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# Effect of biofertilizers and levels of zinc on growth and yield of wheat (*Triticum aestivum* L.)

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**Abstract**
The field experiment was conducted during *Rabi* season of 2020 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.82%), available N (291.24 kg/ha), available P (32.85 kg/ha) and available K (264.78 kg/ha). The experiment was laid out in randomized block design with ten treatments and were replicated thrice. The treatments consisted of different biofertilizers combination (*Azotobacter*, *Azospirillum* and *Azotobacter* + *Azospirillum*) and three zinc levels (Zinc @ 25 kg/ha (Soil application), Zinc @ 0.5% (5 g/l) (Foliar application) at 25 and 50 DAS and Zinc @ 1% (10 g/l) (Foliar application) at 25 DAS) and one control plot, respectively. Results obtained that maximum plant height (102.43 cm), number of tillers (11.07/plant), dry weight (22.32 g/plant), crop growth rate (28.11 g/m$^2$/day), relative growth rate (0.0164 g/g/day), grains (43.47/spike), spikes (402.00/m$^2$), test weight (54.26 g), grain yield (5.93 t/ha), straw yield (9.37 t/ha) and harvest index (39.72%) were recorded with application of *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

**Keywords:** *Azotobacter*, *Azospirillum*, zinc, grain yield, straw yield and economics

## Introduction
Wheat (*Triticum aestivum*) belongs to the family Gramminae. 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 non-edible). 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 Borlauge 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 $C_3$, 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) [7].

*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) [9].

*Azospirillum* represented the best characterized genus of plant growth-promoting rhizobacteria. 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) [17]. Zinc being one of the essential micronutrient 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.

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) [14].

## Materials and Methods

The present examination was carried out during *Rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level. The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.2), low in organic carbon (0.72%), available N (278.48 kg/ha), available P (27.80 kg/ha) and available K (233.24 kg/ha). The treatments consisted of different biofertilizers combination (*Azotobacter*, *Azospirillum* and *Azotobacter* + *Azospirillum*) and three zinc levels (Zinc @ 25 kg/ha (Soil application), Zinc @ 0.5% (5 g/l) (Foliar application) at 25 and 50 DAS and Zinc @ 1% (10 g/l) (Foliar application) at 25 DAS) and one control plot, respectively. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice along with control plot.

The Recommended doses of fertilizers were 120 kg N/ha, 60 kg P/ha, 60 kg K/ha were applied to all the treatments. Urea, Single super phosphate and Muriate of potash were used as the source of nutrients. Nitrogen is applied in split dose, full dose of phosphorus, potassium applied as basal dose. The zinc sulphate was applied as per the treatments *viz*., foliar application and soil application. Numerous growth and yield parameters were recorded Plant height (cm), Number of tillers/plant, Dry matter accumulation (g/plant), crop growth rate(g/m$^2$/day), Relative growth rate (g/g/day), Number of grains/spike, Number of spikes/m$^2$, Test weight (g), Grain yield (t/ha), Straw yield (t/ha), Harvest index (%) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez and Gomez 1984).

## Results

### Growth attributes

The observations of growth attributes regarding wheat in relation to treatments were statistically analysed and were presented in Table 1.

### 1. Plant Height

At harvest, However, maximum plant height (102.43 cm) is recorded in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS and the treatment *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (101.52 cm), was recorded statistically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS

The data clearly indicated that different zinc fertilization treatments increase the leaf stem ratio over no zinc treatment. There is increasing evidence showing that combined soil + foliar application of zinc fertilizers under field conditions are highly effective and very practical way to maximize uptake and accumulation of zinc in plants. Significant variation in the plant height is due to in time availability of the needed nutrients to the plant at the important growth stages and application of zinc has led to production of IAA resulting in increased plant height. Joshi and Chilwal (2018) [15]; Manishaben *et al.* (2018) [11] and Thavaprakaash *et al.* (2018) [16].

### 2. Number of tillers/plant

At harvest, same trend is followed in the following treatments. However, number of tillers per plant was significantly higher in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (11.07/plant). Treatments with *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS and *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (10.73 and 10.13/pant) were recorded statistically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

The enhancement in leaves growth as a result of foliar spray of zinc sulphate and biofertilizers inoculation may be due to the production of phytohormones by the biofertilizers and/or improving the availability of nutrients. Similar observations were recorded by Tariq *et al.* (2014) [1]; Joy Dawson (2017) [4]; Das *et al.* (2018)

### 3. Dry matter accumulation (g/plant)

At harvest, significantly higher dry matter accumulation (22.32 g/plant) was observed in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS and *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS, *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS and *Azotobacter* + 0.5% Zn (Foliar) at 25 and 50 DAS (21.46, 20.67 and 20.27 g/plant) was found to be at par with the *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

The highest of biomass increase was in the combination of zinc and biofertilizers inoculation. Although the application of zinc as foliar spray to wheat increased its dry matter significantly, *Azotobacter* had also performed a significant effect on wheat dry matter yield. High dry matter in those treatments is due to long plant height, high stem girth, and high root weights. These findings are in harmony with those obtained by Mahato and Neupane (2017) [12]; Das *et al.* (2018).

### 4. Crop growth rate (g/m$^2$/day)

Significantly higher crop growth rate (28.11 g/m$^2$/day) was observed in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS and *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (25.03 and 24.09 g/m$^2$/day)were reorded statistically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

This progressive increase in crop growth rate was due to increase in sunshine hours which led to increase the rate of photosynthesis resulted in more CGR. These results are in agreement with the findings of Tariq *et al.* (2014) [1]; Joy Dawson (2017) [4]; Joshi *et al.* (2018).

### 5. Relative growth rate (g/g/day)

Finally at 100 DAS-at harvest interval, no significant difference were found among the treatments. Treatment combination of *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS was noticed highest relative growth rate (0.0164 g/g/day) and lowest relative growth rate (0.0116 g/g/day) was observed in *Azotobacter* + 1% Zn (Foliar) at 25 DAS. These results are in agreement with the findings of Joshi *et al.* (2018) [15] and Naik *et al.* (2020) [2].

**Table 1:** Effect of application of biofertilizers and zinc on Growth attributes of wheat

| Treatments | Plant height (cm) | Tillers/plant | Dry weight (g) | CGR ($g/m^2/day$) | RGR (g/g/day) |
|---|---|---|---|---|---|
| Control | 85.12 | 8.27 | 17.75 | 19.89 | 0.0144 |
| *Azotobacter* + 25 kg Zn/ha (Soil) | 88.24 | 8.13 | 17.95 | 16.83 | 0.0139 |
| *Azotobacter* + 0.5% Zn (Foliar) at 25 and 50 DAS | 91.47 | 8.53 | 20.27 | 22.07 | 0.0128 |
| *Azotobacter* + 1% Zn (Foliar) at 25 DAS | 96.85 | 9.53 | 17.65 | 13.32 | 0.0116 |
| *Azospirillum* + 25 kg Zn/ha (Soil) | 92.96 | 9.20 | 18.79 | 18.01 | 0.0126 |
| *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS | 101.52 | 10.13 | 20.67 | 24.09 | 0.0143 |
| *Azospirillum* + 1% Zn (Foliar) at 25 DAS | 96.96 | 9.60 | 18.13 | 17.99 | 0.0131 |
| *Azotobacter* + *Azospirillum* + 25 kg Zn/ha (Soil) | 92.32 | 9.27 | 19.41 | 20.80 | 0.0139 |
| *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS | 102.43 | 11.07 | 22.32 | 28.11 | 0.0164 |
| *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS | 97.76 | 10.73 | 21.46 | 25.03 | 0.0145 |
| F- test | S | S | S | S | NS |
| S. EM (±) | 1.36 | 0.35 | 0.78 | 1.42 | 0.0030 |
| C. D. (P = 0.05) | 4.04 | 1.03 | 2.31 | 4.21 | - |

## Yield attributes

### 1. Number of grains/spike

Number of grains per spike recorded a significant difference among treatment combinations. However, Grains (43.47/spike) recorded significantly higher in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. Treatment combinations of *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS and *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (42.53 and 41.80/spike), Were recordrd stastistically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

### 2. Number of spike/$m^2$

Number of spike per $m^2$ recorded at harvest stage, is presented in Table 2. The data shown that there was a significant effect among treatments. Significantly higher number of spikes (402.00/$m^2$) were recorded in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS (383.67/$m^2$), was recorded stastically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

### 3. Test weight (g)

Significantly higher test weight (54.26 g) were recorded in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS (53.33 g), was recorded stastically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

Production of photosynthates and their translocation to sink depends upon availability of mineral nutrients whose availability has increased the zinc uptake also. Most of the photosynthetic pathways are dependent on enzymes and co-enzymes, which are synthesized by mineral nutrients such as nitrogen, phosphorus and potassium activated by zinc. Application of biofertilizer proved beneficial for development of wheat attributing characters mainly due to availability of nutrients in proper amount during reproductive phase of the crop. The increase in yield attributes due to application of zinc was caused by higher chlorophyll contents, and seed treatment with biofertilizers which had apparently a positive effect on photosynthetic activity, synthesis of metabolites and growth-regulating substances, oxidation and metabolic activities and ultimately better growth and development of crop, which led to increase in yield attributes of wheat. These results are in agreement with the findings of Chand *et al.* (2017) [13]; Mahapatra *et al.* (2018) [8]; Pal and Joshi (2018) [15]; Amutham *et al.* (2018) [16]; Thavaprakaash *et al.* (2018) [16] and Naik *et al.* (2020) [2].

### 4. Grain yield (t/ha)

Significantly higher grain yield was noticed in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (5.93 t/ha). *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS, *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS and *Azotobacter* + *Azospirillum* + 25 kg Zn/ha (Soil) (5.84, 5.47 and 5.43 t/ha), were recorded stastically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

### 5. Straw yield (t/ha)

The data shows that there was a significant difference among the treatments over straw yield which was presented in Table 2. At harvest stage, straw yield was significantly higher (9.37 t/ha) in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS. *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS, *Azotobacter* + *Azospirillum* + 25 kg Zn/ha (Soil) and *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS (8.80, 8.72 and 8.67 t/ha), were recorded stastically at par with *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS.

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### 6. Harvest index (%)

The harvest index obtained on the basis of grain yield and straw yield was given in Table 2. The data shown that there was no significant difference among treatments combinations. However, highest harvest index (39.72%) was noticed in *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS and least was occurred in control plot (37.71%), respectively.

Improved yield and growth attributes might be interpreted as the manifestation of higher micro-nutrient uptake (zn) by the plants. Increase in dry matter production per unit area is a first step in achieving higher yield and yield attributes resulted in obtaining higher cob yield. Dry matter production at different growth stages of any crop is an important pre-requisite for higher yields as it signifies photosynthetic ability of the crop.

Zinc fertilization has beneficial effect on physiological process, plant metabolism and plant growth, which leads to higher yield. Increase in grain and straw yield with application of zinc and biofertilizers and the results were supported by the findings of Tariq *et al.* (2014) [1]; Kumar *et al.* (2015) [10]; Jinjala *et al.* (2016) [5]; Joy Dawson (2017) [4]; Chand *et al.* (2017) [13] and Palai *et al.* (2018) [6].

**Table 2:** Effect of application of biofertilizers and zinc on Yield attributes of wheat

| Treatments | Grains/ spike | Spikes/ $m^2$ | Test weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|
| Control | 34.87 | 334.00 | 44.93 | 4.76 | 7.86 | 37.71 |
| *Azotobacter* + 25 kg Zn/ha (Soil) | 35.93 | 346.00 | 45.52 | 4.98 | 8.12 | 38.03 |
| *Azotobacter* + 0.5% Zn (Foliar) at 25 and 50 DAS | 36.20 | 372.00 | 49.73 | 5.44 | 8.27 | 39.66 |
| *Azotobacter* + 1% Zn (Foliar) at 25 DAS | 39.47 | 350.33 | 47.61 | 5.21 | 8.57 | 37.78 |
| *Azospirillum* + 25 kg Zn/ha (Soil) | 36.60 | 350.67 | 46.40 | 5.07 | 8.20 | 38.22 |
| *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS | 41.80 | 372.67 | 50.08 | 5.47 | 8.67 | 38.73 |
| *Azospirillum* + 1% Zn (Foliar) at 25 DAS | 37.93 | 359.67 | 47.67 | 5.22 | 8.12 | 39.08 |
| *Azotobacter* + *Azospirillum* + 25 kg Zn/ha (Soil) | 38.93 | 363.33 | 49.70 | 5.43 | 8.72 | 38.33 |
| *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS | 43.47 | 402.00 | 54.26 | 5.93 | 9.37 | 39.72 |
| *Azotobacter* + *Azospirillum* + 1% Zn (Foliar) at 25 DAS | 42.53 | 383.67 | 53.33 | 5.84 | 8.80 | 38.82 |
| F- test | S | S | S | S | S | NS |
| S. EM (±) | 1.34 | 9.41 | 1.36 | 0.15 | 0.26 | 1.09 |
| C. D. (P = 0.05) | 3.98 | 27.95 | 4.04 | 0.47 | 0.78 | - |

## Conclusion

From the above experiment, it is concluded that the treatment combination of *Azotobacter* + *Azospirillum* + 0.5% Zn (Foliar) at 25 and 50 DAS is highly remunerative practice registering higher productivity and thereby realizing a higher monetary advantage.

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