Response of different Biofertilizers and Zinc levels on growth and yield of Maize (*Zea mays*. L)

Article type: *Original Research Article*

Abstract

The study aims to highlights the effect of different biofertilizers and zinc levels on growth and yield of maize (*Zea mays*. L). The study was conducted during Rabi 2021 at crop Research farm, Department of Agronomy, SHUATS, Prayagraj, (U.P), India. The soil of this experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), in low organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2kg/ha), available K (232.5kg/ha). This experiment was performed in Randomised Block Design with nine treatments each replicated thrice on the basis of one-year experimentation. The treatments which are T_1: *Azospirillum*+$ZnSo_4$ 10kg/ha, T_2: Azospirillium+0.1% $ZnSo_4$, T_3: *Azospirillum*+0.2% $ZnSo_4$, T_4: *Azotobacter* + $ZnSo_4$ 10kg/ha, T_5: *Azotobacter* + 0.1% $ZnSo_4$, T_6: *Azotobacter* + 0.2% $ZnSo_4$, T_7: *Azotobacter* + *Azospirillum* + $ZnSo_4$ 10kg/ha, T_8: *Azotobacter* + *Azospirillum* + 0.1% $ZnSo_4$, T_9: *Azotobacter* + *Azospirillum* + 0.2% $ZnSo_4$. The results showed that application of *Azotobacter* + *Azospirillum* + 0.2% $ZnSo_4$ was recorded significantly higher Plant height (195.29 cm), Plant dry weight (183.65 g/plant), Whereas significantly highest crop growth rate (5.31 g/m^2/day) was recorded with the treatment *Azospirillum* + $ZnSo_4$ 10kg/ha. Significantly maximum Cobs/plant (2.60), Cob length (27.17 cm), Rows/cob (15.19), Grains/cob (30.16), weight of grains/cob (140.88 g), Test weight (230.66), Cob yield (6.33 t/ha), Stover yield (14.30 t/ha), Harvest index (30.67%), Gross returns (Rs.107553.00/ha), Net returns (Rs.71570.00/ha) and Benefit cost ratio (1.99) were obtained with application of *Azotobacter* + *Azospirillum* + 0.2% ZnSo4 as compared to other treatments.

Keywords: *Azotobacter*, *Azospirillum*, $ZnSo_4$, yield.

Introduction

"Maize (*Zea mays*. L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, Maize is known is "Queen of cereals" because it has the highest genetic yield potential among the cereals. Maize is one of the important cereals next to wheat and rice in the world. The productivity of maize mainly depends on its nutrient management" (**Joshi, G. and Chilwal et al.,2018**) **(Kumar *et al.*,2007).** Being a c4 plant, maize is capable of utilizing solar radiation more efficiently compared to other cereals. Maize is grown throughout the year in all the states of the country for various purposes including fodder for animals, food grain, sweet corn, baby corn, green cobs, and popcorn.

"Biofertilizer is natural input that can be applied as a complement to or as a substituent of chemical fertilizer in sustainable agriculture" **(Ebrahimpour *et al.*, 2011). "**Integrated use of

biofertilizers offers a cheaper low capital intensive and eco-friendly route to boosting farm productivity" **(Thavaprakash *et al.*, 2005). "**Azotobacter is a beneficial free-living (non-symbiosis) nitrogen-fixing bacteria which is reported to fix 20-60 kg/ha nitrogen in soil annually. Azotobacter was the first and is the most common biofertilizer for some plants such as maize, wheat, sorghum, and rice which produces some plant growth promoting metabolites, enzymes, and hormones (auxins, cytokinin, and gibberellins) in addition to fixing air nitrogen" **(Forlain *et al.*, 1998).**

"Application of micronutrients also play a significant role in improvement of grain yield of maize. Among micronutrients, zinc plays an important role in photosynthesis and nitrogen metabolism and regulates auxin concentration in the plant. The zinc deficiency was found widespread in Indian soil. Zn is most crucial among the micronutrients that take part in plant in plant growth and development due to its catalytic action in metabolism of almost all crops" **(George and Schmitt, 2002).**

Maize is one of the crops most sensitive to Zinc deficiency **(Mattiello *et al.*, 2015).** Zn is a micronutrient which enhances the grain productivity in the maize production. The supply of Zn in the crops can be done directly on the soil, as fertilizers, via foliar fertilization or seed treatments. Zinc being essential nutrient plays a significant role in stomata regulation and reducing the tensions of less water by creating ionic balance in plants system and is involved in various physiological processes such as synthesis of protein and carbohydrates.

Materials and Methods

The present examination was carried out during Rabi 2021 at Crop Research Farm, Department of Agronomy, SHAUTS, Prayagraj, UP, which is located at 25.28^{o} N latitude, 81.54^{o} E longitude and 98 m altitude above mean sea level. The experiment laid out in Randomized Block Design which consists of nine treatments with T1: Azospirillium + $ZnSO_4$ 10kg/ha, T2: Azospirillium + 0.1% $ZnSO_4$, T3: Azospirillium + 0.2% ZnSO4, T4: Azotobacter + $ZnSO_4$ 10kg/ha, T5: Azotobacter + 0.1% $ZnSO_4$, T6: Azotobacter + 0.2% $ZnSO_4$, T7: Azotobacter + Azosporillium + $ZnSO_4$ 10kg/ha, T8: Azotobacter + Azospirillium + 0.1% $ZnSO_4$, T9: Azotobacter

+ Azospirillium + 0.2% $ZnSO_4$ are used. DAP is applied for the fulfilment of Phosphorous and Seed inoculation of bio fertilizers was done as per the treatment details.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg/ha), higher available P (19.50 kg/ha) and medium available K (213.7 kg/ha). In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded, those parameters are growth parameters, plant height, no. of nodules per plant, branches per plant and plant dry weight were recorded. The yield parameters like pods per plant, seeds per pod, test weight, seed yield (kg/ha) and stover yield (kg/ha) were recorded and statistically analysed using analysis of variance (ANOVA) as applicable to Randomized Block Design .

Results and Discussion

Growth attributes

Plant height

At harvest significantly highest plant height (195.29 cm) was recorded in the treatment with Azotobacter + Azospirillum + 0.2% $ZnSO_4$ over all other treatments. However, the treatments with application of Azospirillum + 0.2% $ZnSO_4$ (193.89 cm) and Azotobacter + Azospirillium + 0.1% $ZnSO_4$ (194.26 cm) which were found to be par with treatment Azotobacter + Azospirillium + 0.2% $ZnSO_4$ as compared to all the treatments.

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. Increased plant height may be due to the application of recommended microbial consortium of nitrogen fixer and PDPR bacterium with nutrient rich organic source like enriched compost. Bacterization of maize with Azotobacter + Azospirillium and foliar application of zinc inclined to stimulate the growth of treated plants as characterized by the increase of root and shoot lengths. Similar results were reported by **Patidar and Mali (2004) and Amanullah *et al.* (2016)**

Plant dry weight (g/plant)

At harvest, treatment with Azotobacter + Azospirillium + 0.2% $ZnSO_4$ was recorded with significantly maximum dry weight (183.65 g/plant) over all the treatments. However, the treatments Azospirillium + 0.2% $ZnSO_4$ (182.00 g/plant) and Azotobacter + Azosprillium + 0.1% $ZnSO_4$ (182.80 g/plant) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% $ZnSO_4$.

The highest of biomass increase was in the combination of zinc and biofertilizers inoculation. Although the application of zinc as foliar spray to maize increased its dry matter significantly. Azotobacter had also performed a significant effect on maize 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 the harmony with those obtained by **Marngar and Dawson (2017) and Palai et al. (2018).**

Yield attributes and Yield

Cobs/plant

Significantly maximum cob length (27.17 cm) was recorded with the treatment of application of Azotobacter + 0.2% ZnSO4 over all the treatments. However, the treatments Azospirillium + 0.2% ZnSO4 (2.30) and Azotobacter + Azospirillium + 0.1% ZnSO4 (2.43) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Variations in days to 50% flowering due to dates of transplanting fails to exert its significant effect which might be due to flowering of plant depends on length of photoperiods and hormonal factors and these factors unaffected by date of transplanted the results are in conformity with those reported by **(Rathore and Gautam 2003).**

Cob length

Significantly maximum cob length (27.17cm) was recorded with the treatment of application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the other treatments. However, the treatments Azospirillium + 0.2% ZnSO4 (26.59 cm) and Azotobacter + Azospirillium + 0.1% ZnSO4 (26.87 cm) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Number of rows/cobs

Significantly maximum number of grains row/cob (15.19) was recorded with the treatment of application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the

treatments Azospirillium + 0.2% ZnSO4 (14.90) and Azotobacter + Azospirillium + 0.1% ZnSO4 (15.05) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Number of grains/rows

Significantly maximum number of grains/row (30.16) was recorded with the treatment of application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments Azospirillium + 0.2% ZnSO4 (29.93) and Azotobacter + Azospirillium + 0.1% ZnSO4 (30.02) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Weight of grains/cob

Significantly highest weight of grains/cob (140.88 g) was recorded with the treatment of application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments Azospirillium + 0.2% ZnSO4 (139.78 g) and Azotobacter + Azospirillium + 0.1% ZnSO4 (140.50 g) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Test weight (g)

Significantly highest test weight (230.66 g) was recorded with the treatment of application Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments Azospirillium + 0.2% ZnSO4 (222.86 g) which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

Production of photosynthesis 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, phosphorous, and potassium activated by zinc. Application of biofertilizer proved beneficial for development of corn 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 increase in yield attributes of maize. These

results are in agreement with findings of **Mahapatra *et al.* (2018), Panchal et al. (2018) and Kumar *et al.* (2015).**

Grain yield (q/ha)

Significantly highest cob yield (6.33 t/ha) was recorded with the treatment of application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments with (6.18 t/ha) in Azospirillium + 0.2% ZnSO4 and with (6.26 t/ha) in Azotobacter + Azospirillium + 0.1% ZnSO4 which were found to be statistically at par with Azotobacter + Azosporillium + 0.2% ZnSO4.

Stover yield (kg/ha)

Significantly highest stover yield (14.30 t/ha) was recorded with the treatment application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments with (14.12 t/ha) in Azospirillium + 0.2% ZnSO4 and with (14.22 t/ha) in Azotobacter + Azospirillium + 0.1% ZnSO4.

Harvest index (%)

Significantly highest harvest index (30.67%) was recorded with the treatment application of Azotobacter + Azospirillium + 0.2% ZnSO4 over all the treatments. However, the treatments with (30.63 %) in Azospirillium + 0.2% ZnSO4, (30.26 %) in Azotobacter + Azospirillium + ZnSO4 10kg/ha and with (30.55 %) in Azotobacter + Azospirillium + 0.1% ZnSO4 which were found to be statistically at par with Azotobacter + Azospirillium + 0.2% ZnSO4.

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 attributes resulted in obtaining higher yield and yield attributes resulted in 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 green cob and green fodder yield with application of zinc and bio fertilizers such as Azotobacter, Azospirillium, and the results were supported by the findings of **Marngar and Dawson (2017), Rathod *et al.* (2018), Palai *et al.* (2018) .**

CONCLUSION

It is concluded that application of treatment Azotobacter + Azospirillium + 0.2% ZnSO4 was recorded significantly higher cob yield (6.33 t/ha), higher gross returns (Rs.107553.00/ha), net returns (Rs.71570.00/ha) and benefit cost ratio (1.99) as compared to other treatments. Since, the findings based on the research done in one season.

Hence, the treatment Azotobacter + Azospirillium + 0.2% ZnSO4 is recommended for the Eastern U.P conditions.

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Table 1: Response of different Bio-fertilizers and zinc Levels on growth attributes of Maize

Treatments	Plant height (cm)	Dry weight (g/plant)
1. *Azospirillum* + $ZnSO_4$ 10 kg/ha	190.12	177.97
2. *Azospirillum* + 0.1% $ZnSO_4$	191.84	180.02
3. *Azospirillum* + 0.2% $ZnSO_4$	193.89	182.00
4. *Azotobacter* + $ZnSO_4$ 10 kg/ha	188.02	175.03
5. *Azotobacter* + 0.1% $ZnSO_4$	189.06	176.85
6. *Azotobacter* + 0.2% $ZnSO_4$	190.80	178.89
7. *Azotobacter* + *Azospirillum* + $ZnSO_4$ 10 kg/ha	192.85	180.79
8. *Azotobacter* + *Azospirillum* + 0.1% $ZnSO_4$	194.26	182.80
9. *Azotobacter* + *Azospirillum* + 0.2% $ZnSO_4$	195.29	183.65
F- test	S	S
S. EM (±)	0.54	0.56
C. D. (P = 0.05)	1.63	1.67

Table 2. Response of different Bio-fertilizers and Zinc levels on Yield attributes and Yield of Maize.

Treatments	Cobs/plant	Cob length (cm)	Grains row/ cob	Grains/row	Wt. of Grains/cob (g)	Seed Index(g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1. *Azospirillum* + $ZnSO_4$ 10 kg/ha	1.97	24.10	14.03	28.97	138.20	225.06	5.58	13.30	29.55
2. *Azospirillum* + 0.1% $ZnSO_4$	2.13	25.74	14.60	29.54	138.78	227.03	5.93	13.79	30.07
3. *Azospirillum* + 0.2% $ZnSO_4$	2.30	26.59	14.90	29.93	139.78	228.86	6.18	14.12	30.63
4. *Azotobacter* + $ZnSO_4$ 10 kg/ha	1.83	23.23	13.83	28.56	137.07	224.09	5.31	12.96	29.41
5. *Azotobacter* + 0.1% $ZnSO_4$	1.90	23.76	13.96	28.74	137.72	224.85	5.47	13.13	29.38
6. *Azotobacter* + 0.2% $ZnSO_4$	2.00	25.15	14.46	29.22	138.43	225.89	5.85	13.59	30.07
7. *Azotobacter* + *Azospirillum* + $ZnSO_4$ 10 kg/ha	2.23	26.10	14.75	29.74	139.31	227.81	6.05	13.95	30.26
8. *Azotobacter* + *Azospirillum* + 0.1% $ZnSO_4$	2.43	26.87	15.05	30.02	140.50	229.88	6.26	14.22	30.55
9. *Azotobacter* + *Azospirillum* + 0.2% $ZnSO_4$	2.60	27.17	15.19	30.16	140.88	230.66	6.33	14.30	30.67
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. EM (±)	0.11	0.23	0.10	0.08	0.51	0.70	0.05	0.07	0.19
CD (P = 0.05)	0.34	0.69	0.31	0.24	1.53	2.10	0.1	0.20	0.58