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Effect of Biofertilizer and Micronutrient on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

During the winter crop season of 2025-26 at the Crop Research Farm, School of Agriculture, Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand, India, the growth and yield of wheat were investigated in a field trial using various biofertilizers and micronutrient in sandy loam soil in Dehradun, Uttarakhand. The experiment used a Randomised Block Design with three replications per treatment, and the wheat seeds were sown at a rate of 80 kg ha⁻¹. Data was collected before and after harvest and analysed statistically. On the basis of the research findings of present investigation the following conclusion may be drawn: Application of 75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS and 75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS greatly influenced all yield and growth parameter positively. Plant height at all four stages was maximum in treatment 6 (75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS (T₆). Among the treatment combination T₆ and T₅ recorded the highest grain yield, straw yield and biological yield. From the economic study it is concluded that maximum net return was obtained from treatment 6 and maximum gross return was obtained from 75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS (T₆).

Keywords: Wheat, biofertilizer, zinc, growth, yield, *Triticum aestivum*

Introduction

Wheat (*Triticum aestivum*) belongs to the family Gramineae. In India, it is an important crop because, it has a wide range of geographical adaptation, unique chemical composition, good nutritional values, functional health benefits and variety of end-uses (food, feed and nonedible). In India, wheat is predominantly *rabi* crop with 220.4 m ha of the total area under cultivation in the season. It is most important crop after rice in tropical and sub-tropical regions. In India, wheat crop is the second most after rice, so wheat is called as “King of cereals”. Uttar Pradesh, Punjab, Madhya Pradesh, Haryana are leading states in area and production of wheat. Common bread wheat (2n = 42) hexaploid species mostly grown in India, occupying about 87% of wheat area, and are good for chapati making and bakery products. It is introduced in India by Dr. Norman Borlaug from Mexico, hence called “Mexican dwarf wheat” and responsible for green revolution. Temperature required during growth period of wheat is 21°C to 24°C. It is a C₃, long day plant hence, cool and moist weather period during vegetative growth is required whereas, warm and dry weather during grain formation is ideal (Kumar *et al.*, 2011).

Azotobacter, an aerobic free-living soil microbe widely used as biofertilizer, binds atmospheric nitrogen and release it in the form of ammonium ions into the soils. They are ubiquitous and abundantly found in neutral to weakly acidic soils. In dry soils, *azotobacter* can survive in the form of cysts for up to 24 years. The aerobic bacteria *Azotobacter chroococcum* known to fix considerable quantity of nitrogen in the range of 20- 40 kg of nitrogen per hectare in the rhizosphere in non-leguminous crops (Moreno *et al.*, 1986).

In plants, Zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes in many important biochemical pathways. It is a required as a structural component of a large number of proteins, such as transcription factors and metallo enzymes (Singh and Kumar, 2009).

Azospirillum represented the best characterized genus of plant growth-promoting rhizobacteria.

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Four major aspects of the *Azospirillum*- plant roots interaction are highlighted: natural habitat, nitrogen fixation, plant root interaction and biosynthesis of growth hormones. Bacteria of the genus *Azospirillum* (α -subclass of Proteobacteria) are well known for many years as plant growth promoting rhizobacteria (PGPR) under certain environmental and soil conditions, *Azospirillum* can positively influence the plant growth, crop yield and nutrient content of the plant (Tien *et al.*, 2000). Zinc being one of the essential micronutrients plays significant role in various enzymatic and physiological activities. When the supply of plant available Zinc is inadequate, not only crop yields will be reduced but also the quality of crop products for use as food or feed can be expected to be sub-optimal.

Materials and procedures

A study named "Effect of Biofertilizer and micronutrient on growth and yield of wheat (*Triticum aestivum* L)" was undertaken from 2025-2026 at Crop Research Farm, School of Agriculture Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand, India. The research farm is situated near Dehradun. It is located in the lower Himalayan region in latitude 30.010 North and longitude 31.200 East, with an elevation of 450 meters above mean sea level. The study was conducted using a Randomised Block Design. One factor consists of irrigation management, and another comprises of seed rate. Seven treatment combinations, each replicated three times. The treatments were distributed at random within each replication, with twenty one plots assigned to various treatments. Growth attributes were plant height, dry matter accumulation, number of shoots plant⁻¹, leaf area index, and days to 50% heading, while yield attributes comprised number of effective tillers plant⁻¹, number of seeds ear⁻¹, and test weight. The crop's overall production was measured in terms of grain yield and straw yield. To arrive at a credible conclusion, the data gathered during the investigation was organised and analysed statistically. The data was analysed using the standard approach for "Analysis of Variance" (ANOVA) described by Gomez and Gomez (1984). An 'F' test (variance ratio) was used to determine the significance of treatments. The standard deviation of the mean was determined in each case. The Critical Difference (CD) was employed to examine the variation in treatment means at a 5% level of significance, and the 'F' test revealed significant differences among means.

Results and Discussion

Growth characters

The application of nutrients through inorganic and organic sources in combination had significant effect on the growth of Wheat crop. All the treatments where the 75% recommended dose of NPK fertilizers was applied in combination with Biofertilizer and Zinc recorded higher plant height, more number of tillers, higher dry matter accumulation of Barley at all the observational stages over the control. This might have resulted from the higher availability of nutrients and also the better growing conditions in the root zone created by the Biofertilizers and Zinc applied to the wheat crop.

Plant height

Vegetative and reproductive growth of a crop decides the final yield of crop plants. Poor growth and development of a crop, particularly in wheat, may have adverse effect on yield attributing characters and excessive plant growth may cause lodging and may reduce the yield attributes and yield of wheat crop.

Plant growth not only depends on the acquisition of carbohydrates through photosynthesis but also on nutrient elements taken through absorption and assimilation, and complex interactions occur between the sources of carbohydrates and nutrient elements. Therefore crop nutrition is an essential factor for obtaining higher yield of wheat through higher photosynthetic activities. Among the entire nutrient elements nitrogen plays most important role in growth, development and final crop yield. Therefore it is required in large amounts and its short supply causes poor growth and reduces the grain yield and quality of the crop.

The data pertaining to plant height at harvest indicate that every increase in the supply of nutrient with Zinc with biofertilizer increased the plant height significantly in present investigation. At harvest maximum (164.54 cm) plant height was recorded with the application of 75% RD NPK + *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS followed by 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil), 75% RD NPK + *Azotobacter* + 1% Zn (Foliar) at 25 DAS, 75%RD NPK + *Azotobacter* + 25 kg Zn/ha (Soil). This increase in plant height of wheat might be due better availability of nutrient through both chemical and organic sources (biofertilizer) of the nutrient through out the crop growth stages, where the chemical fertilizer supplied the nitrogen at initial growth stages of the crop and biofertilizer at later stages. These results are in conformity with the findings of Gopal & Nautiyal (2012) ^[23] while conducting a pot experiment reported that growth of wheat plants was improved by applications of Zn (20 mg Zn kg⁻¹) with two foliar sprays of zinc sulfate (ZnSO₄) ^[3] @ 0.5% as compared to only Zn (20 mg Zn kg⁻¹) and control.

At Lucknow Nautiyal *et al.* (2011) conducted a pot experiment in wheat with four levels of zinc including control (no Zn), 5 mg Zn, 10 mg Zn, and 10 mg Zn kg⁻¹ soil with urea instead of ammonium nitrate. They observed higher plant height and total dry weight with the supply of zinc added at 10 mg kg⁻¹ over the control.

Afzal *et al* (2017) while evaluating different methods of zinc application (control, zinc application in soil before planting 23 kg ha⁻¹, zinc foliar application, 4% ZnSO₄ ^[3] solution at two stages) reported that maximum plant height at maturity and total number of tillers were recorded in treatment where zinc was applied both in the soil and by foliar application.

Dry matter accumulation

Increasing trend of dry matter accumulation (g mrl⁻¹) was observed with advancement of crop stages and maximum dry matter of wheat was recorded at harvest stages of the crop during year of experiment. Application of 75% RD NPK + *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS produced significantly higher dry weight of wheat followed by application of 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil) at stages of the observations during the experimentation. Similarly at harvesting of crop, maximum dry matter of wheat (212.840g / m⁻¹) during 2024-25) were recorded with application of T₆ which was statistically at par with application of 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil) (190.350g / m⁻¹) and application of 75% RD NPK + *Azotobacter* + 1% Zn (Foliar) at 25 DAS (176.037g / m⁻¹) during the year of study. It was observed that application of T₆ produced 80.8280 percent higher dry matter at harvest of wheat over control treatment during the study. This increase in dry matter of wheat is attributed to the higher plant height and leaf area index which were produced due sufficient and adequate supply of nutrient and further these increased growth characters

contributed to higher dry matter production. Such types of results have been reported by Singh *et al.* (2014) at Pantnagar carried out a pot culture experiment to examine the individual and interactive effects of zinc and boron on growth, and yield in wheat (var. HD 2285). Results revealed that plant height and total dry matter content were increased with the application of zinc sulfate at 10 mg Zn kg⁻¹ soil.

Yield characters and yield

Yield attributes

Integrated application of inorganic fertilizers (75% RD NPK + Zinc) along with Biofertilizers increased the ear length, number of spikelets, number of grains per spike, grain weight per plant and the test weight. The enhanced early vegetative growth in terms of higher plant height and dry matter accumulation resulted in more number of tillers m³ which consequently increased the number of ear bearing tillers significantly. The combined application of 75% RD NPK with Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS also increased the number of grains per ear and test weight. However, in case of test weight, the treatment difference lacked significance including control. Stimulated vegetative growth of Wheat on account of adequate and prolonged supply of essential nutrients in treatments receiving Zinc and biofertilizers in addition to the 75% of RD NPK manifested itself in increased number of effective tillers m²; , grain weight per plant, number of grains per ear and test weight. Increased number of ear per plant with RDF might be due to stimulatory effect on N on tillering through cytokinin biosynthesis, resulting in more number of tillers in Wheat. Similar results had been observed by Hussain *et al.* (2012) [26] while conducting an experiment to study different zinc applications to soil (0, 4.5 or 9 mg Zn kg⁻¹), seed (100 m L of either 0 or 6.75% Zn w/v sprayed on 1 kg seed) and foliage (distilled-water-sprayed control, 1 m L of 0.05% Zn w/v at jointing, 2 × 1 m L of 0.50% Zn w/v at heading or combined jointing and heading sprays) reported an increased grain yield (29%) with soil application of zinc as compared to other application methods.

Spike length

The longer spike length of wheat (11.033) was recorded with application of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS which was statistically at par with application 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil). These results are in line with Bhutto *et al.* (2016) [2] conducted a field experiment to examine the effect of foliar fertilization of zinc on the growth and yield response of wheat. They observed significantly higher spike length (9.2 cm), number of grains spike⁻¹ (46.4), seed index (51.0, g) and grain yield (5540.7 kg ha⁻¹) with a higher foliar zinc concentration of 2.0% followed by lower treatments.

Number of grains per spike: The number of grains per spike of

wheat was significantly affected by of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. Higher number of grains per spike (46.140) of wheat were obtained with application of of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS which was significantly higher over Control treatment. Similarly findings also have been reported by Bhutto *et al.* (2016) [2] conducted a field experiment to examine the effect of foliar fertilization of zinc on the growth and yield response of wheat. They observed significantly higher spike length (9.2 cm), number of grains spike⁻¹ (46.4), seed index (51.0, g) and grain yield (5540.7 kg ha⁻¹) with a higher foliar zinc concentration of 2.0% followed by lower treatments. Jan *et al.* (2013) [29] while evaluating the effect of zinc on yield of wheat during a field trial in winter 2006-2007 concluded that markedly higher grains per spike, grain yield, straw yield, biological yield and harvest index were observed in plot receiving 15 kg Zn ha⁻¹ over control

Test weight

The significantly higher test weight (45.513) of wheat was recorded with application of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS which was statistically at par with application 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil). Application of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS produced higher test weight over control treatment. This increase might be due to better availability of nutrient for longer time, which maintained the greenery of the crop and delayed the maturity of wheat for longer duration by giving more chance for the crop for translocation more photosynthates from vegetative parts to grain formation thus increased the test weight of the crop. Similarly finding also have been reported by Singh *et al.* (2014) at Pantnagar carried out a pot culture experiment to examine the individual and interactive effects of zinc and boron on the yield of wheat (var. HD 2285). They reported that the increase in the ear length of wheat was 16.4 to 20.0% greater with Zn application of 5 or 10 mg kg⁻¹ soil over the control. They also observed an increase in the total grain weight, and 100-grain weight was with Zn application of 10 mg kg⁻¹ soil among all.

Yield studies

The grain and straw yield of wheat significantly increased with application of 75% RD NPK + Azotobacter + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 followed by 75% RD NPK + *Azospirillum* + 25 kg Zn/ha (Soil) over control treatment. Similarly finding also have been reported by the Zou *et al.* (2012) carried out an experiment in 23 different experimental sites with four Zn treatments: nil Zn, soil Zn application, foliar Zn application and soil + foliar Zn application for biofortification of wheat with Zinc. They observed 5% increase in grain yield with soil Zn application over other.

Table 1: Impact of Biofertilizer and Micronutrient on the growth characteristics of wheat

Treatment	Plant height (cm)	Dry weight (g)	No. of tillers/ plant				
60 DAS	90 DAS	60 DAS	90 DAS	20 DAS	25 DAS		
T ₁	Control	58.92	88.66	8.57	46.23	2.62	5.34
T ₂	75%RD NPK + Azotobacter + 20 kg Zn/ha (Soil)	65.47	98.96	9.52	51.36	2.92	5.93
T ₃	75% RD NPK + Azotobacter + 0.5% Zn (Foliar) at 25 and 50 DAS	66.22	99.65	9.64	51.96	2.95	6.00
T ₄	75% RD NPK + Azotobacter + 1% Zn (Foliar) at 25 DAS	64.75	98.54	9.42	50.80	2.88	5.86
T ₅	75% RD NPK + Azospirillum + 25 kg Zn/ha	66.12	99.69	9.62	51.87	2.94	5.99

	(Soil)						
T ₆	75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS	66.50	100.44	9.68	52.17	2.96	6.02
T ₇	75% RD NPK + Azospirillum + 1% Zn (Foliar) at 25 DAS	63.39	97.58	9.22	49.73	2.82	5.74
	SEm±	1.94	2.84	0.282	1.522	0.09	0.18
	CD at 5%	4.23	6.19	0.615	3.316	0.19	0.38

Table 2: Effect of Biofertilizer and Micronutrient on yield attributes and overall yield of wheat

Treatment	No. of effective tillers/ m ²	Number of Grains/spike	Test weight (g)	Grain yield q ha ⁻¹	Straw yield q ha ⁻¹	
T ₁	Control	118.41	21.22	29.93	31.83	60.99
T ₂	75%RD NPK + Azotobacter + 20 kg Zn/ha (Soil)	173.66	23.58	33.26	35.36	69.64
T ₃	75% RD NPK + Azotobacter + 0.5% Zn (Foliar) at 25 and 50 DAS	175.67	23.85	33.64	35.77	67.05
T ₄	75% RD NPK + Azotobacter + 1% Zn (Foliar) at 25 DAS	171.75	23.32	32.89	34.98	68.49
T ₅	75% RD NPK + Azospirillum + 25 kg Zn/ha (Soil)	175.40	23.81	33.59	35.72	69.25
T ₆	75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS	176.41	23.95	33.79	35.92	69.94
T ₇	75% RD NPK + Azospirillum + 1% Zn (Foliar) at 25 DAS	168.15	22.83	32.20	34.24	68.25
	SEm±	5.07	0.70	0.99	1.05	1.83
	CD at 5%	11.04	1.52	2.15	2.28	3.99

Conclusion

According to the findings of the current study, utilizing 75% RD NPK + Azotobacter + Azospirillum + 0.5% Zn (Foliar) at 25 and 50 DAS was the most beneficial combination of Biofertilizer and Micronutrient for growing wheat in the experimental year.

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