
G ₀	60.50	75.76	80.42	38.25	145.41	240.71	346.71	411.33	397.28	37.9
G ₁	61.42	76.70	81.87	41.08	156.95	276.14	355.92	427.45	405.52	38.4
G ₂	63.82	79.64	84.90	43.09	175.52	295.89	385.02	453.87	437.73	40.4
G ₃	61.95	77.82	82.96	41.34	163.22	283.03	361.62	441.24	417.10	38.8
G ₄	63.24	79.08	84.23	42.60	171.72	287.15	377.62	448.35	422.43	39.6
G ₅	64.47	81.22	86.41	44.09	178.71	305.70	392.24	459.63	448.43	41.0
SE(d)±	0.815	1.081	0.947	0.435	2.243	4.144	3.810	4.682	5.498	0.51
LSD ($p=0.05$)	1.627	2.218	1.944	0.893	4.603	8.504	7.818	9.609	11.282	1.060

LSD, Least Significant Difference. Refer to Methodology for treatment details.

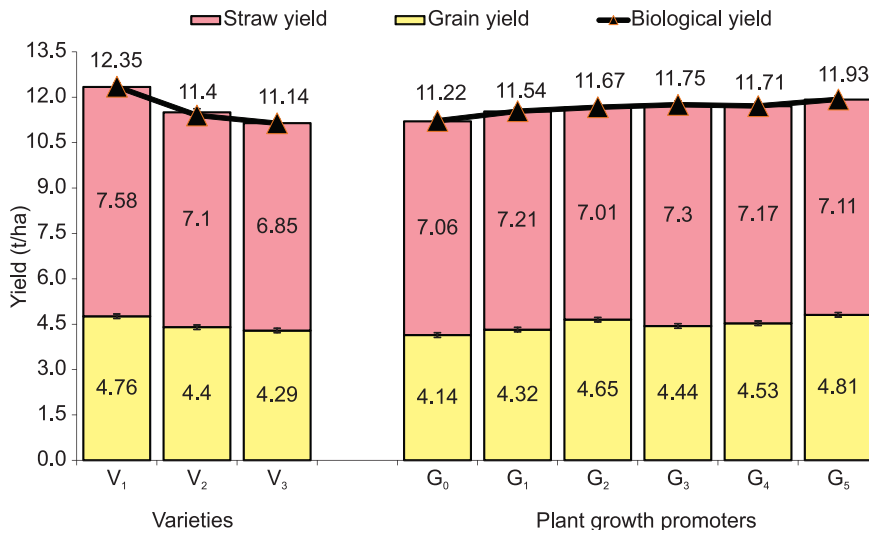


Fig. 1 Effect of plant growth promoters and micronutrient applications on the yield performance of wheat cultivars. Refer to Methodology for treatment details.

to yield formation. The wheat variety DBW-187 exhibits the maximum productive tillers at harvest (429.2 m²), while K-607 showed the minimum tillers. Among PGPs, micronutrients @0.5% result in the highest productive tillers (392.24, 459.63 and 448.43 m² at maximum tillering, flowering and harvest, respectively), followed by gibberellic acid and seaweed extract liquid while lowest in the control treatment. Application of micronutrients promotes nutrient uptake, enhances plant health like chlorophyll formation and vigour, leading to increased productive tillers and higher crop productivity (Dhaliwal *et al.* 2022).

The application of growth promoter significantly ($p < 0.05$) impacted the wheat varieties, leading to substantial effects on grain, straw, biological yield and harvest index (Table 1 and Fig. 1). This emphasizes the role of plant growth promoter and micronutrient (Zn, Fe, Mn and Cu) as a crucial element in enhancing crop productivity due to enhance growth and yield attributes. The highest grain (4.76 t/ha), straw (7.58 t/ha), biological (12.35 t/ha) yield and harvest index (41.2%) was recorded in wheat variety DBW-187, followed by K-1006, while the lowest was in K-607 (Malik *et al.* 2009). Among PGPs, micronutrients @0.5% revealed the maximum grain yield (4.81 t/ha), straw yield (7.11 t/ha), biological yield (11.93 t/ha) and harvest index (41.0%), followed by seaweed extract, and gibberellic acid, while the lowest under control treatment (Guru *et al.* 2024, Shivay *et al.* 2016). The application of micronutrients enhances the uptake of essential plant nutrients and optimizes nutrient use efficiency, thereby contributing to improved crop productivity (Kumar *et al.* 2019). Supplementation with micronutrients such as Fe, Zn, B, and Cu exerts a positive influence on plant growth by synergistically augmenting photosynthetic activity and associated metabolic processes, resulting in increased grain and total biological yields. Likewise, the application of seaweed-extracts reinforces the source-sink dynamics,

enhances photosynthetic efficiency, and consequently promotes higher grain yield and overall productivity (Jawale *et al.* 2020).

SUMMARY

The experiment was conducted to evaluate the influence of plant growth promoters and micronutrient on growth and yield parameters of wheat varieties. It can be concluded from the study that, DBW-187 and K-1006 demonstrated significantly higher growth and yields, with increasing grain yields by 9.87% and 2.41%, respectively, compared to K-607. The application of micro-nutrient mixture (Zn, Fe, B and Cu) resulted in the most favourable outcomes specifically, productive tillers (+11.90) and grain yield (+13.84). In general

the application of various PGPs, including micronutrients, GA, seaweed extract, and nitrobenzene, led to significant increase in productivity of wheat varieties.

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