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Influence of potassium and potassium solubilizing bacteria on growth and yield of maize (*Zea mays* L.)

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Abstract
The present investigation was carried out to study the effect of potassium and potassium solubilizing bacteria in maize on sandy loam soils at College Farm, Agricultural College, Mahanandi, Acharya N. G. Ranga Agricultural University during *rabi* Season, 2023-2024. The experiment comprises seven treatments with different levels of potassium (25, 50, 75 and 100% recommended dose) and KSB as soil application. The experiment was laid out in randomized block design with three replications. Among different treatments tried in experimentation, application of Potassium Solubilizing Bacteria (KSB) along with 100% recommended dose of K_2O (T_7) increased the growth attributes like plant height, Leaf Area Index (LAI), SPAD chlorophyll meter readings, dry matter accumulation, and grain and stover yields which were on par with KSB + 75% recommended dose of K_2O (T_6), recommended dose of fertilizer N-P_2O_5- K_2O @ 260: 80: 80 kg ha^{-1} (T_2).

Keywords: Maize, potassium solubilizing bacteria, potassium, growth parameters and yield

Introduction
Maize (*Zea mays* L.), often referred to as the "Queen of Cereals" is renowned for its high genetic yield potential among cereal crops. It is cultivated on approximately 190 million hectares across 165 countries, contributing to 39% of global cereal production. Maize comprises 60-68% starch and 7-15% protein, and is notably rich in phosphorus and potash. In India, maize is grown on an area of 12.09 million hectares, with a production output of 43.40 million tonnes and a productivity rate of 3590 kg ha^{-1} (www.indiastat.com, 2023-2024). Specifically, in Andhra Pradesh, maize cultivation in an area of 3.30 lakh hectares, yielding a production of 21.48 lakh tonnes and a productivity of 6510 kg ha^{-1} in 2023-2024 (www.indiastat.com). Maize is a nutrient-intensive crop, requiring substantial nutrient inputs, and it demonstrates a particularly strong response to the application of potassium.

Potassium (K) occupied third place among the essential plant nutrients after nitrogen and phosphorus. The total potassium content of soils frequently exceeds 20,000 ppm. Although potassium is abundant in soil, merely 1-2% of K is accessible to crop plants that helps to increase the crop yields with quality produce. The remaining K is anchored to other minerals and is inaccessible to plants.

Potassium-solubilizing bacteria (KSB) play a crucial role in dissolving both potassium-containing minerals and insoluble K_2O, thereby making it easier for plants to absorb. The use of KSB also stimulates the use of organic carbon, which releases organic acids and enzymes that dissolve otherwise inaccessible potassium, thus improving plant uptake. KSB effectively liberates potassium from both inorganic and insoluble sources within the total soil potassium through solubilization. Considering these aspects, the current field experiment was designed to investigate the impact of potassium and potassium-solubilizing bacteria on maize growth and yield.

Materials and Methods
A field study was conducted at the College Farm, Agricultural College, Mahanandi, Acharya N. G. Ranga Agricultural University during *rabi*, 2022-2023. The experiment was laid out in a

randomized block design with seven treatments and replicated thrice. The treatments adopted 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).

The soil of the experimental field was a sandy loam texture, a neutral pH of 7.42 with a low organic carbon content of 0.45%. It contained available nitrogen at 200 kg ha^{-1}, phosphorus at 45 kg ha^{-1}, and potassium at 557 kg ha^{-1}. The maize hybrid PAC-751, recognized for its broad adaptability and high germination rate, was selected for the study. This variety is noted for its semi-dent kernels with excellent tip filling and a growth period of 120-140 days. It was planted with a spacing of 60 cm X 20 cm. A uniform application of the recommended doses of nitrogen and phosphorus was applied across all treatments; phosphorus was applied as a basal dose, while nitrogen and potassium were distributed in three equal parts at basal, knee-high, and tasseling stage of crop growth. The potassium source, muriate of potash, was measured according to the treatments, and KSB at 5 kg ha^{-1} was mixed with FYM at 250 t ha^{-1} and applied to the soil during sowing. Hand weeding was performed during the early stages of crop growth.

Observations regarding growth parameters like plant height, leaf area index, dry matter accumulation and yield parameters like grain yield and stover yield were recorded. The data was collected from five randomly selected plants and it was subjected to statistical analysis.

Results and Discussion

Effect on Growth Parameters

Plant Height

The plant height was significantly influenced by the potassium application and higher plant height (202.07 cm) was registered with application of KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5 along with 100% recommended dose of K_2O (T_7), which was on par with the application of KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5 + 75% recommended dose of K_2O *i.e.*, T_6 (190.43 cm) and the treatment T_2 (185.77 cm) in which recommended dose of fertilizer- N, P_2O_5, K_2O- 260:80:80 kg ha^{-1} was applied. The higher plant height with the treatment T_7 might be due to enough potassium which was solubilized by the KSB and it releases various organic acids and performs enzymatic activities, favours the availability of potassium in the soil solution. Moreover, potassium favours in the synthesis of chlorophyll that influences the photosynthesis, to encourage the nitrogen availability to the plant. Similar reports were also stated by the Ghetiya *et al*. (2018) [1] and Iqbal *et al*. (2020) [4].

Leaf Area Index

Highest leaf area index (1.27). was noticed by the application of (T_7) T_3 + 100% recommended dose of K_2O the utilization of KSB along with the potassium aided to achieve higher LAI that might be attributed to cell osmotic pressure, improvement in nitrogen assimilation. The nutrients that were made available through the administration of biofertilizer speed up the cell division, cell elongation and made a great impact on metabolic processes in plant organs thus increase the size of the leaf area there by increasing the leaf area index. These findings are in close agreement with the earlier works of Vamsi *et al*. (2023) [8], Hajam *et al*. (2024) [3].

SPAD Reading

Significantly higher SPAD readings were recorded under the application of (T_7) T_3 + 100% recommended dose of K_2O (47.1) which was on par with the (T_6) (46.7) and (T_2) recommended dose of fertilizer-N-P_2O_5-K_2O-260:80:80 kg ha^{-1}(45.2). Improved SPAD values were obtained due to the higher K application along with the KSB which favours the nitrogen availability and improves the chlorophyll content. These results are in line with the findings of Madar *et al*. (2020) [6] and Padwar *et al*. (2020) [7].

Drymatter Accumulation

Higher dry matter accumulation (27222 kg ha^{-1}) was observed by the application of T_7 (T_3 + recommended dose of K_2O) which was in accordance with the (T_6) T_3 + 75% recommended dose of K_2O (26981 kg ha^{-1}) and (T_2) recommended dose of fertilize- N-P_2O_5-K_2O-260:80:80 kg ha^{-1}). The probable reason for the higher dry matter accumulation was due to the influence of K on the availability of nitrogen, which increases the photosynthetic area as a result of an increase in leaf size and increase in the dry matter accumulation. Moreover, potassium also helps in the translocation of photosynthates which is responsible for the higher development of dry matter. Similar findings were also reported by Ghetiya *et al*. (2018) [1] and Lakshmi *et al*. (2022) [5].

Effect on Grain and stover Yield

Greater grain yield was recorded with the adoption of treatment T_7 *i.e.* T_3 + 100% recommended dose of K_2O (9194 kg ha^{-1}) which was statistically on par with the (T_6) T_3 + 75% recommended dose of K_2O (8237 kg ha^{-1}), (T_2) recommended dose of fertilizer- N-P_2O_5-K_2O-260:80:80 kg ha^{-1}(8203 kg ha^{-1}). The increase in grain 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 also promoted the greater extraction of nutrients from the soil environment to aerial plant parts which was aided by the potassium. These findings were in close agreement with the findings of Lakshmi *et al*. (2022) [5] and Goud *et al*. (2023) [2].

An assessment of results reported that higher stover yield was observed in the treatment (T_7) T_3 + 100% recommended dose of K_2O (10795 kg ha^{-1}), which was on par with the (T_6) T_3 + 75% recommended dose of K_2O (9752.4 kg ha^{-1}), (T_2) recommended dose of fertilizer- N-P_2O_5-K_2O- 260:80:80 kg ha^{-1} (9731.3 kg ha^{-1}) and (T_5) T_3 + 50% recommended dose of K_2O (9246.4 kg ha^{-1}). Increase in stover yield might be due to overall improvement in vegetative growth due to better and continuous availability of nutrients at peak growth period and greater synthesis of carbohydrates and their translocation. Conjunction of nutrient sources from both biofertilizer and chemical fertilizer leads to better uptake, translocation and accumulation leading to production of dry matter thus contributing to the higher stover yield. These findings are in equivalence with the findings of Lakshmi *et al*. (2022) [5] and Goud *et al*. (2023) [2].

Table 1: Growth parameters of maize as influenced by different levels of potassium and potassium solubilizing bacteria

Treatments	Growth parameters			
	Plant height (cm)	LAI	SPAD readings	Dry matter accumulation (kg ha^{-1})
T_1: Control	150.67	0.53	24.6	13443
T_2: Recommended dose of N-P_2O_5-K_2O (260:80:80 kg ha^{-1})	189.70	0.97	45.2	25322
T_3: KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5	174.87	0.80	38.5	20202
T_4: T_3 + 25% recommended dose of K_2O	177.87	0.93	40.2	22780
T_5: T_3 + 50% recommended dose of K_2O	185.77	0.97	40.5	24222
T_6: T_3 + 75% recommended dose of K_2O	190.43	0.97	46.7	26981
T_7: T_3 + 100% recommended dose of K_2O	202.07	1.27	47.1	27222
S.Em±	6.73	0.08	1.9	836.32
CD (P=0.05)	21.70	0.27	6.05	2576.97

Table 2: Grain and straw yields of maize as influenced by different levels of potassium and potassium solubilizing bacteria

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1: Control	3568.6	5928.2
T_2: Recommended dose of N-P_2O_5-K_2O (260:80:80 kg ha^{-1})	8203.6	9731.3
T_3: KSB @ 5 kg ha^{-1} as soil application + recommended dose of N, P_2O_5	6603.3	7840.2
T_4: T_3 + 25% recommended dose of K_2O	7377.6	8737.3
T_5: T_3 + 50% recommended dose of K_2O	7790.6	9246.4
T_6: T_3 + 75% recommended dose of K_2O	8273.3	9752.4
T_7: T_3 + 100% recommended dose of K_2O	9194.6	10795.3
S.Em±	583.40	652.42
CD (P=0.05)	1797.50	2010.20

Conclusion
Based on the above results, it can be concluded that the growth parameters such as plant height, leaf area index, dry matter accumulation and yield parameters like grain yield and stover yield of maize increased with the combined application of potassium and KSB @ 5 kg ha^{-1} as soil application *viz*., (T_7) KSB + 100% recommended dose of K_2O & (T_6) KSB + 75% recommended dose of K_2O.

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