Original Research Article

Influence of Biofertilizers and Zinc Sulphate on growth and yield of Maize (Zea mays L.)

ABSTRACT

The field experiment was conducted during *Rabi* season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of Bio-fertilizers and Zinc Sulphate on growth and yield of Maize. The treatments consist of PSB, *Azotobacter*, PSB + *Azotobacter*, and Zinc Sulphate 20, 25, 30 kg/ha. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%). Results revealed that the higher plant height (159.03 cm), higher plant dry weight (162.70 g/plant), higher crop growth rate (26.250 g/m^2/day), number of cobs/plant (1.8), higher number of rows/cob (16.8), number of seeds per cob (553.4), higher 100 seed weight (29.3 gm), higher Grain yield (6.5 t/ha) higher straw yield (12.9 t/ha), and Harvest index (33.8) were significantly influenced withapplication of PSB + *Azotobacter* + zinc Sulphate 30 kg/ha.

Keywords: *Maize, Bio-fertilizers, Zinc Sulphate, growth parameters, and yield attributes*

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereals, next to wheat and rice in world as well as in India **(Paramasivan *et al.*, 2010).** It is grown successfully in warm temperate regions as well as in the humid and sub-tropical zones and is also cultivated in tropics. Maize production holds a special position historical, commercially and agronomically. It is used as food, feed and fodder and now a days it is gaining immense importance on account of its potential uses in the manufacture of starch, plastic, rayon, dye, resins, boot polish, syrups ethanol etc. Maize grain contains about 70% carbohydrate, 10% protein, 4% oil, 2.3% crude fiber, 10% aluminizes, 1.4% ash. The productivity of maize is very high because of its C4 nature of plants and it is very efficient in converting solar energy into production of dry matter. It is a miracle crop and that is why it is called "Queen of cereals" **(Singh *et al.*, 2017)**. Maize is being cultivated in almost all the part of country from the latitude 50˚ N to 40˚ S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 500 mm **(Alley *et al.*, 1972).**

Biofertilizer is a material containing microorganism(s) added to a soil to directly or indirectly make certain essential elements available to plants for their nutrition. Various sources of biofertilizers include nitrogen fixers, Phyto stimulators, phosphate solubilizing bacteria, plant growth promoting rhizobacteria, etc… **(Shekh, 2006)**. Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution **(Shevananda 2008)**. Bio-fertilizer usually contains microorganisms having specific function such as Azospirillum to fix N_2 and P solubilizing bacteria to solubilize P from the soil and fertilizer to be available to the plants **(Saraswati& Sumarno 2008)**. Several researchers had conducted the experiments to evaluate the responses of various plants such as young Robusta coffee **(Junaedi *et al.*, 1999)**, soybean and turfgrass **(Guntoro *et al*., 2007)** to the bio-fertilizer application, but the results were still inconsistent. Further research is still needed in this area.

Zinc is the micro-nutrient that most commonly limits maize yield in North America and worldwide. Zinc is commonly applied to maize crop in physical blends with phosphorus (P)or potassium (K) fertilizers. Zinc sulphate is most commonly used zinc source **(Alloway, 2009)**. Maize is the most susceptible crop to zinc deficiency. Because high yielding maize varieties are selectively grown, chemical fertilizers used have been of increased purity and cropping has become increasingly intensive; zinc deficiency in soil-crop system has become more prevalent in last decades **(Fageria N.K. 2010)**. Zinc plays an important role in the correct functioning of many enzyme systems, the synthesis of nucleic acids and auxins (plant hormone), protein metabolism and normal crop development and growth **(Mengel and Kirkby 1982)**. Phosphorus and zinc, essential for plant growth, are antagonistic to each other in certain circumstances, such as when phosphorus supplied in high level and zinc uptake becomes slower or inadequate.

Materials and Methods

The experiment was conducted during *Rabi* of 2022, Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. Which is located at 25.24' 42'' N latitude, 81·50' 56" E longitude and 98m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. Factors are Bio-fertilizers (PSB , *Azotobacter*, PSB + *Azotobacter*/kg seed) and the Zinc Sulphate levels (20,25,30 kg/ha).

The maize crop was sown on 17 November 2022. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The treatment details are as follows, T_1 -(PSB + ZnSO4 - 20 kg/ha), T_2 -(PSB+ ZnSO4 -25 kg/ha), T_3 – (PSB+ Zn ZnSO4 - 30 kg/ha), T_4 -(*Azotobacter* + ZnSO4 - 20 kg/ha), T_5 -(*Azotobacter* + ZnSO4- 25 kg/ha), T_6 -(*Azotobacter* + ZnSO4- 30 kg/ha), T_7 -(PSB + *Azotobacter* + ZnSO4 - 20 kg/ha), T_8 -(PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), T_9 -(PSB + *Azotobacter* + ZnSO4 -30 kg/ha), and Control Plot. The observations were recorded for plant height, dry weight, Crop growth rate, number of No. of cobs/plant, No. of seeds/cob, No. of seed row/cob, Seed index, see yield and stover yield. The data was subjected to statistical analysis by analysis of variance method **(Gomez and Gomez, 1976).**

Results and Discussion

Growth parameters:

PLANT HEIGHT - At Harvest, the significantly higher plant height (159.03 cm) was observed in treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha) was statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). At Harvest, the significantly higher plant height was observed with the application of bio-fertilizers as seed inoculation before sowing. Significant variation in the plant height is due to in time availability of the nutrients to the plant at the important growth stages and application of zinc has led to production of IAA resulting in increased plant height. Bacterization of maize with *Azotobacter* 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 Garima Joshi and Aaradhana **Chilwal (2018) and Alka Jyoti Sharma *et al*. (2020).**

Dry weight/plant- At Harvest, the significantly higher plant height (162.70 gm) was observed in treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha) was statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). Remarkably fresh weight and dry weight of plant was recorded with the inoculation of *Azotobacter*. *Azotobacter* can affect plant growth not only by fixing nitrogen but also by altering microbial balance, suppression of pathogenic microorganisms, metabolism of soil phosphate and by providing metabolites that stimulate plant development after germination **(Meshram and Shende, 1982)**. The effect on dry weight of plant with *Azotobacter* inoculation are in line with the earlier report of **Jarak *et al*., (2012)** in maize. **Ghodpage *et al*. (2008)** reported that the increase in yield could be attributed to the proper

supply of Zn up to harvesting stages in soil and which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby finally increased dry-matter accumulation**.**

Crop growth rate - At 60-80 DAS, the significantly crop growth rate (64.12 g/m^2/day) was observed in treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha) was statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). Increase in soil nitrogen through fixation by inoculation of *Azotobacter* has increased the crop growth as found by **Monib *et al.*, (1979).** According to **Fallik *et al.*, (1988)** the enhancement of root and shoot in Zea mays were observed under controlled conditions. Although only relatively small amounts of fertilizers are required during the very early stages of plant growth, high concentration of nutrients in the root zone at that time are beneficial in promoting early growth **(Ritchie *et al.*, 1993).**

YIELD ATTRIBUTES:

Number of Cobs/plant - The significant and higher number of Cobs/plant (1.8) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4- 30 kg/ha). A significant increase in number of cobs per plant as a consequence of seed inoculation with *Azotobacter* and PSB in the present investigation is attributed to an improvement in nutrition status of the soil and creation of congenial environment for better root growth through secretion of growth promoting substances such as Gibberellin, cytokinin and auxin and availability of nitrogen fixed by the micro-organisms **(Singh and Totawat, 2002).**

Number of Seeds/cob

The significant and higher number of Seeds/cob (553.4) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). Combined application of biofertilizers and zinc has increased the number of grains per cob insignificantly in this field experiment. The increment in number of grains per cob might be due to the presence of magnesium in multi-nutrients solution as grains number are direct index of pollen viability and where magnesium is proved to increase fruit set and pollen viability and significant effect on pollen formation as reported **by Mahgoub *et al.*, (2010) and Siam *et al.*, (2008).**

Number of Rows/cob

The significant and higher number of Rows/cob (16.85) were observed in treatment-9 with (PSB +

Azotobacter + ZnSO4 - 30 kg/ha), which was significantlysuperior over rest of thetreatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). The significant and higher number of Rows/cob (15.5) were observed with the application of Zinc. The positive response of yield components of maize because of due to the greateravailability of zinc and metabolites for growth and development of reproductive structure which ultimately led to recognition of higher productivity of individual plant. The findingsof present investigation are supported by **Gupta *et al.*, (2018).**

Seed Index (gm)

The significant and higher Test weight (29.35 gm) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of thetreatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4- 30 kg/ha). The increase in the yield components might be due to the increased of the availability of nitrogen which resulted in the increase of the leaf area. The obtained results were in agreement with findings of (Kader et al. 2002) who reported that bio-fertilizer (*Azotobacter*) increases Nitrogen availability in the soil which could enhance the numbers of grains and 100-grain weight.

Seed Yield (t/ha) - The significant and higher Seeds yield (6.5 t/ha) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of thetreatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). Application of biofertilizer proved beneficial for development of corn yield 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, which has increased chlorophyll content. Seed treatment with biofertilizers had apparently a positiveeffect on photosynthetic activity, synthesis of metabolites and growth regulatingsubstances, oxidation and metabolic activities and ultimately better growth and development of crop, which led to increase in yield attributes of baby corn. These results are in agreement with the findings of **Shaikh Wasim Chand *et al.*, (2017) and Chandra Naik *et al.*, (2020).**

Stover Yield (t/ha) - The significant and higher Stover yield (12.9 t/ha) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of thetreatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30

kg/ha). Zinc fertilization has beneficial effect on plant metabolism and plant growth, which leads to higher yield. Increase in green cob and green fodder yield with application of zinc and biofertilizers such as *Azotobacter* and the results were supported by the findings of **Tariq *et al.* (2014) and Palai *et al.* (2018).**

Harvest Index (%)

The significant and higher Harvest Index (33.8%) were observed in treatment-9 with (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha), which was significantly superior over rest of thetreatments. However, treatment-8 (PSB + *Azotobacter* + ZnSO4 - 25 kg/ha), was found to be statistically at par with treatment-9 (PSB + *Azotobacter* + ZnSO4 - 30 kg/ha). positive effect of biofertilizer may resulted from its ability to increase the availability of phosphorus and other nutrients especially under the specialty of the calcareous nature of the soil which cause decreasing on the nutrients availability, results agree with **Afzal *et al.***

CONCLUSION

It was concluded that with the application of (PSB + *Azotobacter* + ZnSO4- 30kg/ha) has performed higher seed(6.5 t/ga) compared to other treatments. Results are based on studies conducted in one season , So further testing may be required to confirm results.

Table 1. Influence of Bio-fertilizers and zincSulphate on growth parameters of Maize.

S. No.	Treatment combinations	Plant height	Plant Dry Weight	Crop growth rate
1.	PSB + ZnSO4 - 20kg/ha	148.23	142.72	52.50
2.	PSB + ZnSO4 - 25kg/ha	149.87	148.33	54.75
3.	PSB + ZnSO4 - 30 kg/ha	152.45	151.32	57.75
4.	*Azotobacter* + ZnSO4 - 20kg/ha	151.99	152.70	60.37
5.	*Azotobacter* + ZnSO4 - 25kg/ha	154.04	156.71	60.16
6.	*Azotobacter* + ZnSO4 -30kg/ha	155.72	158.72	61.61
7.	PSB + *Azotobacter* + ZnSO4 - 20 kg/ha	154.97	159.00	63.75
8.	PSB + *Azotobacter* + ZnSO4 - 25 kg/ha	156.65	161.32	62.62
9.	PSB + *Azotobacter* + ZnSO4 - 30 kg/ha	159.03	162.70	64.12
10.	Control RDF (120-60-40) kg/ha	143.50	146.07	53.62
	F test	S	S	S
	SE m (±)	2.88	2.07	1.63
	CD (p=0.05)	8.54	6.15	4.85

Table 2. Influence of Bio-fertilizers and zincSulphate on yield attributes of Maize.

S. No.	Treatments	No. of. Cobs/plant	No. of. Rows/Cobs	No. of. Seeds/Cob	Seed index (gm)	Grain yield(t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	PSB + ZnSO4 -20kg/ha	1.3	12.1	332.6	26.0	3.6	7.4	32.1
2.	PSB + ZnSO4 - 25kg/ha	1.4	14.1	351.5	26.8	3.8	8.9	30.4
3.	PSB + ZnSO4 - 30kg/ha	1.5	14.5	383.4	27.6	3.9	9.8	28.6
4.	*Azotobacter* + ZnSO4 -20kg/ha	1.3	12.7	374.3	26.9	4.0	10.5	27.7
5.	*Azotobacter* + ZnSO4 - 25kg/ha	1.6	14.7	425.4	27.4	4.2	11.1	27.6
6.	*Azotobacter* + ZnSO4 - 30kg/ha	1.7	14.9	463.7	27.9	4.5	11.4	29.3
7.	PSB + *Azotobacter* + ZnSO4 - 20 kg/ha	1.6	14.4	495.3	27.2	5.4	11.9	32.1
8.	PSB + *Azotobacter* + ZnSO4 - 25 kg/ha	1.7	16.1	519.7	28.4	6.3	12.3	33.4
9.	PSB + *Azotobacter* + ZnSO4 - 30 kg/ha	1.8	16.8	553.4	29.3	6.5	12.9	33.8
10.	Control RDF (120-60-40) kg/ha	1.4	12.4	336.4	26.7	4.3	9.9	30.7
	F-Test	S	S	S	NS	S	S	S
	SEm(+)	0.05	0.38	6.51	0.74	0.07	0.85	0.77
	CD (p=0.05)	0.14	1.13	19.34	---	0.22	2.52	2.28

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