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Response of Maize (*Zea mays* L.) to Integrated Application of Potassium and Potassium Solubilizing Bacteria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

A field experiment on study of response of maize to integrated application od potassium and potassium solubilizing bacteria on yield and yield attributes was carried out at College Farm, Agricultural College, Mahanandi, Acharya N.G. Ranga Agricultural University during *rabi*, 2022-2023. The experiment was laid out in randomized block design with seven treatments and three replications. The results revealed that maximum cob length, number of grains per cob, test weight, kernel yield, stover yield and higher economics were recorded by the application of KSB @ 5 kg ha^{-1} as soil application and 100 % recommended dose of K_2O (T_7) which was on par with the KSB + 75 % recommended dose of K_2O (T_6) and recommended dose of N, P, K @ 260:80:80 kg ha^{-1} (T_2). Harvest index does not exhibit any significant variations across different treatments tried during the study.

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Keywords: Potassium; potassium solubilizing bacteria; maize; yield attributes and yield.

1. INTRODUCTION

"Maize (*Zea mays* L.) is a versatile and multifunctional crop of cereals due to its high genetic yield potential among the cereals. It is cultivated on almost 190 m ha in about 165 countries that contributes 39 % of production. It contains 60-68 % starch, 7-15 % protein and rich in phosphorus and potash content. In India, maize is cultivated in an area of 12.09 million ha. with production of 43.40 million tonnes and productivity of 3590 kg ha^{-1} in 2023-2024" (Indiastat, 2024). "In Andhra Pradesh, maize is cultivated in an area of 3.30 lakh ha with a production of 21.48 lakh ha and productivity is 6510 kg ha^{-1} in 2023-2024" (Indiastat, 2024). Maize is exhaustive crop and relatively demands high amounts of nutrients. It responds well to applied nutrients, especially to the potassium.

"Potassium (K) is the essential plant nutrients after nitrogen and phosphorus. The total potassium content of soils frequently exceeds 20,000 ppm. Although only 1-2 % of K is accessible to the crop plants that helps to increase the crop yields with quality produce. The remaining K is anchored with other minerals and inaccessible to the plants. K helps in transport of sugars and starches and in nitrogen uptake and it also activates the enzymes responsible for different processes *viz*., starch synthesis, nitrate reduction, photosynthesis and sugar degradation in plants" (Ghetiya *et al.*, 2018).

"Soil microbial population is proficient to impact the soil fertility by the soil processes *viz*., decomposition, mineralization and storage of plant nutrients. KSB solubilize the K-bearing minerals and solubilize insolubilize K_2O and facilitates easy uptake by the plants. KSB application activates the utilization of organic carbon and this process secretes organic acids and enzymes which solubilize the unavailable K and enhance the plant acquisition. KSB is effective in releasing K from inorganic and insoluble pools of total soil K through the solubilization. Recognition of suitable bacterial strains capable of solubilizing K minerals can quickly conserve existing resources and avoid environmental pollution hazards" (Ahmad *et al.*, 2016; Meena *et al.*, 2016; Bakhshandeh *et al.*, 2017).

Keeping this in view, the present field experiment was carried out to study the response of maize to integrated application of potassium and potassium solubilizing bacteria on growth and yield.

2. MATERIALS AND METHODS

A field experiment was conducted at College Farm, Agricultural College, Mahanandi, Acharya N. G. Ranga Agricultural University during *rabi* season, 2022-2023. The treatments tried in the study were control (T_1), recommended dose of fertilizer, N, P_2O_5, K_2O -260: 80: 80 kg ha^{-1} (T_2), KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5 (T_3), T_3 + 25 % recommended dose of K_2O (T_4), T_3 + 50 % recommended dose of K_2O (T_5), T_3 + 75 % recommended dose of K_2O (T_6), T_3 + 100 % recommended dose of K_2O (T_7) and recommended dose of N & P_2O_5 are uniform for all the treatments. The experiment was laid out in randomized block design with three replications.

The soil of the experimental field was sandy loam in texture with neutral p^H (7.42), low organic carbon (0.45 %), available nitrogen (200 kg ha^{-1}), available phosphorus (45 kg ha^{-1}) and available potassium (557 kg ha^{-1}). Maize hybrid PAC-751 was adopted in the study of experimentation which has wider adaptability, higher germination rate, semi dent kernels with excellent tip filling with the duration of 120-140 days and was sown with a spacing of 60 cm x 20 cm. Recommended dose of nitrogen and phosphorus were applied uniformly for all the treatments. Muriate of potash was quantified according to the treatments and KSB @ 5 kg ha^{-1} mixed with FYM @ 250 t ha^{-1} and was applied to soil at the time of sowing. The data on cob length, number of kernels cob^{-1}, 100 seed weight, kernel yield, stover yield and harvest index recorded from five randomly selected plants and it was subjected to statistical analysis.

3. RESULTS AND DISCUSSION

Effect on Yield Attributes: Research results on yield attributes of maize with potassium and potassium solubilizing bacteria (KSB)revealed that the application of KSB @ 5 kg ha^{-1} as soil application along with 100 % recommended dose of K_2O (T_7) proved better in attaining the higher yield attributes (Table 1) such as higher cob length (16.2 cm), number of grains cob^{-1} (492) and higher test weight (38.4 g) over other levels of nutrients tried during the study. However, the

treatments T_6, T_2 and T_5 which were at par with the treatment T_7. The treatment T_3 (KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5) did not showed any significant influence on all the yield attributes and the treatment T_4 also followed the similar trend as that of T_3 except in cob length. The lowest yield attributes such as cob length (11.00 cm), number of grains cob^{-1} (289) and higher test weight (17.1 g) were recorded with the treatment control (T_1). Cob weight, no of grains per cob and test weight were increased by 32.0%, 41.0% and 55.0% respectively due to the T_7 over T_1 treatment and T_7 treatment was on per with other treatments except T_4 and T_3. This proved that the application of potassium in conjunction with KSB has significantly improved the yield attributes like cob length, number of grains cob^{-1} and test weight mainly due to the enhanced nutrient uptake due to proliferated roots through growth promoting bacteria (KSB) and also higher yield attributes greatly influenced by maintenance of source - sink relationship and chlorophyll content which was favored by the KSB as it make potassium available in soil solution and increase the nitrogen availability there by photosynthesis proceeds in an abrupt manner and also potassium helps in translocation of photosynthates which leads to obtain higher produce to the plant. These findings are in correlation with Ghetiya *et al.* (2018), Raghavendra *et al.* (2018), Game *et al.* (2020), Priyavardhini *et al.* (2021), Mahmud *et al.* (2022), Kundu *et al.* (2023) and Patel *et al.* (2023).

Effect on Yield: Significantly higher grain yield and stover yield (9194 and 10795 kg ha^{-1}, respectively) of maize (Table 2) were obtained with the treatment T_7 i.e., with application of KSB @ 5 kg ha^{-1} as soil application along with 100 % recommended dose of K_2O which was statistically on par with the treatments T_6 (8237 and 9752 kg ha^{-1}), T_2 (8203 and 9731 kg ha^{-1}) and T_5 (7790 and 9246 kg ha^{-1}) and superior to the remain treatments such as T_4 (7377 and 8737 kg ha^{-1}), T3(6603 and 7840 kg ha^{-1}) and T1 (3568 and 5928 kg ha^{-1}). However, the lowest grain yield and straw yield were observed with control(T_1). From the results it is clear evident that the application of KSB along with 25%, 75% and 100% recommended dose of fertilizers which enhanced the grain as well as stover yield of maize over the other treatment s which were not received KSB. This enhancement in grain yield and stover yield might be due to integrated effect of KSB with K fertilization which aids in releasing K from inorganic and insoluble pools of total soil K through solubilization and nutritional status and promoted the greater extraction of nutrients from the soil environment to aerial plant parts which was aided by the potassium. The similar findings were in close agreement with the findings of Reddy *et al.* (2021), Lakshmi *et al.* (2022) and Goud *et al.* (2023).

Effect on Harvest Index (%): The higher harvest index (Table 2) of 46.02 % obtained with the treatment T_7 (T_3 + 100 % recommended dose of K_2O) which was at par with all other treatments. Provision of sufficient amount of nutrients using biofertilizer and chemical fertilizer in T_7 (T_3 + 100 % recommended dose of K_2O) has the potential to increase biomass yield and grain yield. However, it does not appear to have a substantial impact on the harvest index as supported by the previous studies conducted by Reddy *et al.* (2021) and Kundu *et al.* (2023).

Table 1. Yield attributes of maize as influenced by potassium and potassium solubilizing bacteria

Treatments	Cob length (cm)	No. of grains cob^{-1}	Test weight (g)
T_1: Control	11.00	289	17.1
T_2: Recommended dose of N-P_2O_5-K_2O	15.50	471	36.7
T_3: KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5	13.33	441	26.4
T_4: T_3 + 25 % recommended dose of K_2O	14.00	451	31.8
T_5: T_3 + 50 % recommended dose of K_2O	14.67	464	34.9
T_6: T_3 + 75 % recommended dose of K_2O	15.63	476	36.8
T_7: T_3 + 100 % recommended dose of K_2O	16.20	492	38.4
S.Em±	**2.29**	**7.60**	**1.70**
CD (P=0.05)	**8.65**	**23.40**	**5.30**

Table 2. Yields (kg ha^{-1}) and harvest index (%) of maize influenced by potassium and potassium solubilizing bacteria

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
T_1 : Control	3568	5928	37.57
T_2 : Recommended dose of N-P_2O_5-K_2O (260:80:80 kg ha^{-1})	8203	9731	45.74
T_3: KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5	6603	7840	45.71
T_4: T_3 + 25 % recommended dose of K_2O	7377	8737	45.78
T_5: T_3 + 50 % recommended dose of K_2O	7790	9246	45.72
T_6: T_3 + 75 % recommended dose of K_2O	8273	9752	45.89
T_7: T_3 + 100 % recommended dose of K_2O	9194	10795	46.00
S.Em±	**583.40**	**652.42**	**2.47**
CD (P=0.05)	**1797**	**2010**	**NS**

Table 3. Economics (₹ ha^{-1}) of maize as influenced by the potassium and potassium solubilizing bacteria

Treatments	Cost of Cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1 : Control	40881	86173	45292	2.1
T_2 : Recommended dose of N-P_2O_5-K_2O (260:80:80 kg ha^{-1})	53077	211094	158017	4.0
T_3: KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5	50571	169919	119348	3.4
T_4: T_3 + 25 % recommended dose of K_2O	51165	189831	138666	3.7
T_5: T_3 + 50 % recommended dose of K_2O	51825	197908	146083	3.8
T_6: T_3 + 75 % recommended dose of K_2O	52419	211949	159530	4.0
T_7: T_3 + 100 % recommended dose of K_2O	53078	236527	183449	4.5
S.Em±	--	11970.91	11748.68	0.18
CD (P=0.05)	--	36886.06	36201.28	0.56

Effect on Economics: The data regarding to economics of maize as influenced by integrated effect of KSB and potassium has been exhibited and presented in Table 3. The higher gross, net returns and B:C were achieved by the (T_7) T_3 + 100 % recommended dose of K_2O) (₹ 236527 ha^{-1}, ₹ 183449 ha^{-1}, 4.5), respectively which was comparable to (T_6) T_3 + 75 % recommended dose of K_2O (₹ 211949 ha^{-1}, ₹ 159530 ha^{-1}, 4.0) respectively, T_2 (recommended dose of N-P_2O_5-K_2O kg ha^{-1}) (₹ 158017 ha^{-1}, ₹ 158017 ha^{-1}, 4.0), respectively.

The grain and stover yields were improved by the application of chemical fertilizers and also with the integration of the KSB leads to higher gross returns. Though cost of cultivation was higher it was compensated by grain yield and stover yield which were achieved higher in treatment T_7 (T_3 + recommended dose of K_2O). Net returns and B:C ratio were positively correlated with the grain and stover yield of maize. Similar findings are in accordance with the findings of Ghetiya *et al.* (2018), Sri and Singh (2022) and Pagar *et al.* (2022).

4. CONCLUSION

From the above results, it can be concluded that higher yield attributes such as cob length, number of grains per cob, test weight, and grain yield, stover yield and economics *i.e,.* higher gross, net returns and B:C ratio were obtained by the application of KSB @ 5 kg ha^{-1} as soil application and 100 % recommended dose of K_2O (T_7) which was on par with the KSB + 75 % recommended dose of K_2O (T_6) and recommended dose of N, P, K @ 260:80:80 kg ha^{-1} (T_2).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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