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Response of sorghum to soil and foliar application of potassium fertilizers under sandy clay loam conditions

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ABSTRACT

This study investigates the potential of potassium-releasing bacteria (KRB) and foliar application of potassium fertilizers—potassium nitrate (KNOƒ) and potassium humate (KH), as alternatives to conventional muriate of potash (KCl) in sorghum cultivation. Potassium, a vital macronutrient, plays a critical role in various physiological functions, yet its availability in sandy clay loam soils is often constrained due to leaching and fixation, necessitating effective potassium management strategies. A field experiment was conducted in a randomized block design to evaluate the impact of KRB and foliar potassium sources in combination with varying levels of inorganic fertilizers on crop yield and soil fertility. The treatment receiving 100% recommended dose of potassium (RDK) + KRB recorded the highest grain yield and available potassium. Treatments with 100% RDK and 75% RDK + foliar spray of 1% KNOƒ at 30 and 45 days after sowing (DAS) were statistically on par with 100% RDK + KRB in terms of grain yield. Similarly, 75% RDK + KRB was comparable to 100% RDK + KRB for available potassium. The findings suggest that both KRB and foliar KNOƒ application can effectively enhance crop performance and soil potassium availability. Integrating biofertilizers with inorganic fertilizers and employing foliar nutrition offers a viable strategy for reducing chemical fertilizer use, minimizing nutrient losses, and promoting sustainable sorghum production.

Keywords: *Potassium releasing bacteria (KRB), Potassium nitrate (KNO_3), Potassium humate (KH) and potassium.*

Sorghum (*Sorghum bicolor* L. Moench) ranks fifth among the world's major cereal crops after wheat, rice, maize, and barley (FAOSTAT, 2021). It is well-adapted to arid and semi-arid climates due to its drought resistance and efficient nutrient utilization, making it an important crop for food, fodder, and biofuel. Despite its potential, sorghum productivity remains low in many regions. In India, it is grown on 4.89 million hectares with a productivity of 900 kg ha^{-1}, while in Andhra Pradesh, it yields 3166 kg ha^{-1} (Agricultural Statistics at a Glance, 2022).

Potassium (K) plays a crucial role in crop growth, influencing protein synthesis, enzyme activation, photosynthesis, and stress tolerance (Marschner, 2012). However, its availability in soil, particularly sandy clay loam, is often limited due to fixation and leaching. Although Indian soils contain substantial total K (Mengel and Kirkby, 1987), only 1–2% is readily available to plants. Conventional fertilization practices often emphasize nitrogen and phosphorus, while potassium is underutilized due to assumptions of sufficient native K and the high cost of K fertilizers.

Alternative strategies such as potassium-releasing bacteria (KRB), foliar application of potassium nitrate (KNOƒ), and potassium humate (KH) offer promising solutions. KRB enhance K solubilization through organic acid production and improve plant growth and stress resilience (Meena *et al.,* 2016). KH improves soil physical and biochemical properties, nutrient uptake, and microbial. Foliar application of K, especially as KNOƒ , ensures rapid uptake during critical stages and is effective under conditions of low soil K availability (Ahmad and Jabeen, 2005).

Thus, integrating biofertilizers and foliar nutrition with conventional K management may enhance potassium use efficiency, minimize losses, and improve sorghum productivity in nutrient-deficient soils.

MATERIALS AND METHODS

The experiment was conducted during *rabi* 2024 – 25 at the Agricultural college farm, Bapatla, using Sorghum hybrid CSH -16 as the test crop. The site is located in the Krishna-Godavari agro-climatic zone, characterized by a tropical climate with moderately dry winter. The experiment comprised of ten treatments viz., T1- Control, T2 - 100% RDK, T3 - 100% RDK + KRB, T4 - 75% RDK + KRB, T5 - 75% RDK + Foliar spray of KH @ 0.5% at 30 & 45 DAS, T6 -75% RDK + Foliar spray of KH @ 1% at 30 & 45 DAS, T7 -75% RDK + Foliar spray of KNO_3 @ 0.5% at 30 & 45 DAS, T8 -75% RDK + Foliar spray of KNO_3 @ 1% at 30 & 45 DAS, T9 - 50% RDK + Foliar spray of KH @ 1.5% at 30 & 45 DAS, T10- 50% RDK + Foliar spray of KNO_3 @ 1.5% at 30 & 45 DAS and replicated thrice. Well decomposed farmyard manure @ 10 t ha^{-1} was applied 10 days before sowing. Recommended dose of nitrogen and phosphorus were supplied through urea, single super phosphate (SSP), respectively. Recommended dose of potassium was supplied through muriate of potash (MOP) and foliar application through potassium nitrate and potassium

Fig 1. Layout of the experimental field

Fig 2. Sowing

humate. Recommended doses of nitrogen @ 80 kg ha^{-1} and phosphorus @ 60 kg ha^{-1} were applied uniformly to all the plots along with potassium. Recommended dose of potassium @ 40 kg ha^{-1} was applied as per the treatments. Whereas nitrogen was applied in three equal splits (1/3rd each at the time of sowing, knee high and blooming stages). Farmyard manure was mixed with biofertilizers *viz.,* KRB @ 1.25 L ha^{-1} and applied uniformly to T3 and T4 the treatments. Recommended dose of fertilizers were 80-60-40 (N, P_2O_5, K_2O).

Soil analysis involved measuring available nutrients (Nitrogen, phosphorus, potassium) was determined using standard chemical methods. Data was statistically analyzed to evaluate the effects of different treatments on soil properties and plant performance, with significant differences using the Tukey's HSD test at a 5% significance level. Quality control measures included instrument calibration, use of standard reference materials, and repeated measurements to ensure accuracy and reliability.

INITIAL SOIL PARAMETERS

The experimental soil was neutral in reaction with a pH of 7.26 and non-saline with EC value with 0.42 dS m^{-1}. The soil was sandy clay loam in texture, low in organic carbon (4.4 g kg^{-1}) and low in available nitrogen (214 kg ha^{-1}), medium in available phosphorus (41.5 kg P_2O_5 ha^{-1}) and medium in available potassium (328 kg K_2O ha^{-1}).

RESULTS AND DISCUSSIONS

Available macronutrients

The results pertaining to N, P, K at the harvest stage is presented in Table 1. The results indicated that available nitrogen and phosphorus were showed non-significant difference among the treatments. However, the highest available N and the P_2O_5 were found highest in the T_3 (100% RDK + KRB) and the lowest was found in the control. The non-significant difference might be due to that N and P sources were common for all the treatments. The highest availability of nitrogen and phosphorus was higher in T_3 (100% RDK + KRB) is might be due to the application of inorganic fertilizers along with KRB enhances the nitrogen availability by producing growth promoting hormones. This has been reported by Meena *et al.* (2012). Similarly the available recorded highest in T_3 in which the application of biofertilizer solubilizes the native phosphates which ultimately resulted in the increased available phosphorus that can be taken up by the plant. These results supports that of Seoud and Mageed (2011).

The highest available potassium was found in the treatment T_3 (100% RDK +KRB) followed by the T_4 (75% RDK + KRB) and T_2 (100% RDK). The treatments T_4 and T_2 are found to be on par with each other T_3 significantly higher to the rest of the treatments. The highest available potassium in the treatment with the combined application with biofertilizers might be due to the microbes which can

Table 1. Effect of nutrient management of potassium on available macronutrients (N, P_2O_5, K_2O) in kg ha^{-1} of sorghum

TREATMENTS	AVAILABLE N	AVAILABLE P2O5	AVAILABLE K2O
T1- Control	158.00	42.70	209.0
T2 - 100% RDK	178.00	46.50	316.0
T3 - 100% RDK + KRB	187.00	48.10	365.0
T4 - 75% RDK + KRB	166.00	43.10	323.0
T5 - 75% RDK + Foliar spray of KH @ 0.5% at 30 & 45 DAS	163.00	43.60	247.0
T6 -75% RDK + Foliar spray of KH @ 1% at 30 & 45 DAS	166.00	44.20	252.0
T7 -75% RDK + Foliar spray of KNO3 @ 0.5% at 30 & 45 DAS	162.00	44.10	270.0
T8 -75% RDK + Foliar spray of KNO3 @ 1% at 30 & 45 DAS	174.00	45.00	289.0
T9 - 50%RDK + Foliar spray of KH @ 1.5% at 30 & 45 DAS	159.00	43.10	218.0
T10 - 50% RDK + Foliar spray of KNO3 @ 1.5% at 30 & 45 DAS	162.00	43.00	232.0
S. Em (±)	6.92	1.81	12.6
CD (p=0.05)	NS	**NS**	37.4
CV (%)	7.15	7.10	8.0

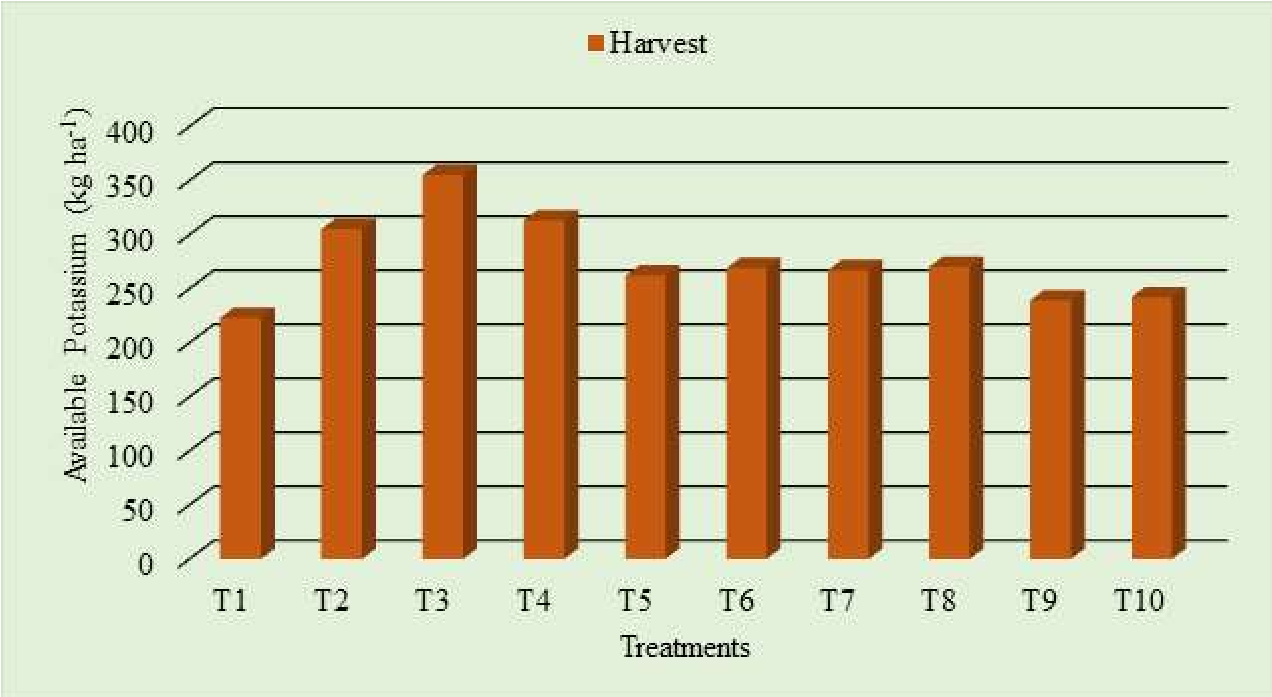

Fig 3. Effect of nutrient management of potassium on available potassium

Table: 2. Effect of nutrient management of potassium on yield (kg ha^{-1}) of sorghum

TREATMENTS	GRAIN YIELD	STOVER YIELD
T1- Control	2526	4471
T2 - 100% RDK	3513	6421
T3 - 100% RDK + KRB	3552	6621
T4 - 75% RDK + KRB	2893	5148
T5 - 75% RDK + Foliar spray of KH @ 0.5% at 30 & 45 DAS	2944	5160
T6 -75% RDK + Foliar spray of KH @ 1% at 30 & 45 DAS	3159	5820
T7 -75% RDK + Foliar spray of KNO3 @ 0.5% at 30 & 45 DAS	3130	5572
T8 -75% RDK + Foliar spray of KNO3 @ 1% at 30 & 45 DAS	3480	6386
T9 - 50%RDK + Foliar spray of KH @ 1.5% at 30 & 45 DAS	2610	4712
T10 - 50% RDK + Foliar spray of KNO3 @ 1.5% at 30 & 45 DAS	2732	4809
SEm (±)	120	206
CD (p=0.05)	356	613
CV (%)	7	6.48

release the soluble potassium from the potassium bearing minerals. these microbes quickly release organic acids which quickly dissolves the rock and chelate silicon ions, releasing K into the soil (Habib *et al.* 2014).

The results indicating the grain and stover yield was shown in Table 2. The highest grain yield and stover yield were recorded in T_3 (100% RDK + KRB) followed by T_2 (100% RDK) and T8 (75% RDK + Foliar spray of KNO_3 @ 1% at 30 & 45 DAS) and the both treatments (T_2 & T_8) were found on par with T_3 (100% RDK + KRB). The increase in the yield in the T3 is due to the KRB enhancing the nutrient availability of potassium improve uptake and metabolism. This synergy promoted better root growth, nutrient use efficiency and ultimately higher grain production. The findings are in close agreement with and well supported by Meena *et al.* (2016), Goud *et al.* (2023)

Among the foliar applications the KNO_3 @ 1% performed better and the results are almost similar to the results of the 100% RDK which indicates the foliar application can supplement the inorganic fertilizers in improving the yield of the sorghum crop.

CONCLUSION

This study highlights the potential of KRB in improving yields and increasing the nutrient availability in the sorghum crop. The foliar supplementation gave results similar to the 100% RDK it indicates the yield can be improved by combined use of inorganic and foliar application rather depending completely on inorganic fertilization. The availability of nutrient can be improved by potential use of biofertilizers which enhance the solubility and helps in higher uptakes. It is recorded highest in 100% RDK + KRB in which complete recommended doses were applied in addition to KRB which improved the soi health by improving the microbial population around the rhizosphere zone that might reduced the effect of chemical fertilizers. Thus, foliar supplements have indirect effect on soil properties they may not improve the nutrient status but the yields can be increased. However, the potassium releasing bacteria improves both yield and the nutrient status of the soils.

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