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Effect of Doses of Potassium, FYM and Potassium Solubilizing Bacteria on Kernel Yield, Stover Yield and Drymatter Production in Maize

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ABSTRACT: The experiment was conducted during 2021 at Agricultural College Farm, Bapatla. The design of the experiment used 3 × 2 × 2 factorial randomized block design having 3 factors *viz*., three levels of K [0% RDK, 75% RDK and 100% RDK (RDK- 80 kg ha^{-1})], two levels of FYM (0 and 10 t ha^{-1}) and two levels potassium solubilizing bacteria (2 kg ha^{-1} and 5 kg ha^{-1}). Application of potassium @ 100% RDK (K_3) gave the highest kernel yield (5588 kg ha^{-1}), stover yield (8592 kg ha^{-1}) and drymatter accumulation at knee-high stage (801 kg ha^{-1}), flag-leaf stage (5413 kg ha^{-1}) and silking stage (6902 kg ha^{-1}) all these attributes were significantly higher over K_1 (0% RDK) and K_2 (75% RDK). Application of FYM @ 10 tha^{-1} (F_2) recorded highest kernel yield (4910 kg ha^{-1}), stover yield (7372 kg ha^{-1}) and drymatter accumulation at knee-high stage (725 kg ha^{-1}), flag-leaf stage (4120 kg ha^{-1}) and silking stage (5997 kg ha^{-1}) which was significantly higher over no FYM (F_1) application. Potassium solubilizing bacteria (KSB) @ 5 kg ha^{-1} (KS_2) recorded highest kernel yield (4782 kg ha^{-1}), stover yield (7159 kg ha^{-1}) and drymatter accumulation at knee-high stage (717 kg ha^{-1}), flag-leaf stage (3925 kg ha^{-1}) and silking stage (5865 kg ha^{-1}) these were statistically superior over 2 kg ha^{-1} (KS_1) KSB application.

Keywords: FYM, kernel yield, potassium, potassium solubilizing bacteria.

INTRODUCTION

Maize (*Zea mays* L.) also known as corn, is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. It is an important crop for billions of people as food, feed and industrial raw material. In India, area under maize crop is 9.8 m ha, production and productivity of 31.6 million tonnes and 3199 kg ha^{-1}.

Potassium (K) is an essential plant macronutrient and plays a key role in the synthesis of cells, enzymes, protein, starch, cellulose and vitamins, in nutrient transport and uptake, in conferring resistance to abiotic and biotic stresses, and in enhancing crop quality. Without adequate potassium, the plants will have poorly developed roots, grow slowly, produce small seeds and have lower yields.

Incorporation of FYM is known to influence favorably the physical, chemical and biological properties of soil and thus enhance crop productivity by means of maintaining soil health. They also supply secondary and micro nutrients in available form while chemical fertilizers might supply one or two nutrients only. Manures play a key role to maintain soil pH and also increase soil organic carbon, total nitrogen, stable aggregates, structure, porosity, water holding capacity and soil biota.

Potassium solubilizing bacteria helps in improving the development of plant and yield. These microorganisms are powerful in discharging K from inorganic and insoluble pools of aggregate soil K by solubilization process (Maurya *et al.*, 2014). Integrated and balanced use of nutrients through inorganic and organic sources and bio-fertilizers is a pre-requisite to sustain soil health and to produce maximum yield.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural College Farm, Bapatla during *rabi* season, 2021-22. The design of the experiment used was 3×2×2 factorial randomized block design having 3 factors *viz*., three levels of K [0% RDK, 75% RDK and 100% RDK (RDK-80 kg ha^{-1})], two levels of FYM (0 and 10 t ha^{-1}) and two levels of potassium solubilizing bacteria (2 kg ha^{-1} and 5 kg ha^{-1}).

The experimental soil was neutral in reaction with a pH of 7.6 and non-saline with an EC value of 0.26 d S m^{-1}. The soil was clay in texture, medium in organic carbon (0.63%), medium in available nitrogen (297 kg ha^{-1}), high in available phosphorus (42.5 kg P_2O_5 ha^{-1}) and available potassium (284 kg K_2O ha^{-1}). The soil was sufficient in zinc (1.15 mg kg^{-1}), copper (3.63 mg kg^{-1}), manganese (8.39 mg kg^{-1}) and iron (9.39 mg kg^{-1}). Biofertilizer potassium solubilizing bacteria (2 kg ha^{-1} and 5 kg ha^{-1}) were mixed with FYM (for plot that has FYM dosage), vermicompost (for plot that do not have FYM dosage), separately and applied to the field according to the treatments two weeks before sowing. Inorganic nitrogen (urea) was applied in three splits (as basal dose, 30 DAS and at 60 DAS). The phosphorus and potassium were applied to all the plots in the form of SSP (basal) and MOP (two equal splits treatment wise). The air-dried cobs from net plot were threshed, cleaned and weight of the grain was recorded. The grain yield per ha was worked out based on the grain yield per net plot and expressed in kilogram per hectare. Stover yield was recorded by taking the weight of stover from each net plot after leaving the stover in the field for complete sun drying until a constant weight was obtained. On the basis of this, stover yield per hectare was calculated. For calculating drymatter production, plants collected from border rows at knee-high stage, flag- leaf stage and silking stage were dried under sunlight for two days followed by drying in hot air oven at 65°C till a constant weight was obtained.

RESULTS AND DISCUSSIONS

Kernel yield. Data pertaining to the Table 1 indicated significant effect of different doses of potassium, FYM and KSB application on kernel yield.

Among the three levels of recommended dosage of potassium, 100% RDK (5588 kg ha^{-1}) recorded the highest kernel yield than the other levels *viz*., 0% RDK (3438 kg ha^{-1}) and 75% RDK (4747 kg ha^{-1}). Maize yield increases in response to K^+ fertilization as potassium helps in synthesis of carbohydrates and increases their translocation (Ebelhar and Varsa 2000).

While seeing the performance of two levels of FYM, 10 t ha^{-1} (4910 kg ha^{-1}) dosage has given the highest yield than 0 t ha^{-1} (4333 kg ha^{-1}) FYM application. Application of organic manure can enhance humic acid in the rhizosphere zone could improve the plant growth and development by increasing the availability of essential nutrients and biomolecules for root absorbance thus increasing yield (Asli *et al*., 2010).

At the same time, the two dosages of KSB among which KSB applied at the rate of 5 kg ha^{-1} (4782 kg ha^{-1}) has given the highest yield than 2 kg ha^{-1} (4461 kg ha^{-1}). Production of amino acids, vitamins and growth promoting substances like indole acetic acid and gibberellic acid secreted by these microorganisms which resulted in enhanced nutrient uptake, translocation and synthesis of photosynthate assimilates which resulted in increased plant growth characters and yield (Singh *et al.*, 2005; Suke *et al.*, 2011).

Stover yield. The different dosages of potassium, FYM and potassium solubilizing bacteria showed their significance with regard to stover yield (Table 2).

Among the three levels of recommended dosage of potassium, 100% RDK (8592 kg ha^{-1}) recorded the highest kernel yield than the other levels *viz*., 0% RDK (5317 kg ha^{-1}) and 75% RDK (7001 kg ha^{-1}). The increase in yield may also be attributed 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 (Datt *et al.*, 2003).

While seeing the performance of two levels of FYM, 10 t ha^{-1} (7372 kg ha^{-1}) dosage has given the highest yield than 0 t ha^{-1} (6570 kg ha^{-1}) FYM application. At the same time, the two dosages of KSB among which KSB applied at the rate of 5 kg ha^{-1} (7159 kg ha^{-1}) has given higher yield than 2 kg ha^{-1} (6783 kg ha^{-1}).

Table 1: Effect of K-fertilization, FYM and KSB on grain yield (kg ha^{-1}) of maize.

Kernel yield (kg ha^{-1})					
RDK	**FYM**	**KSB**		**K*F**	**K-Mean**
		KS_1	**KS_2**		
K_1	**F_1**	2932	3292	3112	3438
	F_2	3527	3999	3764	
	K* KS	3229	3646		
K_2	**F_1**	4264	4669	4466	4747
	F_2	4902	5151	5026	
	K* KS	4583	4910		
K_3	**F_1**	5315	5525	5420	5588
	F_2	5723	5789	5941	
	K* KS	5569	5792		
F*KS				**F-Mean**	
F_1		4170	4496	4333	
F_2		4751	5070	4910	
KS-Mean		4461	4782		
		SEm±	**CD @ 0.05**	**CV (%)**	
K		131.8	386.6	9.88	
F		107.6	315.7		
KS		107.6	315.7		
K × F		186.4	NS		
F × KS		152.2	NS		
K × KS		186.4	NS		
K × F x KS		263.7	NS		

Similar findings of increase in stover yield due to combined application of organic manures and biofertilizer was reported by Patil (2011); Krishnaprabhu (2014).

Drymatter production. Data pertaining to the Tables 3, 4 and 5 indicated the significant effect of different doses of potassium, FYM and KSB application on water- soluble K at knee-high stage, flag-leaf stage and silking stage respectively.

Among the three doses of potassium, 100% RDK markedly recorded higher drymatter production at knee-high stage (801 kg ha^{-1}), flag-leaf stage (5413 kg ha^{-1}) and silking stage (6902 kg ha^{-1}) than the other doses of potassium. The probable reason for higher drymatter production was due to the prolonged vegetative growth and potassium influences the synthesis of phytohormones which are involved in the growth of meristematic tissue that that enabled plant to absorb more nutrients and moisture which empowered the plant to manufacture more quantities of photosynthates. Similar findings were reported by Baque *et al.* (2008).

Table 2: Effect of K-fertilization, FYM and KSB on stover yield (kg ha^{-1}) of maize.

Stover yield (kg ha^{-1})					
RDK	**FYM**	**KSB**		**K*F**	**K-Mean**
		KS_1	**KS_2**		
K_1	**F_1**	4781	5212	4997	5317
	F_2	5531	5748	5639	
	K* KS	5160	5480		
K_2	**F_1**	6221	6753	6487	7001
	F_2	7298	7732	7515	
	K* KS	6759	7242		
K_3	**F_1**	8106	8338	8222	8592
	F_2	8751	9174	8962	
	K* KS	8428	8756		
F*KS				**F-Mean**	
F_1		6372	6767	6570	
F_2		7193	7551	7372	
KS-Mean		6783	7159		

	SEm±	**CD @ 0.05**	**CV (%)**
K	157.1	462.0	8.84
F	128.7	377.6	
KS	128.7	377.6	
K × F	223.0	NS	
F × KS	182.1	NS	
K × KS	223.1	NS	
K × F × KS	315.4	NS	

Note: **K_1** – 0 RDK, **K_2** – 75% RDK, **K_3** – 100% RDK (RDK – 80 kg ha^{-1}), **F_1** – 0t/ha and **F_2** – 10t/ha FYM, **KS_1**– 2kg/ha and **KS_2** – 5 kg/ha of KSB

Table 3: Effect of K-fertilization, FYM and KSB on dry matter production at knee-high stage (kg ha^{-1}) of maize.

Knee-high stage					
RDK	**FYM**	**KSB**		**K*F**	**K-Mean**
		KS_1	**KS_2**		
K_1	**F_1**	511	557	534	571
	F_2	609	605	607	
	K* KS	560	581		
K_2	**F_1**	684	731	707	725
	F_2	722	765	743	
	K* KS	703	748		
K_3	**F_1**	745	808	776	801
	F_2	810	838	825	
	K* KS	778	823		
F*KS				**F-Mean**	
F_1		647	699	673	
F_2		714	736	725	
KS-Mean		680	717		

	SEm±	**CD @ 0.05**	**CV (%)**
K	15.1	44.4	7.51
F	12.3	36.2	
KS	12.3	36.2	
K × F	21.4	NS	
F × KS	17.4	NS	
K × KS	21.4	NS	
K × F × KS	30.2	NS	

Table 4: Effect of K-fertilization, FYM and KSB on dry matter production (kg ha^{-1}) at flag-leaf stage of maize.

Flag-leaf stage					
RDK	FYM	KSB		K*F	K-Mean
		KS_1	KS_2		
K_1	F_1	2113	2224	2169	2362
	F_2	2485	2627	2556	
	K* KS	2299	2426		
K_2	F_1	3153	3347	3250	3528
	F_2	3682	3928	3805	
	K* KS	3418	3637		
K_3	F_1	4539	5114	4827	5413
	F_2	5691	6309	5999	
	K* KS	5115	5712		
F*KS				F-Mean	
F_1		3269	3562	3415	
F_2		3952	4288	4120	
KS-Mean		3610	3925		

	SEm±	CD @ 0.05	CV (%)
K	128.6	377.1	11.83
F	105.0	307.9	
KS	105.0	307.9	
K × F	181.9	NS.	
F× KS	148.5	NS	
K × KS	181.9	NS	
K × F × KS	257.2	NS	

Note: K_1 – 0 RDK, K_2 – 75% RDK, K_3 – 100% RDK (RDK – 80 kg ha^{-1}), F_1 – 0t/ha and F_2 – 10t/ha FYM, KS_1– 2kg/ha and KS_2 – 5 kg/ha of KSB

Table 5: Effect of K-fertilization, FYM and KSB on dry matter production (kg ha^{-1}) at silking stage of maize.

Silking stage					
RDK	FYM	KSB		K*F	K-Mean
		KS_1	KS_2		
K_1	F_1	3775	4310	4042	4413
	F_2	4618	4948	4783	
	K* KS	4197	4629		
K_2	F_1	5195	5629	5412	5648
	F_2	5756	6011	5884	
	K* KS	5476	5820		
K_3	F_1	6295	6665	6480	6902
	F_2	7021	7626	7324	
	K* KS	6658	7145		
F*KS				F-Mean	
F_1		5088	5535	5312	
F_2		5799	6195	5997	
KS-Mean		5443	5865		

	SEm±	CD @ 0.05	CV (%)
K	175.8	515.5	10.77
F	143.5	420.9	
KS	143.5	420.9	
K × F	248.6	NS	
F × KS	203.0	NS	
K × KS	248.6	NS	
K × F×KS	351.6	NS	

Note: K_1 – 0 RDK, K_2 – 75% RDK, K_3 – 100% RDK (RDK – 80 kg ha^{-1}), F_1 – 0t/ha and F_2 – 10t/ha FYM, KS_1– 2kg/ha and KS_2 – 5 kg/ha of KSB

In case of doses of FYM, the drymatter production was found to be higher with 10 t ha^{-1} application of FYM at knee-high stage (725 kg ha^{-1}), flag-leaf stage (4120 kg ha^{-1}) and silking stage (5997 kg ha^{-1}). This might be due to the favourable effects of FYM in conjunction with fertilizers on growth and yield parameters which resulted in more dry matter yield and consequently more utilization of nutrients by the crop. These findings are in close conformity with those of Singh and Singh (2005) and Kushwaha *et al*., (2014). With KSB doses, 5 kg ha^{-1} dosage of KSB recorded higher dry matter production at knee-high stage (717 kg ha^{-1}), flag-leaf stage (3925 kg ha^{-1}), silking stage (5865 kg ha^{-1}). This might be due to a linkage between balanced mineral nutrition and increase in plant growth inoculated with KSB (Zhang and Kong 2014).

CONCLUSION

From the present investigation it can be concluded that application of 100% RDK, 10 t ha^{-1} FYM and 5 kg ha^{-1} KSB increased the kernel yield, stover yield and drymatter production of maize significantly.

FUTURE SCOPE

1. Study of interaction (positive or negative) between KSB with other PGPRs in the availability of potassium.
2. Well-designed, large scale and long-term field trails are required to evaluate the feasibility of KSB application in increasing the availability of K and other nutrients and economic feasibility of different K sources should be investigated.
3. Study of role of KSB in increasing the availability of other nutrients (nutrients that their availability is affected by pH) as P, N, Fe, Zn, etc.

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