Original Research Article

Impact of Foliar application of Zinc and Biofertilizers on Growth of Sorghum (*Sorghum bicolor* L.)

Abstract

The field experiment took place in the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, during the *kharif* season of 2021. (UP), India. The objective of the experiment is to lessen the use of chemical fertilizers by using techniques of integrated nutrient management in an efficient way without compromising on the nutrient availability to the crop which ultimately reduce the effect of chemicals used in agroecosystem. The experiment was set up in a randomized block design with ten treatments, including control, that was replicated thrice using various biofertilizers. *viz*., *Azospirillum* species 25 gram/kilogram seeds, Phosphate solubilizing bacteria 25 g/kg seeds and combination of *Azospirillum* sps. 25 g/kg seeds + PSB 25 g/kg seeds and foliar application of 0.5% zinc at 30, 50 and 30 + 50 days after sowing per hectare. The research revealed that foliar application of zinc 0.5% at 50 DAS along with seed inoculation by *Azospirillum* sps. 25 g/kg Seeds + PSB 25 g/kg seeds significantly increased the growth parameters of Sorghum *viz*., plant height (163.31centimeter), dry matter accumulation (92.71 g), No. of Leaves (12.87), absolute growth rate (1.33 g/plant/day), crop growth rate (44.31 g/m^2/day) and leaf area (414.67 cm^2).

Keywords: Sorghum, Biofertilizers, Zinc, *Azospirillum* sps., Phosphate solubilizing bacteria, Growth

1. INTRODUCTION

Sorghum is one of the most significant crops produced in India, and it is used on a daily basis by the majority of Indians. After wheat, corn, rice, and barley, it ranks fifth in cereal production. It is also important in the industrial sector, since it is used in malting, the production of high fructose syrup, breads and many value added products, and animal feed. Sorghum is a millet with many health benefits and it is recommended to diabetic patients. Sorghum is also a drought tolerant crop, it can be easily grown in areas with dry climate and less rainfall. Minimum 350-400 mm of rainfall is good for cultivation, it can tolerate both drought as well as water logging conditions. Sorghum can be grown on wide range of soil but

sandy loam soil is considered to be best for its cultivation. Sorghum can be grown on wide range of soil but sandy loam soil is considered to be best for its cultivation. Sorghum is a good source of vitamins and minerals, along with providing great protein content and making up for a large portion of your dietary fiber intake. For every 100 grams of sorghum cereal, you get about 3.5 grams of fat, out of which only 0.6 grams is saturated fat. The 100 g grain content 10.4 g proteins, 1.9 g fats, 72.6 g carbohydrates, 1.6 g crude fiber and 25 g calcium. Major pest problem is very less in this crop and that's why it can be stored easily for long time. Sorghum has high content in vitamins and fiber rich source. Sorghum is known to be rich in phenolic compounds, many of which act as antioxidants, which helps in reduction of tumor.

The sorghum productivity has been low due to growing of this crop on small and marginal lands and continuous use of harmful fertilizers. Micronutrient deficiency in soil especially zinc, is the most common problem in the soil due to which there is severe yield loses and nutritional quality get affected. The integrated nutrient management is being implemented on many of the crops because of that the use of biofertilizers uses has been increased in all types of crops especially using biofertilizers in the cereal crops has been proven beneficial in many ways for fixing the nitrogen. For successful cultivation, nutrient management is important and the quantity and quality of crops can be affected by biofertilizers [14]. In agriculture, the nitrogen-fixing bacteria especially *Azotobacter* and *Azospirillum* increase the yield in cereals and also exerts many positive effects on the crop when various biotic and abiotic factors influence crop growth and yield [29]. Biofertilizers applied to either soil, plant surface or seed results in increase of the supply or availability of primary growth nutrients to the host plant [33].

There are several approaches adopted to eliminate micronutrient malnutrition. The biofortification of zinc is a promising and cost effective measure to increase Zn concentration (agronomic biofortification) in cereal grain to address Zn malnutrition [31]. Application of nitrogen fertilizer positively affect Zinc concentrations in wheat grain and also reported that change in mineral status of soil which will affect the nutrient concentration of plant [8]. Nitrogen fertilization along with Zinc not only increases the yield but also enhance zinc content in grain pearl millet [26]. Viewing the above circumstances, the study was conducted in order to examine the Biofertilizers and foliar application of Zinc on growth of sorghum.

Use of biofertilizers and foliar application of zinc combined can result in good growth of the sorghum crop. Biofortification of zinc strategy appears to be essential in keeping sufficient amount of available zinc in plants to maintain adequate zinc transport to grain during the reproductive stage and other growth stages.

2. MATERIALS AND METHODS

The experiment was conducted in the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, during the *kharif* season of 2021. (U.P), India. which is situated at 25^{o} 39' 42" north latitude, 81^{o} 67' 56" east longitude, and 98 meters above sea level. The soil in the experimental plot was sandy loam in texture, pH 7.7, low in organic carbon (0.57 percent), available N (230 kg/ha), available P (32.10 kg/ha), and available K (346.00 kg/ha). The crop was planted on July 19, 2021, with the NTJ-5 variety. The experiment used a randomized block design with three replications and a total of ten treatments. *viz*., T_1: Control - 80: 40:40 kg NPK/ha (Farmer's Practice), T_2: *Azospirillum* sps. 25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T_3: *Azospirillum* sps. 25 g/kg seeds + 0.5 % zinc foliar spray 50 DAS, T_4: *Azospirillum* sps. 25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS, T_5: PSB 25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T_6: PSB 25 g/kg seeds + 0.5 % zinc foliar spray 50 DAS, T_7: PSB 25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS, T_8: *Azospirillum* sps. + PSB: 25+25 g/kg seeds + 0.5% zinc foliar spray 30 DAS, T_9: *Azospirillum* sps + PSB: 25+25 g/kg seeds + 0.5 % zinc foliar spray 50 DAS. T_{10}: *Azospirillum* sps. + PSB: 25+25 g/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS. All nutrients were applied as urea, single super phosphate (SSP), and muriate of potash through the soil (MOP). For each plot, a full dose of P and K was applied basal, and half of the nitrogen (as urea) was applied basal. The remaining half of the nitrogen should be top dressed 30-35 days following sowing. The growth parameters of the randomly selected five tagged plants in each treatment were measured at intervals of 20,40,60,80 DAS and at harvest stage.

3. RESULTS AND DISCUSSION

3.1. Impact of foliar application of zinc and biofertilizers and on growth parameters

Impact of foliar application of zinc and biofertilizers on growth parameters of sorghum are in Table 1.

3.1.1. Plant height

The findings resulted that the treatment with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha recorded maximum plant height (163.31 cm). Similar findings were reported by Rafi and Charyulu *et al*., [27] and Priyanka *et al*., [16].

ANOVA Table 1. Plant height (cm) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	830.953	92.328	5.625	S	S
Replication	2	27.755	13.877	0.845		
Error	18	295.405	16.411			
TOTAL	29	1154.115				

3.1.2 Number of leaves per plant

The results revealed that maximum number of leaves per plant (12.87) was recorded with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was maximum over the other treatment combinations. Similar findings were reported by Anil kumar *et al*., [2]

ANOVA Table 2. Number of leaves in 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	7.558	0.839	2.487	S	NS
Replication	2	0.296	0.148	0.438		
Error	18	6.077	0.337			
TOTAL	29	13.932				

3.1.3. Dry matter accumulation

The results recorded that significantly highest plant dry matter accumulation (92.71 g) was observed with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was higher over the treatments. It is due to better availability of nitrogen and phosphorus and the action of biofertilizer which lead in overall better development of the crop. The combined use of biofertilizer and foliar application of zinc just before flowering stage at 50 DAS helped in good foliage and good panicle development in the crop which improved the growth parameters due to increased dry matter production, which in turn contributed to improved yield attributes. Similar findings were reported by Rafi and Charyulu *et al*., [27].

ANOVA Table 3. Dry matter accumulation (g) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	**9**	578.42	64.27	30.89	S	S
Replication	**2**	4.18	2.09	1.00		
Error	**18**	37.45	2.08			
TOTAL	**29**	620.04				

3.1.4. Absolute growth rate

At 80-100 DAS, results revealed that significantly highest absolute growth rate (1.33 g/plant/day) was observed with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha which was superior over the treatments.

ANOVA Table 4. Absolute growth rate of sorghum (g/g /day) 80-100 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	9	0.52	0.06	5.87	S	S
Replication	2	0.00	0.00	0.08		
Error	18	0.18	0.01			
TOTAL	29	0.70				

3.1.5. Crop growth rate

At 80-100 DAS, significantly highest crop growth rate (44.31 g/m^2/day) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of zinc at 50 DAS over control.

ANOVA Table 5. Crop growth rate of sorghum (g/m^2 /day) 80-100 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)

Treatment	9	577.26	64.14	5.87	S	S
Replication	2	1.81	0.90	0.08	NS	NS
Error	18	196.70	10.93			
TOTAL	29	775.76				

3.1.6. Leaf area

At 80 DAS, significantly highest leaf area (414.67 cm^2) has been recorded with dual inoculation by *Azospirillum* sps. and phosphate solubilizing bacteria (PSB) along with foliar application of zinc at 50 DAS.

ANOVA Table 6. Leaf area (cm^2) of sorghum 80 DAS

Source	D.F.	SS	MSS	Cal. F	TAB F(5%)	TAB F(1%)
Treatment	**9**	24967.77	2774.20	433.16	S	S
Replication	**2**	39.98	19.99	3.12		
Error	**18**	115.28	6.40			
TOTAL	**29**	25123.03				

Table 7. Impact of biofertilizers and foliar application of zinc on growth parameters of sorghum

Treatment Combinations	Growth parameters (80DAS)					
	Plant height (cm)	**No. of leaves per plant**	**Dry matter accumulation**	**Absolute growth rate (g/plant/day) 80-100 DAS**	**Crop growth rate (g/m^2/day) 80-100 DAS**	**Leaf area (cm^2)**
1. Control 80:40:40 kg NPK/ha (Farmer's Practice)	143.98	11.53	75.71	1.12	37.32	312.90
2. *Azospirillum* sps. 25 gm/kg seeds + 0.5% zinc foliar spray 30 DAS	153.75	11.67	81.66	1.15	38.32	343.03
3. *Azospirillum* sps. 25 gm/kg seeds + 0.5 % zinc foliar spray 50 DAS	153.90	12.47	83.30	1.19	39.57	337.50
4. *Azospirillum* sps. 25 gm/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS	157.07	12.67	85.54	1.25	41.74	383.00
5. PSB 25 gm/kg seeds + 0.5% zinc foliar spray 30 DAS	158.95	11.73	86.03	0.99	32.99	374.90
6. PSB 25 gm/kg seeds + 0.5 % zinc foliar spray 50 DAS	161.30	11.93	85.03	1.15	38.29	362.57
7. PSB 25 gm/kg seeds + 0.5 % zinc foliar spray 30 + 50 DAS	161.67	11.60	90.32	1.02	33.83	396.53
8. *Azospirillum* sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 30 DAS	155.91	11.53	86.19	0.86	28.81	386.13
9. *Azospirillum* sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 50 DAS	163.31	12.87	92.71	1.33	44.31	414.67
10. *Azospirillum* sps. + PSB 25+25g/kg seeds + 0.5% zinc foliar spray 30 + 50 DAS	154.73	12.60	86.69	1.00	33.35	378.07
F test	S	S	S	S	S	S
SEd (±)	3.31	0.41	1.18	0.08	2.70	2.07
Sem (±)	2.34	0.34	0.83	0.06	0.91	1.46
CD (P=0.05)	6.95	1.00	2.47	0.17	5.67	4.34

Conclusion

The findings of the field experiment suggest that sorghum should be sown with dual inoculation of *Azospirillum* sps. and PSB along with foliar application of 0.5% zinc at 50 DAS/ha as it has resulted in higher growth and development of sorghum crop.

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