Eco. Env. & Cons. 30 (October Suppl. Issue) : 2024; pp. (S25-S29)
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ISSN 0971–765X

DOI No. http://doi.org/10.53550/EEC.2024.v30i06s.004

Effect of Azospirillum and Potash Solubilizing Bacteria (KSB) on growth and Yield of Finger Millet (*Eleusine coracana* L.)

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(Received 15 March, 2024; Accepted 3 May, 2024)

ABSTRACT

A field experiment was conducted during kharif 2023 at research farm, Department of Plant Pathology RCSM college of Agriculture, Kolhapur to determine the "Effect of *Azospirillum* and KSB on growth and yield of finger millet (*Eleusine coracana* L.)". In the present study, The co-inoculation of *Azospirillum* and potash solubilizing bacteria (KSB) along with application of 75% of recommended dose of nitrogen, potash and 100% of recommended dose of phosphorus was recorded the highest seed germination (96.16 %), plant height at 30 DAS (34.58 cm), 60 DAS (56.65 cm) and at harvest (122.63 cm), number of tillers at 30 DAS (2.27), 60 DAS (6.67) and at harvest (7.89),number of fingers per ear head (8.73), finger length (9.70 cm),1000 seed wt.(3.18 g), grain yield per plant (6.20 g),grain yield per ha (19.09 qt),straw yield (24.81 qt) whereas available N (218.27 Kg/ha), available P (33.26 Kg/ha) and available K (319.32 Kg/ha) in the soil. The co-inoculation of *Azospirillum* and potash solubilizing bacteria (KSB) along with application of 75% of recommended dose of nitrogen, potash and 100% of recommended dose of phosphorus was recorded highest *Azospirillum* and potash solubilizing bacteria (KSB) microbial count i.e. (30.72 × 104 CFU g^{-1} soil) and (15.28 × 104 CFU g^{-1} soil) at 50% flowering.

Key words: *Finger millet, Azospirillum, KSB*

Introduction

In India, the finger millet *(Eleusine coracana* L.) is referred to as "ragi." In several regions of India and eastern Africa and central Africa, it is a significant staple food. Among the different states of India, it is widely grown from which Maharashtra is one. Finger millet is grown on an area of 1159.40 thousand hectares in India with production of 1998.36 thousand tones. In Maharashtra, finger millet occupies an area of 81.60 thousand hectares, with of 93.92 thousand tones production. Additionally, finger millet may be grown on wide range soils with little rainfall and few nutrients, where other grains cannot thrive. It is a highly resilient plant. It is somewhat resistant to salt, water logging, and drought. Ragi needs less moisture, so it can withstand the effects of climate change. It is the crop of the future (Anuradha *et al.,* 2017).

In order to enhance finger millet yields and promote soil fertility, it is crucial to combine chemical fertilizers with biofertilizers such as *Azospirillum, Azotobacter* and bacteria that solubilize phosphorus and potash in soil. These biofertilizers, in conjunction with chemical fertilizers, offer the essential elements required for robust crop growth, including Nitrogen, Phosphorus, and Potassium. Certain soil microorganisms, like *Azospirillum, Azotobacter*, and

Acetobacter, possess the ability to fix atmospheric nitrogen into the soil. Among these microorganisms, some are free-living, while others reside in the root zone of the crop. *Azospirillum brasiliense, A. lipoferum, A. halopraeferens, A. doebereinerae* were stated to restore atmospheric nitrogen and decrease use of chemical fertilizers up to 20 to 25%

Bacteria that solubilize potassium are those that liberate potassium from insoluble minerals. It has the ability to change insoluble or solid structured potassium molecules into soluble forms in soil, creating a soil solution, which plants may use (Zeng *et al.*, 2012).

Various bacteria *viz.Acidothiobacillus ferrooxidans, Bacillus mucilaginosus, Bacillus edaphicus, Bacillus circulans, Paenibacillus* spp., and *Pseudomonas* has been found to release K from potassium-bearing minerals in soil in an accessible form. (Sheng *et al.*, 2008).

Bacillus and *Pseudomonas* has been recognized as potassium solubilizing bacteria and play a significant role in potassium availability for growth of different plants (Narula *et al.*, 2005).

Materials and Methods

The research was conducted at Plant Pathology and Agricultural Microbiology Section, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur, during 2022-23. Fifteen rhizospheric soil samples were collected from different tehsils of Kolhapur District. Out of these, four isolates of *Azospirillum* and three isolates of potash solubilizing bacteria were isolated by serial dilution and plating method on *Nfb* semi solid medium and Aleksandrov medium respectively. They were identified, screened and selected as efficient isolates on the basis of morphological and cultural characteristics (colour and shape), biochemical characterization. The efficient isolates of *Azospirillum* and potash solubilizing bacteria were selected for field studies. The experiment was laid out in Randomized Block Design with three replications and twelve treatments *viz.* T_1 *Azospirillum* + KSB, T_2 50% N + RD of P & K + Efficient isolate of *Azospirillum*, T_3 75% N + RD of P & K + Efficient isolate of *Azospirillum*, T_4 RDF + Efficient isolate of *Azospirillum*, T_5 50% K + RD of N & P + Efficient isolate of KSB, T_6 75% K + RD of N & P + Efficient isolate of KSB, T_7 RDF + Efficient isolate of KSB, T_8 50% N, K & RD of P + Efficient isolate of *Azospirillum* & KSB, T_9 75% N K & RD of P + Efficient isolate of *Azospirillum* and KSB, T_{10} RDF + Efficient isolate of *Azospirillum* & KSB, T_{11} RDF (Control), T_{12} Absolute control. As per the plan of layout, Seeds of Phule kasari were sown in respective plots. Data was recorded and analyzed statistically to express the yield.

Results and Discussion

The study revealed that, different growth parameters and yield parameters *viz*. seed germination, plant height, number of tillers, number of fingers per ear head, finger length, grain yield per plant, 1000 seed weight, grain yield per hectare and straw yield were significantly increased when seeds of fin-

Fig. 1. Growth Parameters

Treatment	Plant Height			Number of Tillers		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1	31.57	46.32	66.47	1.80	3.80	4.09
T_2	31.33	47.45	97.67	1.67	4.40	5.09
T_3	31.14	50.44	109.91	1.60	5.20	5.69
T_4	32.39	53.62	116.97	1.87	6.00	7.39
T_5	32.29	49.57	109.03	1.73	4.80	5.22
T_6	31.96	51.25	110.49	1.67	5.27	5.75
T_7	32.35	54.71	118.62	2.00	6.13	7.48
T_8	33.35	51.76	111.89	1.60	5.53	5.82
T_9	34.58	56.65	122.63	2.27	6.67	7.89
T_{10}	34.12	54.90	120.73	2.07	6.27	7.65
T_{11}	31.01	51.80	112.43	1.40	5.60	5.95
T_{12}	30.51	36.73	45.83	1.27	2.67	3.15
Sem	1.14	1.54	3.32	0.19	0.25	0.19
CD 5%	NS	4.52	9.72	NS	0.73	0.58

ger millet treated with *Azospirillum* and potash solubilizing bacteria compared to untreated control.

Growth Parameters

Seed Germination

The results demonstrated that, the treatment of efficient isolate of *Azospirillum* + efficient isolate of KSB and a recommended dose of 75% nitrogen, potash and 100% phosphorus (T_9) recorded highest mean seed germination (96.16%) as compared to rest of treatments. The percentage of germination was observed in range from 81.60% to 96.16%. Treatment T_{10}, T_7, and T_4 were found statistically at par with treatment T_9.

Plant Height

The data revealed that, significantly higher plant height at 30, 60 DAS and at harvest was observed with treatment efficient isolate of *Azospirillum* + efficient isolate of KSB with 75% recommended dose of nitrogen and potash and 100% phosphorous (T_9). However, treatment T_{10}, T_7 and T_4 were statistically at par with treatment T_9.

Similar results were observed by Gangothri *et al.* (2023), Raoni *et al.* (2015), Kappes *et al.* (2013), Goswami and Maurya, 2020, Kumar *et al.*, 2021; Garima *et al.*, 2020.

Number of Tillers

The significantly and higher number of tillers was recorded with treatment efficient isolate of *Azospirillum* + efficient isolate of KSB with 75% recommended dose of nitrogen and potash and 100% phosphorous (T_9). However, in treatment T_{10}, T_7 and T_4 were statistically at par with treatment T_9.

Gangothri *et al.* (2023) demonstrated that, the significantly and higher number of tillers (8.67/plant) was recorded with the application of 60 kg N/ha and *Azospirillum* 2 g/kg

Yield Parameters

Number of Fingers/ Ear Head

Significantly higher number of fingers/ear head was recorded with treatment T_9, which was significantly higher over rest of all the treatments and statistically at par with treatment T_4, T_7 and T_{10}.

"Gangothri *et al.*, (2023) reported that, significant higher number of fingers/plants was recorded with the application of nitrogenous fertilizer + *Azospirillum* 2 g/kg, which was significantly higher over rest of all the treatments. Also, similar effect observed by Nigade and More (2013)".

Finger Length

Significantly higher finger length was observed with treatment T_9, which was significantly higher over rest of all the treatments and statistically at par with treatment T_4, T_7 and T_{10}.

Results are in conformity with Nigade and more (2013) and Cavallet *et al*. (2000).

1000 Seed Weight (g)

The significant and higher test weight (1000 seed weight) was recorded with treatment T_9, which was significantly higher over rest of all the treatments and statistically at par with treatment T_4, T_7 and T_{10}.

Fig. 2. Yield Parameters

Treatment	Number of fingers per ear head	Finger length	Grain yield per plant	1000 seed weight	Grain yield per hectare	Straw yield
T_1	4.20	5.11	2.88	2.01	12.59	16.37
T_2	6.07	6.78	4.27	2.18	14.42	18.74
T_3	6.27	7.02	4.91	2.45	16.37	21.28
T_4	8.13	8.81	5.75	2.97	17.89	23.25
T_5	6.20	6.94	4.72	2.28	15.72	20.44
T_6	6.40	7.43	5.01	2.49	16.69	21.70
T_7	8.20	8.75	5.83	2.94	18.18	23.63
T_8	7.20	7.46	5.13	2.09	17.09	22.21
T_9	8.73	9.70	6.20	3.18	19.09	24.81
T_{10}	8.40	8.95	5.91	3.01	18.26	23.74
T_{11}	7.33	7.59	5.21	2.30	17.35	22.56
T_{12}	3.13	3.67	2.56	1.89	9.69	12.60
Sem	0.37	0.36	0.176	0.17	0.48	0.62
CD 5%	1.09	1.08	0.52	0.51	1.41	1.83

Similar results were obtained by Bhaskara Rao and Charyulu (2005) who showed that, compared the inoculated plants with control plants, the grain production of the inoculated plants was significantly greater. Similarly, Goswami and Maurya (2020) concluded that, the use of KSB and K sources had a substantial impact on yield characteristics and yield as compared to the uninoculated control.

Grain Yield/Plant

The findings notified that, the treatment T_9 had the highest grain yield per plant, with a mean of 6.20 gm. However, which was significantly superior over rest of the treatment and statistically at par with treatment T_{10} (5.91 g), T_7 (5.83 g) and T_4 (5.75 g).

Grain Yield (q/ha)

With treatment of 75% N, K & RD of P + Efficient isolate of *Azospirillum* & KSB (19.09 q/ha) recorded higher significant grain yield. However, which was significantly superior over rest of the treatment and statistically at par with treatmentT_{10} (18.26 q), T_7 (18.18q) and T_4 (17.89q).

Seed inoculating with *Azospirillum spp.* increased yield by 7.4% when compared to the control (Lana *et al.*, 2012). Using chemical fertilizers in conjunction with biofertilizers, such as potassium solubilizing bacteria (KSB), has the potential to save a considerable quantity of inorganic fertilizer while also greatly boosting rice output and development when managed properly (Kavya *et al.*, 2023).

Straw Yield

The significant and higher straw yield (24.81 q) were observed with treatment 75% N, K & RD of P + Efficient isolate of *Azospirillum*& KSB, which was significantly higher over rest of the treatments and statistically at par to treatment T_{10} (23.74 q), T_7 (23.63q) and T_4 (23.25q).

Introducing *Azospirillum* isolates into cereal seeds boosted grain and forage yields by 10% and 15%, respectively (Veresoglou *et al.*, 2010). According to Goswami and Maurya 2020, the use of potassium-solubilizing bacteria and potassium supplies greatly enhanced the output of stubbles.

Conclusion

It can be concluded that application of treatment 75% N, K & RD of P + Efficient isolate of *Azospirillum* & KSB has performed better in growth parameters and yield attributes of finger millet (*Phule kasari*).

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