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Effect of zinc and bio-fertilizers on growth, yield and economics of baby corn (*Zea mays* L.)

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Abstract
The field experiment was conducted during *Zaid*, 2021 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). The experiment was laid out in Randomized Block Design with 9 treatments, replicated thrice. Results that observed that significantly highest plant height (162.41cm), dry weight (111.57 g/plant), cobs (1.33/plant), cob length with husk (20.37 cm), cob length without husk (8.07 cm), cob weight with husk (65.75 g), cob weight without husk (23.53 g), green cob yield with husk (15.53 t/ha), green cob yield without husk (5.56 t/ha), green fodder yield (29.47 t/ha) and harvest index (35.53%) were recorded with 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Maximum gross returns (Rs. 2,37,266.70/ha), net returns (Rs. 1,80,596.70/ha) and benefit: cost ratio (3.19) were obtained highest in the treatment combination of 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*.

Keywords: *Azospirillum*, *Azotobacter*, green cob yield, green fodder yield, zinc, Foliar spray returns

Introduction
Baby corn is basically unfertilized young cobs harvested 2 or 3 days after silk emergence, preferred due to shift in dietary habit from non-vegetarian to vegetarian also due to the enhancement of living standards. India has abundance in cheap labour thus this crop serve as the great potential for production and export (Dadarwal *et al*., 2009) [5]. An interesting recent development is of growing maize for vegetable purpose (Dass *et al*., 2008) [6]. Currently, Thailand and China are the world leaders in baby corn production. In India, baby corn is being cultivated in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh (Reena Rani *et al*., 2017) [10].
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 synthesis of protein and carbohydrates. In many cases, aerial spray of nutrients is preferred and gives quicker and better results than the soil application. Foliar feeding practice would be more useful in early maturing short duration crops, where the soil applied fertilizer may not become fully available before maturity of crop (Somla Naik *et al*. 2018).
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. 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. The bacterium produces growth-promoting substances like Indole acetic acid, gibberellins, pantothenic acid which promotes root proliferation and improve the plant growth and yield (Zothanmawii *et al*., 2018)
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. This plant stimulatory effect that exerted by *Azospirillum* has been attributed to several mechanisms like biological nitrogen fixation and auxin production. *Azospirillum brasilense*, a bacterium which fixes nitrogen is found in the rhizosphere of various grass species and was investigated to establish the effect of growth substances which are produced by the bacteria on plant growth (Tien *et al*., 2000).

Materials and Methods
This experimental trial was carried out during *Zaid* 2021 at Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology &

Sciences (SHUATS), Prayagraj (U. P) located at 25˚39"42" North latitude, 81˚67"56" East longitude and 98 m altitude above the mean sea level. The experiment was laid out in Randomized Block Design consisting of nine treatments which are T_1: 15 kg/ha $ZnSO_4$ (soil application) + *Azospirillum*, T_2: 15 kg/ha $ZnSO_4$ (soil application) + *Azotobacter*, T_3: 25 kg/ha $ZnSO_4$ (soil application) + *Azospirillum*, T_4: 25 kg/ha $ZnSO_4$ (soil application) + *Azotobacter*, T_5: 0.5% $ZnSO_4$ (foliar application at 20 and 40 DAS) + *Azospirillum*, T_6: 0.5% $ZnSO_4$ (foliar application at 20 and 40 DAS) + *Azotobacter*, T_7: 1% $ZnSO_4$ (foliar application at 40 DAS) + *Azospirillum*, T_8: 1% $ZnSO_4$ (foliar application at 40 DAS) + *Azotobacter*, T_9: Control replicated thrice to determine the effect of zinc and biofertilizers on growth and yield of baby corn. The soil of the trial plot was sandy loam in texture nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), medium in available P and K (15.2 kg/ha and 232.5 kg/ha respectively). The nutrient sources used in the research plot were urea, DAP and MoP to fulfill the requirements of nitrogen, phosphorous and potassium. The recommended dose of 120 kg N, 60 kg P_2O_5, 40 kg K_2O/ha and zinc sulphate was applied as per the treatments *viz*., foliar application and soil application. Whereas, seeds were inoculated with biofertilizers i.e., *Azospirillum* and *Azotobacter* on the basis of treatment combinations. Thinning and gap filling was done after 11 days of sowing and one irrigation was given just after sowing for ensuring proper germination and one more irrigation during 30 DAS after incorporating second split of nitrogen. Between the period of germination to harvest several plant growth parameters were recorded at equal intervals and after harvest several yield parameters were recorded. In growth parameters plant height (cm) and dry weight (g/plant) were recorded and yield parameters like cobs/plant, cob length (cm) with husk and without husk, cob weight (g) with husk and without husk, green cob yield (t/ha), green fodder yield (t/ha) and harvest index (%) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez, K. A. and Gomez, A. A. 1984).

Results and Discussion

Effect on growth of baby corn: The statistical data regarding growth parameters is presented in Table 1.

Plant height (cm)

Zinc and *Azotobacter* application on baby corn significantly influenced plant height at harvest. Plant height (162.41 cm) was observed significantly highest with application of 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Whereas, 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* and 0.5% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (152.63 and 153.79 cm) respectively were found on par with 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter.* 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) [7] and Alka Jyoti Sharma *et al*. (2020) [1].

Dry weight (g)

Dry weight was significantly influenced at harvest with the foliar application of zinc and *Azotobacter* seed inoculation on baby corn. Significantly higher dry weight (111.57 g/plant) was recorded in application of 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + Azotobacter and 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* and 0.5% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (107.24 and 103.32 g/plant) were found to be statistically on par with the highest. The favourable increase in dry matter of baby corn due to zinc involvement in auxin synthesis, photosynthetic activity of the crop. The present study is in accordance with the findings of Palai *et al.,* (2018). Although the application of zinc as foliar spray to maize increased its dry matter significantly. *Azotobacter* had also performed a significant effect on baby corn dry matter yield. These findings are in harmony with those obtained by Sanjay Mahato and Srijana Neupane (2017) [11] and Chhotan Das *et al*. (2018).

Table 1: Effect of zinc and bio-fertilizers on growth parameters of baby corn

S. No	Treatments	Plant height (cm) (60 DAS)	Dry weight (g/plant) (60 DAS)
1	15 kg/ha ZnSO4 (soil application) + *Azospirillum*	138.25	86.69
2	15 kg/ha ZnSO4 (soil application) + *Azotobacter*	139.13	88.30
3	25 kg/ha ZnSO4 (soil application) + *Azospirillum*	141.46	90.62
4	25 kg/ha ZnSO4 (soil application) + *Azotobacter*	140.98	93.95
5	0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	144.42	97.03
6	0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	152.63	103.32
7	1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	153.79	107.24
8	1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	162.41	111.57
9	Control	125.07	85.65
	S.Em+	6.92	4.32
	CD (P=0.05)	17.76	12.96

Effect on yield and yield attributes of baby corn

The statistical data representing yield and yield attributes is presented in Table 2.

Number of cobs/plant recorded non-significant among the treatments. However the highest number of cobs (1.33) were recorded in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* application and lowest (1.00) in control plot. Cob length was found to be non-significant, maximum Cob length with husk (20.37 cm) and without husk (8.09) was recorded in treatment 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* application. Cob weight per plant with husk recorded a significant difference among treatment combinations. However, cob weight (65.75/plant) was recorded significantly higher in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* and statistically at par values were observed in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* and 0.5% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (62.03 and 59.62 g/plant), respectively. Significantly higher cob weight without husk was recorded in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*

(23.53 g/plant). Whereas, 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* and 0.5% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (22.16 and 21.30 g/plant), respectively found statistically on par with the highest value. 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 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 baby corn. These results are in agreement with the findings of Shaikh Wasim Chand *et al.* (2017) [12] and Chandra Naik *et al.* (2020) [3]

The green cob yield with husk was observed significantly higher in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (15.53 t/ha). However, 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* (13.86 t/ha) was found to be statistically on par with 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Green cob yield without husk (5.56 t/ha) was found to be significantly higher in treatment combination of 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Green fodder yield was significantly higher (29.47 t/ha) in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Whereas, 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* and 0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter* (27.04 and 26.87 t/ha), respectively found statistically on par with 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter*. Significantly highest harvest index (35.53%) was noticed in 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* and application of 1% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azospirillum* (33.82%) and 0.5% $ZnSO_4$ (foliar spray at 20 and 40 DAS) + *Azotobacter* (32.59%), respectively found to be at par with 1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*.

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 Azeem Tariq *et al.* (2014) [2] and Jnana Bharati Palai *et al.* (2018) [9].

Economics

Data in table 3- tabulated that experimental results revealed that application of 1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter* recorded higher gross returns (2,37,266.70 INR) net returns (1,80,596.70 INR) and benefit: cost ratio (3.19) and minimum gross returns (1,34,183.30 INR), minimum net returns (78,933.33 INR) and minimum benefit: cost ratio (1.43) were recorded with control.The application of 1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter* increased the yield parameters, green cob yield and green fodder yield which helped in higher gross returns, net returns and benefit cost ratio. The results were found to be in resonance with Jinjala *et al.* (2016) [8] and Anjum *et al.* (2017).

Table 2: Effect of zinc levels and bio-fertilizers on yield attributes and yield of baby corn

Treatments	Cobs /plant	Cob length (cm)		Cob weight (g)		Yield (t/ha)		Green fodder yield (t/ha)	Harvest index (%)
		With husk	With out husk	With husk	With out husk	With husk	With Out husk		
15 kg/ha ZnSO4 (soil application) + *Azospirillum*	1.07	16.75	6.49	47.94	17.12	9.02	3.22	24.34	27.77
15 kg/ha ZnSO4 (soil application) + *Azotobacter*	1.13	17.19	7.29	48.56	16.96	9.54	3.41	24.49	28.25
25 kg/ha ZnSO4 (soil application) + *Azospirillum*	1.20	17.35	7.31	50.28	17.90	10.73	3.83	25.30	29.88
25 kg/ha ZnSO4 (soil application) + *Azotobacter*	1.13	17.73	7.33	53.04	18.94	10.61	3.79	25.36	29.54
0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	1.27	15.91	7.61	54.62	19.51	11.96	4.27	25.90	31.26
0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	1.20	18.53	7.75	59.62	21.30	12.62	4.51	26.87	32.59
1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	1.27	19.77	7.81	62.03	22.16	13.86	4.95	27.04	33.82
1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	1.33	20.37	8.07	65.75	23.53	15.53	5.56	29.47	35.53
Control	1.00	15.01	6.67	47.49	17.34	8.63	3.08	21.97	28.05
S.Em+	0.10	1.15	0.48	3.49	1.30	0.64	0.23	1.14	1.38
CD (P=0.05)	-	-	-	10.48	3.88	1.91	0.70	3.42	4.13

Table 3: Effect of zinc levels and bio-fertilizers on economics of baby corn

S. No.	Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
1.	15 kg/ha ZnSO4 (soil application) + *Azospirillum*	57,150.00	1,40,836.70	83,686.67	1.46
2.	15 kg/ha ZnSO4 (soil application) + *Azotobacter*	57,150.00	1,48,646.70	91,496.67	1.60
3.	25 kg/ha ZnSO4 (soil application) + *Azospirillum*	58,350.00	1,65,850.00	1,07,500.00	1.84
4.	25 kg/ha ZnSO4 (soil application) + *Azotobacter*	58,350.00	1,64,281.70	1,05,931.70	1.82
5.	0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	56,010.00	1,83,751.70	1,27,741.70	2.28
6.	0.5% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	56,010.00	1,93,701.70	1,37,691.70	2.46
7.	1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azospirillum*	56,670.00	2,11,520.00	1,54,850.00	2.73
8.	1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter*	56,670.00	2,37,266.70	1,80,596.70	3.19
9.	Control	55,250.00	1,34,183.30	78,933.33	1.43

Conclusion

Based on the findings of the investigation it may be concluded that 1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter* performed exceptionally in all growth, yield parameters and in obtaining maximum green cob yield of baby corn, highest gross returns, net returns and B: C ratio. Hence, 1% ZnSO4 (foliar spray at 20 and 40 DAS) + *Azotobacter* is beneficial under Uttar Pradesh Conditions.

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