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Bio efficacy of biopolymers and bio stimulants in enhancing growth and productivity of Wheat (*Triticum Aestivum* L. Emend. Fiori & Paol)

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Abstract

A field experiment was conducted during *Rabi* 2024 at the Instructional Farm, College of Agriculture Bhilwara (Rajasthan), to study the “Effect of Biopolymers and Bio-stimulants on Yield and Yield Attributes of Wheat (*Triticum aestivum* L.)”. The experiment was laid out in a randomized block design with 11 treatment combinations, and 3 replications. The results revealed that yield contributing traits such as ear length, number of grains per ear and test weight were significantly influenced by different treatments. Among the treatments, chitosan-Cu-Zn bio-stimulant @ 5 ml l⁻¹ (T₁₀) recorded the maximum ear length (13.90 cm), number of grains per ear (54.92) and test weight (43.25 g), showing marked improvement over absolute control. Grain yield, straw yield and biological yield were also significantly enhanced due to foliar application of bio-stimulants, whereas harvest index remained non-significant. The highest grain yield (5500 kg ha⁻¹), straw yield (6639 kg ha⁻¹) and biological yield (12139 kg ha⁻¹) were recorded under T₁₀, indicating its superiority over other treatments. The improvement in yield and its attributes may be attributed to enhanced nutrient availability, better physiological activity, improved photosynthesis and efficient assimilate translocation under combined application of chitosan with micronutrients (Zn and Cu).

Keywords: Wheat, chitosan, bio-stimulants, micronutrients (Zn and Cu), yield attributes, grain yield

Introduction

Wheat is one of the most important cereal crops in the world and serves as a staple food for a large part of the global population. It is widely known as the “King of cereals” due to its major contribution to food security. Wheat is cultivated on about 200-225 million hectares globally and provides nearly one-fifth of total calories and about one-fourth of grain-derived energy worldwide (Erenstein *et al.*, 2022; Tosh *et al.*, 2019) ^[4, 17]. Over time, wheat production has increased significantly, from 247.7 million tonnes in 1961 to about 755 million tonnes in 2020, showing continuous improvement in productivity. India ranks second in wheat production after China, with major growing states including Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and Rajasthan (Jat *et al.*, 2021) ^[9]. However, despite achieving self-sufficiency after the Green Revolution, wheat productivity has stagnated in many regions due to factors such as heat stress, limited water availability, and disease problems (Agrawal *et al.*, 2012) ^[1]. Wheat grain is highly nutritious and provides essential carbohydrates, proteins, vitamins, and minerals required for human health. It contains about 13% protein, which is higher than rice and maize, along with important gluten proteins such as gliadins and glutenins. Whole wheat is also rich in dietary fiber, B-group vitamins, vitamin E, and minerals like iron, zinc, magnesium, and phosphorus (Shewry *et al.*, 2012; Iqbal *et al.*, 2022) ^[15, 8].

Micronutrients such as zinc and copper play an important role in plant growth and development. Zinc is essential for hormone production, enzyme activity, and nutrient balance, and its deficiency leads to poor growth and reduced yield. Copper is involved in key physiological processes such as photosynthesis, respiration, and protection against oxidative stress. The level of micronutrients in wheat grain depends on factors like genotype, environmental conditions, and crop management practices (Murphy *et al.*, 2008; Szira *et al.*, 2014) ^[13, 16]. Low wheat productivity is often linked to improper nutrient management and lack of knowledge about

correct fertilizer application methods. In this regard, foliar application is considered an effective method of supplying nutrients directly to plant leaves, which improves nutrient use efficiency and reduces losses. Recently, the use of biostimulants has gained importance in sustainable agriculture. Substances such as humic acid improve nutrient uptake, enhance plant metabolism, and increase tolerance to environmental stresses (Mehrinfar *et al.*, 2022) ^[10]. Similarly, amino acid-based biostimulants and compounds like glycine betaine help in improving plant growth and stress resistance (Calvo *et al.*, 2014) ^[2].

Salicylic acid is an important plant hormone that regulates plant defense mechanisms and helps plants tolerate abiotic stresses such as drought and heat. Among different biostimulants, chitosan has emerged as a promising natural compound for agricultural use. It is derived from seafood waste and is biodegradable, non-toxic, and environmentally safe. Chitosan application improves plant growth, enhances enzyme activity, supports nitrogen metabolism, and increases the production of protective compounds like phenolics and flavonoids (Mondal *et al.*, 2012; Saad *et al.*, 2022) ^[12, 14]. In addition, it helps plants tolerate stress conditions and improves overall crop productivity.

Materials and Methods

The experimental trial was conducted at the Instructional Farm, College of Agriculture Bhilwara (Rajasthan) during *Rabi*, 2024-2025. Soil samples (0-30 cm depth) were collected before sowing and analyzed for physico-chemical properties. The soil was clay loam in texture, slightly alkaline (pH 7.32) with electrical conductivity of 0.828 dS m⁻¹. It had medium organic carbon (0.51%), low available nitrogen (220.5 kg ha⁻¹), medium available phosphorus (15.7 kg ha⁻¹) and high available potassium (310.6 kg ha⁻¹). The experiment was laid out in a randomized block design with three replications, the experiment consisted of 11 treatments including absolute control, water spray and different concentrations of chitosan-based biopolymers and bio-stimulants. Treatments involved foliar application of chitosan alone and in combination with Zn and Cu at 1, 5 and 10 ml l⁻¹. All foliar sprays were applied at 25, 50 and 75 DAS. The gross and net plot sizes were 5.0 x 4.0 m and 4.5 m x 3.5 m, respectively, with a spacing of 22.5 cm (R*R) and the wheat variety Raj-4238 was used at a seed rate of 100 kg ha⁻¹. The recommended dose of fertilizer NPK (120: 60: 40 kg ha⁻¹) was supplied through urea, DAP and MOP, with half of nitrogen applied as basal along with the full dose of phosphorus, potassium and sulphur and the remaining nitrogen top-dressed at 30 DAS. Standard agronomic practices such as gap filling, thinning, weeding, irrigation and plant protection were carried out as required.

Yield attributes such as number of effective tillers, ear length and grains per ear were recorded from randomly selected plants at maturity. Test weight was determined from the weight of 1000 grains. Grain yield was recorded after threshing and expressed as kg ha⁻¹. Straw yield was obtained by subtracting grain yield from biological yield, while biological yield was calculated from total biomass per plot. Harvest index was computed as the ratio of grain yield to biological yield and expressed in percentage.

Results and Discussion

Yield Attributes

Yield contributing traits such as ear length, number of grains per ear and test weight were significantly influenced by foliar application of biopolymers and bio-stimulants (Table 4.6). The

maximum ear length (13.90 cm) was recorded under T₁₀ (Chitosan-Cu-Zn @ 5 ml l⁻¹), whereas the absolute control (T₁) produced comparatively lower values, showing an increase to the tune of 127.9 per cent. Similarly, the number of grains per ear increased from control to 54.92 under T₁₀, reflecting an improvement of 87.4 per cent. The improved yield attributes under chitosan-Cu-Zn bio-stimulant may be attributed to enhanced availability and efficient utilization of micronutrients, particularly zinc and copper, during reproductive stages. Zinc improved pollen viability, fertilization and grain setting, resulting in higher grains per ear, while copper supported photosynthetic activity and carbohydrate supply. Chitosan further enhanced micronutrient absorption, membrane permeability and stress tolerance, thereby sustaining reproductive development. The findings were supported by of Dubey *et al.* (2020) ^[3], Zheng *et al.* (2019) ^[18], Mohan *et al.* (2024) ^[11].

Test weight also followed a similar trend, with the highest value (43.25 g) recorded under T₁₀ as compared to control, showing an increase of 12.8 per cent. Lower values were observed under water spray (2-3% increase) and chitosan alone (5-8% increase), indicating that micronutrient enrichment further enhanced seed development. The improvement in test weight may be due to better assimilate translocation and increased accumulation of photosynthates under balanced nutrient supply. Similar findings have also been reported in wheat and other crops where combined application of bio-stimulants and micronutrients improved yield attributes and seed quality (Gobel *et al.* 2024)

Yield

Grain yield, straw yield and biological yield of wheat were significantly influenced by foliar application of biopolymers and bio-stimulants, whereas harvest index remained non-significant (Table 4.7). The maximum grain yield (5499.27 kg ha⁻¹) was recorded under T₁₀ (Chitosan-Cu-Zn @ 5 ml l⁻¹), which was superior over control treatments and other combinations, showing an increase of 84.1 per cent over absolute control. Similarly, straw yield increased to 6638.97 kg ha⁻¹ and biological yield to 12138.23 kg ha⁻¹ under T₁₀, indicating substantial improvement over lower treatments.

The increase in yield may be attributed to enhanced nutrient availability and efficient utilization of micronutrients, particularly zinc and copper, which improved photosynthetic activity, assimilate production and overall plant growth. Chitosan might have further enhanced nutrient absorption, metabolic activity and stress tolerance, thereby contributing to higher biomass accumulation and yield. Harvest index was not significantly influenced by different treatments. However, numerically higher values were observed under T₆ (45.33%), T₈ (45.33%) and T₁₀ (45.29%), while lower values were recorded under control treatments. The increase in grain, straw and biological yield may be attributed to improved nutrient use efficiency, enhanced physiological activity and better assimilate production under chitosan-based bio-stimulant application. Improved micronutrient availability might have stimulated photosynthesis and metabolic processes, resulting in higher biomass and grain yield. The relatively higher harvest index under chitosan-Cu-Zn treatment indicates better source-sink relationship and efficient translocation of photosynthates to grains. The variation among treatments was marginal, indicating that partitioning of total biomass into grain remained almost uniform. The findings were supported by Haydar *et al.* (2024) ^[6] and Hossain *et al.* (2024) ^[7].

Table 1: Effect of biopolymers and bio stimulants foliar spray on yield attributes of wheat

Treatment code	Description	Ear length (cm)	Number of grains/ears	Test weight (g)
T ₁	Absolute control	6.10	29.32	38.34
T ₂	Control (water spray) at 25, 50, 75 DAS	7.60	31.21	39.48
T ₃	Chitosan biopolymer (1 ml/l) foliar spray 25, 50, 75 DAS	8.67	35.73	40.23
T ₄	Chitosan biopolymer (5 ml/l) foliar spray 25, 50, 75 DAS	9.27	38.23	40.93
T ₅	Chitosan biopolymer (10 ml/l) foliar spray 25, 50, 75 DAS	9.92	40.91	41.16
T ₆	Chitosan-Zn bio stimulant (1 ml/l) foliar spray 25, 50, 75 DAS	10.62	43.78	39.30
T ₇	Chitosan-Zn bio stimulant (5 ml/l) foliar spray 25, 50, 75 DAS	11.36	46.84	40.88
T ₈	Chitosan-Zn bio stimulant (10 ml/l) foliar spray 25, 50, 75 DAS	12.15	50.12	40.30
T ₉	Chitosan-Cu-Zn bio stimulant (1 ml/l) foliar spray 25, 50, 75 DAS	12.33	53.62	41.32
T ₁₀	Chitosan-Cu-Zn bio stimulant (5 ml/l) foliar spray 25, 50, 75 DAS	13.90	54.92	43.25
T ₁₁	Chitosan-Cu-Zn bio stimulant (10 ml/l) foliar spray 25, 50, 75 DAS	13.87	54.08	42.41
	S.Em±	0.263	0.822	0.833
	CD (P=0.05)	0.777	2.425	2.456

Table 2: Effect of biopolymers and bio stimulants foliar spray on grain, straw, biological yield and harvest index of wheat

Treatment code	Description	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T ₁	Absolute control	2986.55	4380.67	7367.22	40.53
T ₂	Control (water spray) at 25, 50, 75 DAS	4101.88	5177.10	9278.98	44.19
T ₃	Chitosan biopolymer (1 ml/l) foliar spray 25, 50, 75 DAS	4541.60	5482.10	10023.70	45.31
T ₄	Chitosan biopolymer (5 ml/l) foliar spray 25, 50, 75 DAS	4677.90	5773.90	10451.80	44.76
T ₅	Chitosan biopolymer (10 ml/l) foliar spray 25, 50, 75 DAS	4818.20	5814.47	10632.67	45.31
T ₆	Chitosan-Zn bio stimulant (1 ml/l) foliar spray 25, 50, 75 DAS	4962.80	5988.10	10950.90	45.33
T ₇	Chitosan-Zn bio stimulant (5 ml/l) foliar spray 25, 50, 75 DAS	5111.70	6308.57	11420.27	44.76
T ₈	Chitosan-Zn bio stimulant (10 ml/l) foliar spray 25, 50, 75 DAS	5265.00	6351.23	11616.23	45.33
T ₉	Chitosan-Cu-Zn bio stimulant (1 ml/l) foliar spray 25, 50, 75 DAS	5327.67	6596.90	11924.57	44.68
T ₁₀	Chitosan-Cu-Zn bio stimulant (5 ml/l) foliar spray 25, 50, 75 DAS	5499.27	6638.97	12138.23	45.29
T ₁₁	Chitosan-Cu-Zn bio stimulant (10 ml/l) foliar spray 25, 50, 75 DAS	5442.62	6600.63	12043.25	45.15
	S.Em±	178.738	211.561	288.705	1.564
	CD (P=0.05)	527.275	624.103	851.679	NS

Conclusion

The experimental trial conducted at the Instructional Farm, College of Agriculture, Bhilwara (Rajasthan) during Rabi, 2024-2025 demonstrated that foliar application of chitosan-based biopolymers and micronutrient-enriched bio-stimulants significantly influenced yield attributes and productivity of wheat. Among the treatments, chitosan-Cu-Zn bio-stimulant @ 5 ml l⁻¹ (T₁₀) was found to be the best treatment, producing the highest grain yield (5499.27 kg ha⁻¹) along with improved ear length, number of grains per ear and test weight. Enhanced reproductive efficiency, better grain filling and higher biomass production under this treatment highlighted the importance of combined application of chitosan with micronutrients for maximizing wheat productivity under the agro-climatic conditions of Rajasthan.

References

- Agrawal PK, Gupta RK, Jat ML, Singh R. Wheat productivity trends and prospects in India. *Indian J Agric Sci.* 2012;82(4):331-336.
- Calvo L, Nelson JW, Kloepper JW. Agricultural uses of plant biostimulants. *Plant Soil.* 2014;383:3-41.
- Dubey R, Pathak H, Chakrabarti B, Singh S, Gupta DK, Harit RC. Impact of terminal heat stress on wheat yield in India and options for adaptation. *Agric Syst.* 2020;181:102826.
- Erenstein O, Jaleta M, Sonder K, Donovan J. Global trends in wheat production, trade, and consumption. *Glob Food Secur.* 2022;32:100617. doi:10.1016/j.gfs.2021.100617.
- Göbel M, Dulal S, Sommer L, Weinmann M, Al Mamun MA, 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 supply. *Front Plant Sci.* 2024;15.
- Haydar MS, Ghosh D, Roy S. Slow and controlled release nanofertilizers as an efficient tool for sustainable agriculture: Recent understanding and concerns. *Plant Nano Biol.* 2024;7:100058.
- Hossain S, Paul AK, Hasan MM, Prodhan DU. Impact of foliar zinc and boron application on wheat yield, quality and post-harvest soil properties. *Int J Biosci.* 2024;25:219-227.
- Iqbal A, Khalid N, Ateeq N, Khan MI. Nutritional significance and health benefits of wheat and whole grains: A comprehensive review. *Crit Rev Food Sci Nutr.* 2022;62(3):654-670.
- Jat ML, Gupta R, Kumar M. Wheat in South Asia: Trends, challenges, and opportunities. Mexico: CIMMYT; 2021.
- Mehrinfar A, Moradali MR, Mir Mahmoodi T, Yazdan Seta S, Sharafi S. The effect of foliar application of nutrients and humic acid on grain yield and quality of bread wheat cultivars under drought stress.
- Mohan N, Pal A, Saharan V. Nano-armored wheat: Enhancing heat stress resilience and yield via zinc-salicylic acid-chitosan bionanoconjugates.
- Mondal MMA, Malek MA, Puteh AB, Ismail MR, Ashrafuzzaman M, Naher L. Effect of foliar application of chitosan on growth and yield in okra. *Aust J Crop Sci.* 2012;6(5):918-921.
- Murphy KM, Reeves PG, Jones SS. Relationship between yield and mineral nutrient concentrations in historical and modern spring wheat cultivars. *Euphytica.* 2008;163(3):381-390.
- Saad AM, Alabdali AYM, Ebaid M, Salama E, El-Saadony MT, Selim S, *et al.* Impact of green chitosan nanoparticles

- fabricated from shrimp processing waste as a source of nano nitrogen fertilizers on the yield quantity and quality of wheat (*Triticum aestivum* L.) cultivars. *Molecules*. 2022;27(17):5640.
15. Shewry PR, Piironen V, Lampi AM, Edelmann M, Kariluoto S, Nurmi T, *et al.* The healthgrain wheat diversity screen: Effects of genotype and environment on phytochemicals and dietary fiber components. *J Agric Food Chem*. 2012;60(47):11839-11849.
 16. Szira F, Monostori I, Galiba G, Rakszegi M, Bálint AF. Micronutrient contents and nutritional values of commercial wheat flours and flours of field-grown wheat varieties—a survey in Hungary. *Cereal Res Commun*. 2014;42(2):294-302.
 17. Tosh J, Mishra JS, Sharma RK. Wheat production in India: Constraints and opportunities. *J Wheat Res*. 2019;11(2):1-9.
 18. Zheng C, Dong H, Yan J, Xu K, Gui H, Li P, *et al.* Special foliar fertilizer suitable for wheat quality improvement, preparation method and application.