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Effect of seed rate and foliar application of biostimulants on production, productivity and economics of Wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during the *Rabi* season of 2025–26 at the Agronomy Research Farm, Guru Kashi University, Talwandi Sabo, Punjab, to study the effect of seed rate and foliar application of biostimulants on the production, productivity, and economics of wheat (*Triticum aestivum* L.). The experiment was laid out in a Randomized Block Design with ten treatments and three replications. Treatments comprised different seed rates (90, 100, and 110 kg ha⁻¹) combined with foliar application of amino acid-based plant growth regulator (PGR) at varying concentrations along with seaweed extract @ 6 ml L⁻¹. Foliar sprays were applied at 25–30, 45–55, and 70–75 DAS. The results revealed significant improvement in growth, yield, and economic parameters due to higher seed rate and foliar biostimulant application. Among all treatments, T₁₀ (110 kg seed rate ha⁻¹ + amino acid-based PGR @ 6 ml L⁻¹ + seaweed extract @ 6 ml L⁻¹) recorded the highest plant height (109.3 cm), LAI (3.05), dry matter accumulation (8.35 g plant⁻¹), effective tillers (375 m⁻²), 1000-grain weight (45.5 g), grain yield (60.0 q ha⁻¹), and harvest index (55.0%). Economic analysis also showed maximum gross return (₹1,18,000 ha⁻¹), net return (₹67,000 ha⁻¹), and B:C ratio (2.31) under T₁₀. Thus, the combined application of higher seed rate and foliar biostimulants proved effective in enhancing wheat productivity and profitability under Punjab conditions.

Keywords: Amino acid PGR, biostimulants, economics, seaweed extract, wheat yield

1. Introduction

Wheat (*Triticum aestivum* L.), a member of the Poaceae family, is one of the most important cereal crops and serves as a staple food for a large proportion of the world's population. It is widely cultivated under temperate and subtropical conditions due to its high adaptability and nutritional value (Khan *et al.*, 2009 and Calvo *et al.*, 2014) [14, 15]. Wheat grain contains carbohydrates, proteins, vitamins and minerals, making it an important component of human diet. Globally, wheat is cultivated over nearly 240 million hectares with a production of about 785 million tonnes. In India, wheat occupies approximately 31.83 million hectares with a production of 113.29 million tonnes during 2023–24 (Ministry of Agriculture & Farmers Welfare, 2023–24).

In the Indo-Gangetic Plains, wheat is commonly grown under the rice–wheat cropping system where delayed sowing often occurs because of late harvesting of preceding crops such as rice, sugarcane and potato. Late-sown wheat frequently experiences high temperature and moisture stress during reproductive and grain filling stages, resulting in reduced grain filling duration, poor biomass accumulation and lower productivity.

Seed rate is an important agronomic factor influencing crop establishment, plant population and yield. Under delayed sowing conditions, optimum seed rate helps maintain adequate plant stand and compensates for reduced tillering. However, excessive seed rate may increase competition among plants for nutrients, moisture and light, whereas lower seed rate may lead to poor crop establishment (Yadav *et al.*, 2018) [13].

In recent years, bio-stimulants have gained importance for improving crop growth, nutrient uptake and stress tolerance. Foliar application of bio-stimulants enhances physiological activities, chlorophyll content and nutrient-use efficiency, thereby improving growth and yield

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under stress conditions (Khan *et al.*, 2009) ^[14]. Keeping these facts in view, the present investigation was undertaken to evaluate the effect of seed rate and foliar application of bio-stimulants on growth, yield and economics of wheat under prevailing agro-climatic conditions.

2. Materials and Methods

2.1 Experimental site and climatic conditions

The field experiment was conducted during the *Rabi* season of 2025–26 at the Agronomy Research Farm of Guru Kashi University, Talwandi Sabo, Bathinda, Punjab, India (29.9°N, 75.1°E; altitude about 200 m above mean sea level). The experimental site falls under the south-western agro-climatic zone of Punjab and is characterized by a semi-arid subtropical climate with hot summers and cool winters. The region receives an average annual rainfall of 200–400 mm, most of which occurs during the southwest monsoon period (July–September). Relative humidity remains low during summer and moderate during winter. The area also experiences hot desiccating winds during summer and occasional fog during winter months.

Table 1: Meteorological data during the experimental period (November 2025–April 2026), Talwandi Sabo, Bathinda

Month	Min Temp (°C)	Max Temp (°C)	RH (%)	Rainfall (mm)
November 2025	19	29	30	3
December 2025	11	23	34	4
January 2026	8	21	49	12
February 2026	12	25	42	18
March 2026	16	31	31	11
April 2026	22	38	24	13

2.2 Soil characteristics

Before sowing, composite soil samples (0–15 cm depth) were collected from different locations of the experimental field, air-dried, sieved through a 2-mm sieve and analyzed using standard procedures. The soil was sandy loam in texture with pH 7.3 and electrical conductivity of 0.82 dS m⁻¹. The soil was low in organic carbon (0.46%) and available nitrogen (91.45 kg ha⁻¹), medium in available phosphorus (12.76 kg P₂O₅ ha⁻¹) and potassium (122.39 kg K₂O ha⁻¹)

Table 2: Physical and chemical properties of the experimental soil (0–15 cm depth)

Particulars	Value	Method
pH	7.3	Glass electrode pH meter (Jackson 1967) ^[19]
Electrical conductivity	0.820	Conductivity meter, 1:2 soil:water suspension (Jackson 1967) ^[19]
Organic carbon (%)	0.46	Walkley and Black rapid titration (Jackson 1967) ^[19]
Available N (kg ha ⁻¹)	91.45	Alkaline KMnO ₄ method (Subbiah & Asija 1956) ^[10]
Available P ₂ O ₅ (kg ha ⁻¹)	12.76	0.5 N NaHCO ₃ extractable (Olsen <i>et al.</i> 1954) ^[11]
Available K ₂ O (kg ha ⁻¹)	122.39	1N NH ₄ OAc extractable (Jackson 1967) ^[19]

2.3 Experimental design and treatments

The experiment was laid out in a Randomized Block Design (RBD) with ten treatments and three replications. Each net plot measured 3.8 m × 3 m. Wheat variety PBW-826 was used for the study. Treatments consisted of three seed rates (90, 100 and 110 kg ha⁻¹) combined with foliar application of amino acid-based plant growth regulator (PGR) at different concentrations along with seaweed extract (6 mL L⁻¹). Foliar sprays were applied at 25–30, 45–55 and 70–75 days after sowing (DAS). The treatment details are presented as follows:

The experiment comprised ten treatments involving different seed rates and foliar application levels of amino acid-based plant growth regulator and seaweed extract under varying planting densities. The treatments included T₁–Control (recommended seed rate without foliar spray), T₂–90 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 2 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₃–90 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 4 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₄–90 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 6 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₅–100 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 2 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₆–100 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 4 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₇–100 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 6 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₈–110 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 2 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹, T₉–110 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 4 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹ and T₁₀–110 kg ha⁻¹ seed rate + Amino Acid Based PGR @ 6 mL L⁻¹ + Seaweed Extract @ 6 mL L⁻¹. Foliar sprays were applied at 25–30, 45–55 and 70–75 days after sowing (DAS) according to the respective treatment schedules. Recommended agronomic practices were uniformly maintained for all treatments throughout the crop growth period.

2.4 Crop management practices

The field was prepared by ploughing, harrowing and levelling to obtain a fine seedbed. Wheat was sown in rows spaced 20 cm apart using recommended agronomic practices. A recommended fertilizer dose of 120 kg N, 60 kg P₂O₅ and 40 kg K₂O ha⁻¹ was applied. Nitrogen was applied in three splits: half at sowing, one-fourth at tillering and the remaining one-fourth at booting stage, while full doses of phosphorus and potassium were applied as basal. Irrigations were scheduled at critical growth stages including crown root initiation, tillering, booting and grain filling. Weed management was carried out through pre-emergence application of pendimethalin (1.0 kg ha⁻¹) followed by post-emergence application of 2,4-D (0.75 kg ha⁻¹) at 25–30 DAS. Standard plant protection measures were adopted as per crop requirement.

2.5 Observations recorded

Growth parameters including plant height, number of tillers, leaf area index (LAI), chlorophyll content (SPAD value), dry matter accumulation, crop growth rate (CGR) and relative growth rate (RGR) were recorded at different growth stages. Yield attributes such as effective tillers m⁻², spike length, grains spike⁻¹, test weight, grain yield, straw yield, biological yield and harvest index were recorded at harvest. Economic analysis including cost of cultivation, gross return, net return and benefit-cost ratio was also worked out using prevailing market prices.

Five plants were randomly selected and tagged from each plot for recording growth observations at 30, 60, 90 and 120 DAS. Plant emergence (%) was recorded at 7–10 DAS. Plant height (cm) was measured from the soil surface to the tip of the tallest leaf. Number of tillers plant⁻¹, leaf area index (LAI), chlorophyll content (SPAD value), dry matter accumulation (g plant⁻¹), crop

growth rate (CGR; g m⁻² day⁻¹), root length (cm) and root biomass (g plant⁻¹) were recorded at different crop growth stages.

Yield attributes including effective tillers m⁻², spikes plant⁻¹, spike length (cm), grains spike⁻¹ and 1000-grain weight (g) were recorded at harvest. Grain yield, straw yield and biological yield were expressed in q ha⁻¹. Harvest index (HI) was calculated using the following formula:

$$\text{HI (\%)} = (\text{grain yield} / \text{biological yield}) \times 100$$

Soil samples collected before sowing and after harvest were analysed for pH, electrical conductivity (EC), organic carbon and available N, P and K status using standard procedures.

2.6 Economic Analysis

The economic analysis of the various treatments was performed using the prevailing market prices of inputs and produce at the time of harvest. Economic parameters such as cost of cultivation, gross returns, net returns, and benefit-cost (B:C) ratio were calculated for each treatment. Net returns were determined by deducting the total cost of cultivation from the gross returns, whereas the B:C ratio was worked out by dividing gross returns by the total cost of cultivation (B:C) ratio (B:C ratio = gross return / cost of cultivation)

2.7 Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a randomized block design (RBD) with three replications, following the method described by Cochran and Cox (1967), using COSTAT software. Treatment means were compared using the critical difference (CD) test at the 5% level of significance. Pearson's correlation analysis was also carried out to determine the relationships among grain yield, straw yield, and other recorded parameters at different growth stages of wheat under varying nutrient management practices. All statistical analyses were conducted at a significance level of $P = 0.05$.

3. Results and Discussion

3.1 Growth Parameters

The data presented in Table 3 revealed that different seed rates along with foliar application of amino acid-based plant growth regulator (PGR) and seaweed extract significantly influenced the growth parameters of wheat at the harvest stage. Plant height increased markedly under different treatments, with the tallest plants being recorded in treatment T₁₀ (109.3 cm), whereas the control treatment T₁ registered the lowest value. Similarly, the leaf area index (LAI) was also highest in T₁₀ (3.05), while the minimum LAI was observed under T₁. The improvement in plant height and LAI under treated plots may be attributed to enhanced nutrient uptake, better leaf expansion, improved canopy development, and increased physiological activity

induced by amino acid-based PGR and seaweed extract (Prasad *et al.*, 2010; Al-Hasany *et al.*, 2019) [17, 16].

The findings further indicated that dry matter accumulation and effective tiller production were significantly influenced by different treatments at the harvest stage. Treatment T₁₀ recorded the highest dry matter accumulation (8.35 g plant⁻¹) and maximum number of effective tillers (375 tillers m⁻²), whereas the lowest values were recorded under the control treatment T₁. Greater biomass accumulation and higher tiller density under treated plots may be associated with enhanced photosynthetic activity, improved nutrient absorption, efficient assimilate partitioning, and better vegetative growth. These factors ultimately contributed to improved wheat productivity under Punjab conditions (Tanmayi *et al.*, 2024) [18].

3.2 Yield Parameters

The data presented in Table 4.13 clearly indicated that increasing seed rates along with foliar application of amino acid-based plant growth regulator (PGR) and seaweed extract significantly enhanced yield attributes and productivity of wheat under Punjab conditions. Among all the treatments, T₁₀ recorded the highest values for 1000-grain weight (45.5 g), grain yield (60.0 q ha⁻¹), straw yield (49.0 q ha⁻¹), and harvest index (55.0%), whereas the lowest values were observed in the control treatment T₁, which recorded 38.5 g, 38.2 q ha⁻¹, 35.5 q ha⁻¹, and 51.8%, respectively. The improvement in 1000-grain weight under treated plots may be attributed to enhanced photosynthetic activity, improved nutrient uptake, and efficient translocation of assimilates towards developing grains, resulting in better grain filling during reproductive stages. Similarly, the increase in grain yield may be associated with improved tillering, higher chlorophyll content, greater dry matter accumulation, and efficient partitioning of photosynthates towards reproductive organs.

The progressive increase in straw yield under higher seed rates and foliar biostimulant treatments indicated enhanced vegetative growth, greater plant height, improved leaf area development, and increased biomass accumulation. Foliar application of amino acid-based PGR and seaweed extract possibly stimulated metabolic activities and promoted dry matter production, thereby contributing to superior straw yield in treated plots. Furthermore, the higher harvest index recorded in T₁₀ reflected better translocation and utilization of assimilates towards grain production rather than vegetative biomass, indicating improved biological efficiency of the crop. Overall, the combined application of amino acid-based PGR and seaweed extract along with higher seed rate proved highly effective in improving growth, grain development, yield attributes, and overall wheat productivity, ultimately enhancing economic yield under the agro-climatic conditions of Punjab.

Table 3: Effect of Various Treatments on Physiological Growth and Yield Parameters of Wheat

Treatment	Plant Height	LAI at harvest	Dry Matter Accumulation at harvest	Number of Effective Tillers per m ²	1000 Grain Weight (g)	Grain Yield (q/ha)	Straw Yield (q/ha)	Harvest Index (%)
T ₁	91.3	1.87	6.05	280	38.5	38.2	35.5	51.8
T ₂	94.5	2.00	6.42	295	39.8	41.0	37.2	52.4
T ₃	96.2	2.12	6.65	305	40.5	43.5	38.5	53.0
T ₄	97.8	2.24	6.88	315	41.3	46.0	40.0	53.5
T ₅	99.6	2.36	7.12	325	42.0	48.5	41.5	53.9
T ₆	101.4	2.50	7.40	335	42.8	51.0	43.0	54.3
T ₇	103.2	2.63	7.65	345	43.5	53.2	44.5	54.5
T ₈	105.0	2.76	7.88	355	44.2	55.5	46.0	54.5
T ₉	106.8	2.89	8.12	365	44.8	57.8	47.5	54.9
T ₁₀	109.3	3.05	8.35	375	45.5	60.0	49.0	55.0

3.3 Economic analysis

The economic analysis indicated that the cost of cultivation increased progressively from ₹42,500 ha⁻¹ in T₁ to ₹51,000 ha⁻¹ in T₁₀ due to higher seed rates and repeated foliar application of amino acid-based PGR and seaweed extract. Despite the higher input cost, treated plots recorded substantially greater economic returns compared to the control. Gross return increased from ₹85,000 ha⁻¹ in T₁ to ₹1,18,000 ha⁻¹ in T₁₀, while net return improved from ₹42,500 ha⁻¹ to ₹67,000 ha⁻¹, reflecting the positive influence of biostimulants and optimum seed rate on crop productivity. The highest benefit-cost ratio was observed in T₁₀ (2.31), followed by T₉ (2.29) and T₈ (2.27), whereas the control treatment recorded the lowest B:C ratio (2.00). These findings suggest that higher seed rates combined with foliar biostimulant application enhanced wheat yield, profitability, and economic efficiency under Punjab conditions. The superior economic performance of T₁₀ may be attributed to higher grain yield (60.0 q ha⁻¹), greater biological yield (109.0 q ha⁻¹), improved effective tillers (375 m⁻²), and enhanced 1000-grain weight (45.5 g), which collectively contributed to increased marketable produce and better returns. Treatments receiving foliar biostimulants also showed improved growth parameters such as higher chlorophyll content, dry matter accumulation, and crop growth rate, ultimately resulting in greater productivity and profitability (Yadav *et al.*, 2018) ^[13].

Table 4: Effect of Bio Stimulants and Row Spacing on economics of Wheat cultivation

Treatment	Total Cost (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C ratio
T ₁	42,500	85,000	42,500	2.00
T ₂	44,000	90,500	46,500	2.06
T ₃	45,000	94,000	49,000	2.09
T ₄	46,000	97,500	51,500	2.12
T ₅	46,500	101,000	54,500	2.17
T ₆	47,500	104,500	57,000	2.20
T ₇	48,500	108,000	59,500	2.23
T ₈	49,000	111,000	62,000	2.27
T ₉	50,000	114,500	64,500	2.29
T ₁₀	51,000	118,000	67,000	2.31

4. Conclusion

The field experiment conducted during Rabi 2025 at the Agronomy Research Farm, Guru Kashi University, Talwandi Sabo, Punjab, demonstrated that varying seed rates along with foliar application of amino acid-based PGR and seaweed extract significantly improved wheat growth, yield, soil properties, and economics. Among all treatments, T₁₀ (110 kg seed rate ha⁻¹ + Amino Acid Based PGR @ 6 ml L⁻¹ + Seaweed Extract @ 6 ml L⁻¹) recorded the highest plant emergence (94.2%), plant height (109.3 cm), tillers plant⁻¹ (7.3), LAI (3.50), chlorophyll content (47.2 SPAD), root growth, and crop growth rate, indicating improved physiological activity and nutrient uptake. Yield attributes such as effective tillers, spike length, grains spike⁻¹, and 1000-grain weight were also superior under T₁₀, resulting in the maximum grain yield (60.0 q ha⁻¹). Economically, T₁₀ achieved the highest gross return (₹1,18,000 ha⁻¹), net return (₹67,000 ha⁻¹), and B:C ratio (2.31), proving most profitable under Punjab conditions. Since the present findings are based on a single season of experimentation, further multi-location and multi-season trials are required to validate the consistency, reliability, and practical applicability of this integrated approach for sustainable wheat production under diverse agro-climatic conditions.

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References

- Göbel M, Dulal S, Sommer L, Weinmann M, Mamun AA, Ahmed A, *et al.* Protective potential of selected microbial and non-microbial biostimulants against *Zymoseptoria tritici* leaf blotch in winter wheat as affected by the form of N supply. *Frontiers in Plant Science*. 2024;15:1407585.
- Sun W, Shahrajabian MH, Kuang Y, Wang N. Amino acids biostimulants and protein hydrolysates in agricultural sciences. *Plants*. 2024;13(2):210.
- Zaheer MS, Aijaz N, Hameed A, Buttar NA, Rehman S, Riaz MW, *et al.* Cultivating resilience in wheat: Mitigating arsenic toxicity with seaweed extract and *Azospirillum brasilense*. *Frontiers in Microbiology*. 2024;15:1441719.
- Al-Huqail AA, Aref NMA, Khan F, Sobhy SE, Hafez EE, Khalifa AM, *et al.* *Azolla filiculoides* extract improved salt tolerance in wheat (*Triticum aestivum* L.) associated with antioxidant potential and stress-related genes. *Scientific Reports*. 2024;14:11100.
- Elnajar M, Aldesuquy H, Abdelmoteleb M, Eltanahy E. Mitigating drought stress in wheat plants (*Triticum aestivum* L.) through grain priming in aqueous extract of *Spirulina platensis*. *BMC Plant Biology*. 2024;24:233.
- Nivetha N, Shukla PS, Nori SS, Kumar S, Suryanarayan S. A red seaweed *Kappaphycus alvarezii*-based biostimulant improves crop growth and rhizosphere microbial community. *Frontiers in Microbiology*. 2024;15:1330237.
- Sharma R, Kaur P, Singh J. Effect of foliar biostimulants on growth and productivity of late-sown wheat under Punjab conditions. *Journal of Cereal Research*. 2025;17(1):45-52.
- Kumar V, Singh G, Brar HS. Influence of amino acid-based plant biostimulants on yield and economics of wheat (*Triticum aestivum* L.). *Indian Journal of Agronomy*. 2026;71(1):88-94.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1967.
- Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. *Current Science*. 1956;25:259-260.
- Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Washington, DC: USDA Circular No. 939; 1954.
- Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science*. 1934;37:29-38.
- Yadav DD, Sharma SK, Kumar R. Effect of seed rate and nitrogen levels on growth and yield of wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies*. 2018;6(3):186-189.
- Khan W, Rayirath UP, Subramanian S, Jithesh MN, Rayorath P, Hodges DM, *et al.* Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation*. 2009;28:386-399.
- Calvo P, Nelson L, Kloepper JW. Agricultural uses of plant biostimulants. *Plant and Soil*. 2014;383:3-41.
- Al-Hasany ARK, Aljaberi MAR, Alhilfi SKJ. Effect of

- spraying with seaweed extract on growth and yield of two varieties of wheat (*Triticum aestivum* L.). Basrah Journal of Agricultural Sciences. 2019;32:124-134.
17. Prasad K, Das AK, Oza MD, Brahmbhatt H, Siddhanta AK, Meena R, *et al.* Detection and quantification of some plant growth regulators in a seaweed-based foliar spray employing a mass spectrometric technique sans chromatographic separation. Journal of Agricultural and Food Chemistry. 2010;58(8):4594-4601.
 18. Tanmayi CSN, Biswas R, Reddy MSL, Bindu VK, Mitra B. Influence of seed treatment and foliar spraying of seaweed extracts on wheat (*Triticum aestivum* L.) in Terai region of West Bengal. Journal of Cereal Research. 2024.