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Effect of Crop Residue Incorporation and Potassium Releasing Bacteria (KRB) on Potassium Fractions and Yield of Maize (*Zea Mays* L.)

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ABSTRACT

A field experiment was carried out at Agricultural College Farm, Bapatla during *rabi* 2021-22 to study the impact of crop residue incorporation and potassium releasing bacteria (KRB) on the potassium fractions and yield of maize (*Zea mays* L.). The experiment was laid out in a Randomized Block Design with ten treatments replicated thrice. The treatments comprised of T1: Control, T2: KRB alone, T3: 50% RDK+KRB, T4: 75% RDK+KRB, T5: 100% RDK alone, T6: 100% RDK+ KRB, T7: 50% RDK+50% K through rice straw incorporation, T8: 75% RDK + 25% K through rice straw incorporation, T9: 50% RDK + 50%K through rice straw incorporation + decompo A & B and T10:75% RDK + 25% K through rice straw incorporation+ decompo A & B. The results revealed that among K fractions, water-soluble K and exchangeable K were significantly influenced by incorporation of crop residue and application of KRB in both the stages (flowering and harvest stages) of the crop growth.The water-soluble K and exchangeable K were found highest with the application of 100% RDK+ KRB which was on par with the application of 75% RDK + 25% K through rice straw incorporation+ decompo A & B and the lowest water-soluble K and exchangeable K were found in control. There was no significant effect of crop residue incorporation and application of KRB on non- exchangeable K and fixed K.From the study, it was revealed that application of 100% RDK along with KRB recorded the highest grain and stover yield and it was on par with 75% RDK + 25% K through rice straw along with decomposers.

Keywords: *Rice straw, Incorporation of crop residues, KRB, Decomposers (A & B), Water-soluble K, Exchangeable K non- exchangeable K, Fixed K, Grain yield and Stover Yield.*

Regarding adaptability, types, and purposes maize (*Zea mays* L.) is the most flexible crop among cereals. Due to its better production potential and greater adaptability to a variety of climatic and soil conditions, maize is also referred to as the "Queen of Cereals" nationally and globally. Due to its great production potential, variety of industrial applications, increasingly extreme weather patterns, and inadequate water supply for rice cultivation, growers' interest in maize has been expanding.

In India, 9.86 million hectares of land are used to grow maize, with productivity in the *kharif* and *rabi* seasons being 2745 kg ha^{-1} and 4908 kg ha^{-1}, respectively with a production of 31.51 m t. The area of maize cultivated in Andhra Pradesh is 0.3 m ha, with production of 1.95 m t and productivity is 3807 kg ha^{-1} and 8025 kg ha^{-1} for the *kharif* and *rabi* seasons, respectively (DoES-, 2020-2021).

Incorporating crop residues into the soil is a sustainable soil management approach that is also good to the environment. The crop residue contains about 25% of the N and P, 50% of the S, and 75% of the K, making them potential sources of nutrients. Additionally, residues add carbon (C) back to the soil, which strengthens its structure and increases its capacity to hold water and minerals. By replacing important nutrients, particularly P and K, into the soil through straw incorporation, the requirement for inorganic fertilisers may be reduced, thereby saving money. Ironically, about 75% of the K uptake was retained in the paddy straw, making it a valuable source of nutrients. Considering high variability in the K response of cereal crops, the blanket K recommendation may lead to economic loss for farmers due to under or over application in most of the cases.

The price of K fertiliser has risen dramatically over the years. The sharp price increase has expressed concern on alternative sources of K application in cereal crops.

After nitrogen and phosphorus, potassium is regarded as an essential macronutrient because it is the major constituent of living cells, plays an important role in plant metabolism, and is required in large quantities by the majority of crops. Although most soils contain large amounts of K as a key component of the matrix, the soil frequently fails to supply a sufficient amount of potassium to meet the needs of the plants, and responses to its application were observed.Dynamic equilibrium reactions occurring among the different forms of K and it will have effect on K uptake by plant and the rate of these reactions determine the fate of applied K and release of fixed K (Singh *et al*., 2004). Hence, balanced potassium fertilizer application is needed for better crop production.

Through solubilisation, the KRB is effective in releasing potassium from inorganic and insoluble pools of total soil K. Potassium is fixed in the soil and does not readily meet crop demand. Although most agricultural soils in this area contain large amounts of K, these are immobilised and thus mostly unavailable. As a result, using potassium (K) releasing microorganisms is a promising method for increasing K availability in these soils. Keeping all these factors in mind, the present investigation was conducted to investigate the effect of crop residue incorporation and KRB on the potassium fractions and yield of maize (*Zea mays* L.) at Agricultural College Farm, Bapatla, Andhra Pradesh

MATERIAL AND METHODS

A field experiment was carried out during *rabi* season of 2021at Agricultural College Farm, Bapatla to study the impact of crop residue incorporation and potassium releasing bacteria (KRB) on the growth and available nutrient status of maize (*Zea mays* L.) The experiment was laid out in a Randomized Block Design with ten treatments replicated thrice. The treatments comprised of T1: Control, T2: KRB alone, T3: 50% RDK+KRB, T4: 75% RDK+KRB, T5: 100% RDK alone, T6: 100% RDK+ KRB, T7: 50% RDK+50% K through rice straw incorporation, T8: 75% RDK + 25% K through rice straw incorporation, T9: 50% RDK + 50%K through rice straw incorporation + decompo A & B, T10:75% RDK + 25% K through rice straw incorporation+ decompo A & B.

The experiment soil and paddy straw used in the study were analysed before the initiation of experiment and at harvest of the crop.The collected soil was shade dried, gently ground with wooden hammer, sieved through 2 mm sieve and analyzed for pH, EC in 1:2.5 soil: water suspension, organic carbon by the Walkely and Black (1934) method, available N by alkaline potassium permanganate suggested by Subbiah and Asija (1956), available P (Watanabe and Olsen, 1965) and available K by extraction of soil with neutral ammonium acetate solution at pH 7.0 (Jackson 1973). The hybrid used in the study was Pioneer 3396. The soil of the experimental site was sandy clay in texture with a pH of 7.46, electrical conductivity of 0.28 dS m^{-1}, medium in organic carbon (5.5 g kg^{-1}), low in available nitrogen (210 kg ha^{-1}), medium in available phosphorus (44.6 kg P_2O_5 ha^{-1}) and high in available potassium (332kg K_2O ha^{-1}), water soluble –K (6.26 mg kg^{-1}), exchangeable –K (168 mg kg^{-1}), non-exchangeable –K (354 mg kg^{-1}) fixed-K (521 mg kg^{-1}). Nutrient composition in the paddy straw used in the study contains 0.56 % of N, 0.19% P and 2.25 % K.Recommended dose of nitrogen, phosphorus and potassium were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Recommended dose of nitrogen and phosphorus were applied uniformly to all the treatments, whereas potassium was applied as per the treatments. Entire quantity of phosphorus was applied as basal two days before sowing, whereas nitrogen was applied in four equal splits (¼ each at the time of sowing, knee high, between knee high-tasseling and tasseling stages). Recommended dose of Potassium was applied in two splits (½ at the time of sowing and the remaining ½ at the time of tasseling stage). Crop residue (paddy straw) along with decomposers (A & Beach @1 kg ha^{-1}) was incorporated one month before sowing. Biofertilizers namely Potassium Releasing Bacteria (KRB) @1.25 l ha^{-1}through liquid form was applied one week before sowing along with FYM. Maize was sown in the last week of October and raised under assured irrigation and prescribed weed and pest control measures were adopted. Maize crop was harvested at maturity and grain and straw yields were recorded.

Total K in soil samples was determined in HF-HClO4 digests (Black, 1965). Water soluble K was determined by shaking the soil with distilled water (1:5 ratio). The 1N boiling HNO_3 extractable K was estimated by using flame photometer in 1:10, soil: acid suspension boiled for 10 minutes as described by Wood and Turk (1941). Non-exchangeable K was calculated by subtracting available K from 1N boiling HNO_3 extractable K. The amount of K in mineral lattice was calculated by subtracting 1N boiling HNO_3 extractable K from total soil K. The data were analyzed statistically as per the procedure given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Water soluble potassium (K_{ws}): The data from the table 1 revealed that the water-soluble potassium at flowering and harvest stage ranged from 12 to 30.2 mg ha^{-1}, 10.5 to 26.1 mg ha^{-1}, respectively. At flowering stage and harvest stage among all the treatments significantly highest water-soluble K was recorded with 100 % RDK + KRB (30.2 mg kg^{-1} and 26.1 mg kg^{-1}) and followed by 75% RDK + 25% K through rice straw incorporation along with decomposers (28.5 mg kg^{-1} and 25.7 mg kg^{-1}) respectively and both the treatments were stastically on par with each other and significantly superior over the rest of the treatments.The lower amounts of water-soluble K in soil solution could also be due to reason that the soil solution potassium is utilized by crop more readily and also may be subjected to leaching (Mairan and Dhawan, 2015). Combined application of inorganic fertilizers and liquid biofertilizers revealed that there was significantly higher content of water-soluble K. This might be due to water soluble nature of inorganic fertilizer and the potassium solubilizing microorganisms were efficient in solubilizing the native non-exchangeable K by the production of organic acids, which were contributed to the water-soluble K (Habib *et al.*, 2014).

Exchangeable Potassium (K_{ex}): At the flowering stage and harvest stage among all the treatments significantly highest exchangeable potassium (K_{ex}) was recorded with the application of 100 % RDK + KRB (215 mg kg^{-1} , 160 mg kg^{-1}), respectively and followed by 75% RDK + 25% K through rice straw incorporation along with decomposers (207 mg kg^{-1} , 157 mg kg^{-1}), respectively (table 1) and it was ranged from 142 to 215 mg kg^{-1} and 132 to160 mg kg^{-1} a flowering and harvesting stage respectively. It was observed that there was increase in exchangeable K content this might be due to addition of inorganic K fertilizers which has direct soluble nature along with KRB and crop residue. This might also be due to Exchangeable K was the portion of soil potassium that is electro-statically bound as an outer sphere covering to the clay surface and humus complex. It was readily exchangeable by other cations and readily available to plants. The percent of exchangeable K to total K is less than 2% (Mairan and Dhawan, 2015). The above results were in conformity with the findings of Setia and Sharma (2005).

Non-Exchangeable Potassium (K_{nx}): The non-exchangeable potassium at flowering and harvest stage ranged from 343 to 379 mg ha^{-1}, 323 to 362 mg ha^{-1}, respectively (table 1). Among all the treatments highest non-exchangeable potassium (K_{nx}) was observed in treatment with 100 % RDK alone at both the stages(379 mg kg^{-1}, 362 mg kg^{-1}), respectively.Significant portion of K required by plants comes from non-exchangeable K in the absence of optimum K supply in many crops, thus showing the beneficial role of non- exchangeable K. The conversion of exchangeable K and water-soluble K into non-exchangeable K is a very slow process, but this equilibrium plays an important role in K nutrition of plants as it helps in maintaining non- exchangeable K content of soils (Dhar *et al.*, 2009). It was also reported that in many soils with increase in time the applied K converts itself into non-exchangeable form (Ghiri and Abtahi, 2011).

Fixed Potassium (K_{fx}): The data presented in the table (1) revealed that the fixed potassium at flowering and harvest stage ranged from 497 to 624 mg ha^{-1} and 491 to 558 mg ha^{-1}, respectively.At flowering stage and harvest stage, among all the treatments, highest fixed potassium (K_{fx}) was recorded in treatment with 100 % RDK alone(624 mg kg^{-1}, 558 mg kg^{-1}), respectively.In the treatments receiving inorganic fertilizers along with crop residue there was a decrease in the fixed K compared to complete inorganic treatments but not much as in combination with KRB. This could be attributed to that with the increase in organic matter content the clay humus complexes become more active and provide more exchangeable sites and access to K, thereby causing a decrease in fixed K.

Grain and Stover Yield:

The data on the grain yield and stover yield of the maize crop was recorded(Table 2) and the results revealed that maximum grain and stover yield (3360 and 5349 kg ha^{-1}) of the maize crop was recorded in the treatment with 100 % RDK + KRB and it was on par with 75% RDK + 25% K through rice straw incorporation along with decomposers (3283 and 5244 kg ha^{-1}). This might be due to significant increase in the number of kernels cob^{-1} and number of cobs plants^{-1} was recorded when the plants were implicated with biofertilizer and inorganic K source. Similar results were also recorded by Priya and Shashidhara (2016). Integrated use of fertilizers with biofertilizers might have resulted in higher absorption of nutrients responsible for increased photosynthate accumulation and high biomass production and finally resulting in increase in the yield and yield components.

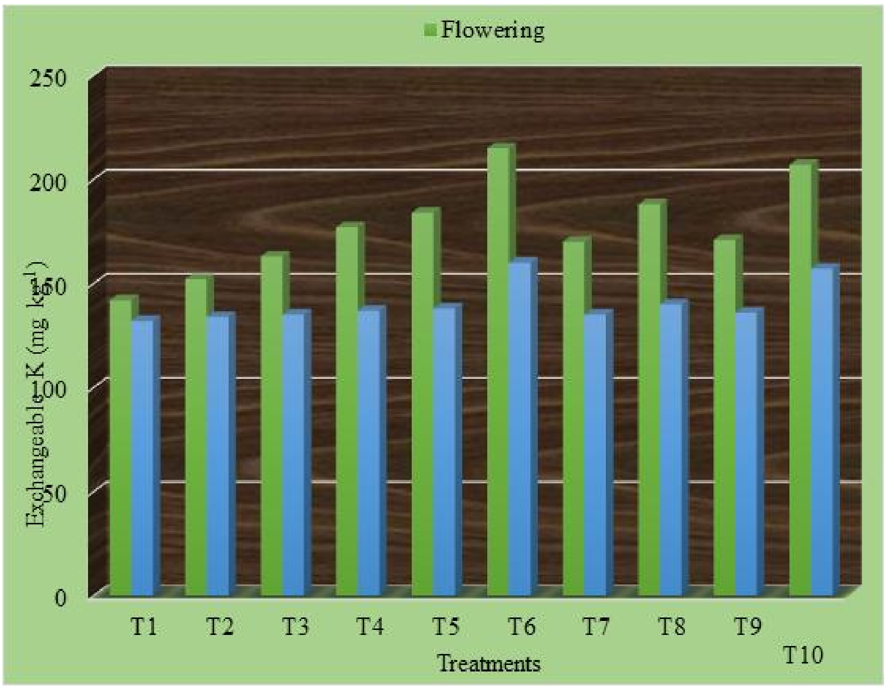

Figure 1. Effect of crop residue incorporation and potassium releasing bacteria on exchangeable potassium of Maize

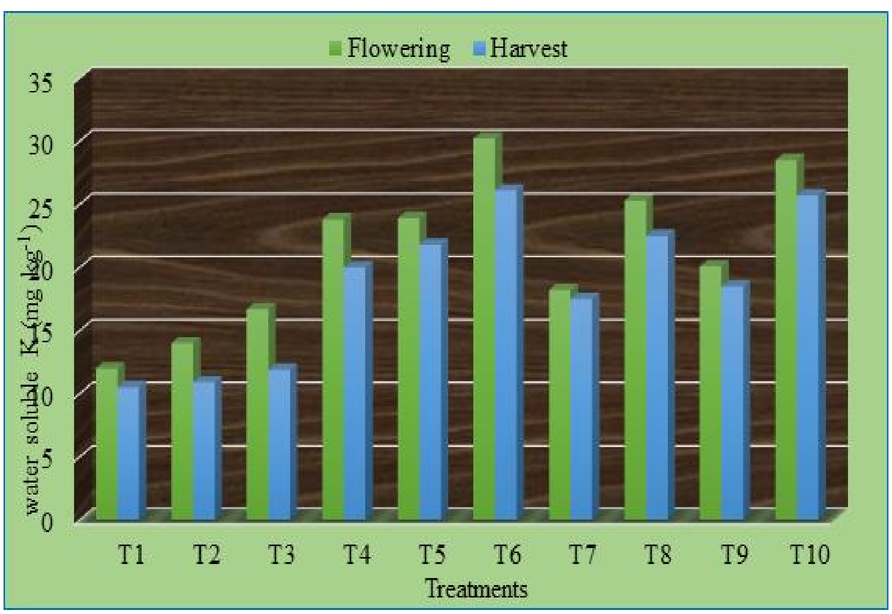

Figure 2. Effect of crop residue incorporation and potassium releasing bacteria on water soluble K of Maize

Table 1. Effect of crop residue incorporation and potassium releasing bacteria on potassium fractions (mg ha^{-1}) of Maize

Treatment	(K_{ws}) (mg ha^{-1})		(K_{ex}) (mg ha^{-1})		(K_{nx})(mg ha^{-1})		(K_{fx}) (mg ha^{-1})	
	Flowering	Harvest	Flowering	Harvest	Flowering	Harvest	Flowering	Harvest
T_1: Control	12	10.5	142	132	343	323	497	491
T_2: KRB alone	14	10.9	152	134	349	329	515	498
T_3:50% RDK + KRB	16.7	11.9	163	135	354	336	534	513
T_4: 75% RDK + KRB	23.8	20	177	137	363	343	564	526
T_5: 100% RDK alone	23.9	21.8	184	138	379	362	624	558
T_6: 100% RDK + KRB	30.2	26.1	215	160	371	351	579	533
T_7: 50% RDK + 50% K through	18.2	17.5	170	135	358	340	546	517
T_8: 75% RDK + 25% K through	25.3	22.5	188	140	372	358	585	540
T_9: 50% RDK + 50% K through + decompo A & B	20.1	18.5	171	136	360	340	551	519
T_{10}: 75% RDK + 25% K throug + decompo A & B	28.5	25.7	207	157	376	360	612	546
SEm(±)	1.5	0.89	6.59	5.06	12	13	29.53	20.04
CD (p=0.05)	4.78	2.85	21.07	16.19	NS	NS	NS	NS
CV(%)	8.18	8.33	6.45	6.25	5.96	6.46	8.12	6.62

Table 2. Effect of Crop Residue incorporation and potassium releasing bacteria on grain and stover yield of maize. (kg ha $^{-1}$)

Treatments	Grain yield	Stover yield
T_1: Control	2404	3389
T_2: KRB alone	2502	3439
T_3:50% RDK + KRB	2572	3685
T_4: 75% RDK + KRB	2708	4528
T_5: 100% RDK alone	2861	4781
T_6: 100% RDK + KRB	3360	5349
T_7: 50% RDK + 50% K through rice straw incorporation	2628	4136
T_8: 75% RDK + 25% K through rice straw incorporation	3026	4974
T_9: 50% RDK + 50% K through rice straw incorporation+ decompo A & B	2672	4334
T_{10}: 75% RDK + 25% K through rice straw incorporation+ decompo A & B	3283	5244
SEm (+)	110	158
CD (p=0.05)	353	507
CV(%)	6.8	6.3

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