E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(6): 216-219
Received: 11-06-2024
Accepted: 22-06-2024

KH Patel
Main Maize Research Station, AAU, Godhra, Gujarat, India

HS Varma
Main Maize Research Station, AAU, Godhra, Gujarat, India

VJ Patel
Main Maize Research Station, AAU, Godhra, Gujarat, India

MB Patel
Main Maize Research Station, AAU, Godhra, Gujarat, India

PK Parmar
Main Maize Research Station, AAU, Godhra, Gujarat, India

DM Rathod
Main Maize Research Station, AAU, Godhra, Gujarat, India

Corresponding Author:
KH Patel
Main Maize Research Station, AAU, Godhra, Gujarat, India

Impact of potassium levels and potassium solubilizing bacteria on yield and economics of maize in *rabi* season

KH Patel, HS Varma, VJ Patel, MB Patel, PK Parmar and DM Rathod

DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sd.846

Abstract
The field experiment was conducted during *rabi* season of 2021 to 2023 at main maize research station, Anand agricultural university, Godhra (Gujarat). The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.5), low in organic carbon (0.40%), medium in available P (58.0 kg/ha) and high in available K (279.4 kg/ha). The treatments consisted of five Levels of K_2O (K_0: 0 kg K_2O ha^{-1} (K_1: 20 kg K_2O ha^{-1}, K_2: 40 kg K_2O ha^{-1}, K_3: 60 kg K_2O ha^{-1} and K_4: 80 kg K_2O ha^{-1}) with and without bio fertilizer (KMB seed treatment and soil application. The experiment was laid out in randomized block design with ten treatments and was replicated thrice. Result defined that test weight of maize was significantly highest with application of 40 kg K_2O ha^{-1}, the grain yield, AV. P_2O_5 and AV. K_2O were maximum observed when KMB (5 ml kg^{-1} seed at sowing + soil application of KMB @ 1 liter/ha after 30 DAS) was apply, highest content of K in straw of maize was found with application of 60 kg K_2O/ha+ KMB (potassium mobilizing bacteria) 5 ml/kg seed and @ 1 liter ha^{-1}**.** Seed treatment of KMB (5 ml/kg seed) and soil application of KMB (1 lit/ha) gave net realization (Rs. 1,40,898/ha) with higher BCR (4.96).

Keywords: Grain yield, KMB, K content, economics, BCR

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}. Maize is one of the most useful initial crops which has a wider adaptability in various Agro-climatic conditions. Maize is an exhaustive crop and utilizes more nutrients from the soil for growth and development. Solubilization of insoluble minerals by bacteria helps to uptake and utilization of nutrient from the soil.

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. Potassium (K) ranks at third among the essential plant nutrients after nitrogen and phosphorus and seventh among all the elements in the earth's crust (Manning 2010) [6]. It is the most essential macronutrient needed for the plant growth to increase crop yields with quality produce (Romheld and Kirk 2010) [10]. In addition to increasing plant resistance to diseases, pests, and abiotic stresses, K is required to activate over 80 different enzymes responsible for plant and animal processes such as energy metabolism, starch synthesis, nitrate reduction, photosynthesis, and sugar degradation (Almeida *et al*. 2015; Hussain *et al*. 2016; White and Karley 2010; Yang *et al*. 2015) [1, 2, 4, 13, 14]. Maize response to applied potassium, however, found to vary considerably across soil types (Csatho 1992) [3], availability of potassium in soils (Kapur *et al*. 1984) [5] and season (Prasad and Shrivastava 1992) [9]. The available information on maize response to applied potassium suggests for the need to conduct experiments to workout site specific potassium recommendation to maize crop. Since potassium is mobile in nature, it helps to regulate the opening and closing of stomata in the leaves and the absorption of water by the root cells.

However potassium exerts balancing effect on both nitrogen and phosphorus (Tisdale and Nelson, 1975) [11, 12].

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) [7, 8]. 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

This study aims to assess the optimal level of potassium application and the efficacy of potash mobilizing microorganisms in enhancing the growth and yield of Rabi maize.

Materials and Methods

The present experiment was carried out during *rabi* 2021 to 2023 at main maize research station, Anand agricultural university, Godhra (Gujarat). GAWMH-2 variety used for sowing Maize with 160 kg N and 20 kg P_2O_5 ha^{-1}. The experiment laid out in Randomized Block Design which consisting of ten treatments, five Levels of K_2O (K_0: 0 kg K_2O ha^{-1} (K_1: 20 kg K_2O ha^{-1}, K_2: 40 kg K_2O ha^{-1}, K_3: 60 kg K_2O ha^{-1} and K_4: 80 kg K_2O ha^{-1}) and two levels of Biofertilizer, with KMB (seed treatment KMB 5 ml kg^{-1} seed and @ 1 liter ha^{-1} soil application) and without bio fertilizer were replicated thrice. Nutrient sources were Urea and DAP to fulfill the necessity of Nitrogen and phosphorous. The application of fertilizers was applied as basal at the time of sowing. The seeds were inoculated with respective bio fertilizers as per the treatment combinations. MOP was applied in the treatment plots to fulfill the needs of potassium. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded, those parameters are growth parameters, plant height, the yield parameters like cob length (cm), cob width (cm), test weight (g), seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design.

Results and Discussion

Effect of Potassium on Maize Grain Yield

Potassium application showed a significant impact on maize grain yield over the two-year study period. Treatment K3 (40 kg K_2O/ha) resulted in the highest grain yield, with 8922 kg/ha and 8529 kg/ha recorded in 2021 and 2022, respectively. However, treatment K4 (60 kg K_2O/ha) yielded a comparable grain yield, indicating no statistically significant difference in pooled analysis. Interestingly, the inclusion of potassium-mobilizing biofertilizer (KMB) significantly boosted grain yield, with treatment B1 yielding 7610 kg/ha, underscoring the potential of microbial inoculants in enhancing yield.

Stover Yield and Plant Stand

Stover yield did not exhibit a significant response to potassium application across treatments. Nonetheless, treatment K3 demonstrated a higher stover yield of 13751 kg/ha. Plant stand results were non-significant among treatments, while plant height at harvest showed a significant increase, particularly in the KMB treatment, indicating enhanced plant vigor.

Cob Characteristics and Quality Parameters

Cob length and girth remained unaffected by potassium application, suggesting that these parameters were not significantly influenced by varying potassium levels. Additionally, test weight and the number of cobs were not notably altered by potassium treatments.

Nutrient Content in Grain and Plant

The total nitrogen, phosphorus, and potassium content in both grain and plant stover were not significantly affected by potassium application, indicating that potassium levels did not influence nutrient composition in maize.

Effect of KMB on Soil Microbial Count

Treatment involving KMB application demonstrated higher soil microbial counts post-harvest, suggesting a positive impact on soil health and fertility. This indicates that KMB application can contribute to enhancing soil microbial populations, which play a crucial role in nutrient cycling and soil health maintenance.

Economic Analysis

In terms of economic viability, treatment with KMB seed and soil application exhibited a higher benefit-cost ratio (BCR) of 4.96, along with a net realization of Rs. 1,40,898/ha. This highlights the economic feasibility and potential profitability of incorporating KMB into maize cultivation practices.

Table 1: Interaction effect of potassium on growth parameter in Rabi season.

Treatments	Initial Plant stand/Net plot			Plant stand at harvest/Net plot			Plant height at harvest			Cob length (cm.)			Cob girth (cm.)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
K_0 (0)	90	89	90	89	87	88	194	207	200	19.42	17.42	18.41	13.95	13.85	13.90
K_1 (20)	91	89	90	89	88	88	199	206	203	20.17	17.66	18.92	14.18	13.80	13.99
K_2 (40)	87	90	90	82	88	84	204	208	206	20.92	17.77	19.35	14.65	13.55	14.10
K_3 (60)	91	90	90	87	88	88	202	211	206	20.58	17.77	19.18	14.40	13.39	13.89
K_4 (80)	89	90	89	85	88	86	202	206	204	20.42	18.44	19.43	14.28	14.16	14.22
S.Em ±	1.280	0.769	0.746	2.808	0.994	1.490	2.11	1.36	1.25	0.13	0.44	0.22	0.14	0.16	0.24
CD (P=0.05)	NS	NS	NS	NS	NS	NS	6.27	NS	3.60	0.39	NS	0.66	0.41	0.49	NS
B_0 (Without KMB)	90	89	90	88	88	88	198	206	203	20.07	17.63	19.03	14.06	13.73	13.90
B_1 (With KMB)	89	90	89	84	88	86	202	209	206	20.53	17.99	19.08	14.52	13.77	14.15
S.Em ±	0.810	0.486	0.472	1.776	0.629	0.942	1.33	0.86	0.79	0.09	0.28	0.30	0.09	0.11	0.15
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	2.28	0.25	NS	NS	0.26	NS	NS
K x B															
S.Em ±	-	-	1.056	-	-	2.107	2.98	1.92	1.77	0.19	0.62	0.32	0.19	0.23	0.25
CD (P=0.05)	-	-	NS	-	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Year															
S.Em ±	-	-	0.472	-	-	0.942	-	-	0.79	-	-	0.14	-	-	0.07

CD (P=0.05)	-	-	NS	-	-	NS	-	-	2.28	-	-	0.42	-	-	0.20
K x Y															
S.Em ±	-	-	1.056	-	-	2.107	-	-	1.77	-	-	0.32	-	-	0.15
CD (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	0.44
B x Y															
S.Em ±	-	-	0.668	-	-	1.332	-	-	1.12	-	-	0.20	-	-	0.09
CD (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	0.59	-	-	0.27
K x B x Y															
S.Em ±	-	-	1.493	-	-	2.979	-	-	2.51	-	-	0.45	-	-	0.21
CD (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	0.62
CV%	3.51	2.11	2.89	7.94	2.76	5.90	2.57	1.60	2.12	1.62	6.01	4.16	2.35	2.96	2.66

Table 2: Interaction effect of potassium on growth parameter and fall armyworm damage in rabi season.

Treatments	Number of cobs			Grain yield (kg/ha)			Stover yield			FAW Damaged (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
K_0 (0)	94202	86956	90579	7714	7623	7668	12409	12679	12544	2.0	1.0	2.0
K_1 (20)	92391	87560	89975	8031	7699	7865	13617	13332	13231	2.0	1.0	2.0
K_2 (40)	94504	86805	90654	8922	8529	8725	13451	14051	13751	2.0	1.0	2.0
K_3 (60)	94202	85748	89975	8786	8303	8657	12303	14405	13354	2.0	2.0	2.0
K_4 (80)	93448	87107	90277	7986	7805	7896	13028	14078	13553	2.0	2.0	2.0
S.Em ±	1114	2836	1382	201	109	448	532	1352	726	0.293	0.241	0.190
CD (P=0.05)	NS	NS	NS	598	326	NS	NS	NS	NS	Ns	NS	NS
B_0 (Without KMB)	91364	87198	89281	8073	6450	7262	12312	13351	12831	2.0	1.0	2.0
B_1 (With KMB)	89311	86473	87892	8502	6718	7610	13611	14067	13839	2.0	1.0	2.0
S.Em ±	704	1794	874	127	69	91	336	855	459	0.185	0.152	1.120
CD (P=0.05)	NS	NS	NS	378	206	263	1000	NS	NS	NS	NS	NS
K x B												
S.Em ±	1575	4011	1955	284	155	205	752	1913	1028	-	-	0.268
CD (P=0.05)	NS	NS	NS	846	462	NS	2236	NS	NS	-	-	NS
Year												
S.Em ±	-	-	874	-	-	91	-	-	459	-	-	0.120
CD (P=0.05)	-	-	NS	-	-	263	-	-	NS	-	-	0.344
K x Y												
S.Em ±	-	-	1955	-	-	205	-	-	1028	-	-	0.268
CD (P=0.05)	-	-	NS	-	-	289	-	-	NS	-	-	NS
B x Y												
S.Em ±	-	-	1236	-	-	129	-	-	650	-	-	0.170
CD (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
K x B x Y												
S.Em ±	-	-	2765	-	-	290	-	-	1453	-	-	0.379
CD (P=0.05)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
CV%	2.91	9.83	6.42	5.95	14.14	10.02	16.06	20.00	18.03	20.00	21.00	20.50

Table 3: Effect of potassium on Total N%, Total P_2O_5% and Total K_2O% of grain and stover and effect of KMB on soil properties after harvesting. (KMB Micro organism) in *Rabi* season.

Treatments	Content in grain (%)			Content in Stover (%)			Effect of KMB on soil properties after harvesting. (KMB Micro organism)		
	N	P	K	N	P	K	Treatments	Total Soil Microbial Count (CFU/g soil)	KMB Count (CFU/g soil)
K_0 (0)	1.30	0.34	0.40	0.87	0.20	0.44	T1: K_0B_0	3.93×10^6	3.5×10^4
K_1 (20)	1.31	0.34	0.37	0.81	0.22	0.47	T2: K_0B_1	3.16×10^9	3.73×10^8
K_2 (40)	1.34	0.41	0.42	0.90	0.23	0.46	T3: K_1B_0	4.66×10^6	3.33×10^4
K_3 (60)	1.33	0.37	0.43	0.83	0.20	0.48	T4: K_1B_1	3.6×10^9	3.0×10^8
K_4 (80)	1.28	0.36	0.40	0.92	0.24	0.47	T5: K_2B_0	3.6×10^6	3.33×10^4
S.Em ±	0.04	0.03	0.03	0.03	0.02	0.01	T6: K_2B_1	2.7×10^9	2.1×10^8
CD (P=0.05)	NS	NS	NS	NS	NS	NS	T7: K_3B_0	5.23×10^6	4.0×10^4
B_0 (Without KMB)	1.32	0.35	0.39	0.86	0.22	0.46	T8: K_3B_1	1.93×10^9	2.76×10^8
B_1 (With KMB)	1.30	0.38	0.41	0.87	0.21	0.46	T9: K_4B_0	4.66×10^6	4.0×10^4
S.Em ±	0.03	0.02	0.02	0.02	0.01	0.008	T10: K_4B_1	2.7×10^9	2.6×10^8
CD (P=0.05)	NS	NS	NS	NS	NS	NS			
K x B							**Initial Microbial counts:**		
S.Em ±	0.06	0.05	0.04	-	0.02	0.02	1.Total bacterial count: 4.3×10^5 cfu/g soil		
CD (P=0.05)	NS	NS	NS	-	NS	NS	2. KMB bacterial count: 2.4×10^3 cfu/g soil		
CV%	8.29	20.35	17.61	9.27	17.75	6.41			

Table 4(1): Economics

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Gross Realization (Rs/ha)	Total cost of cultivation (Rs/ha)	Net Realization (Rs/ha) (4-5)	BCR 4÷5	Treatment cost
1	2	3	4	5	6	7	8
T_1 (K_0B_0)	7638	13285	174352	35220	139132	4.95	0
T_2 (K_0B_1)	8227	11803	176518	35620	140898	4.96	400
T_3 (K_1B_0)	7895	13870	180840	36420	144420	4.97	1200
T_4 (K_1B_1)	8288	13631	185659	36860	148799	5.04	1640
T_5 (K_2B_0)	8499	11846	180792	37620	143172	4.81	2400
T_6 (K_2B_1)	8544	15103	196123	38060	158063	5.15	2840
T_7 (K_3B_0)	7955	12343	174868	38820	136048	4.50	3600
T_8 (K_3B_1)	7699	14365	180127	39260	140867	4.59	4040
T_9 (K_4B_0)	8665	12813	187633	40020	147613	4.69	4800
T_{10} (K_4B_1)	7759	14293	180703	40460	140243	4.67	5240

Maize grain price Rs. 15/kg Maize stover price Rs.4.50/kg Fix cost of cultivation Rs.35220/ha	K_0 = 0 kg K/ha K_1 = 20 kg K/ha K_2 = 40 kg K/ha K_3 = 60 kg K/ha K_4 = 80 kg K/ha	B_0 (Without KMB) B_1 (With KMB)

Table 4(2): Economics

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Gross Realization (Rs/ha)	Total cost of cultivation (Rs/ha)	Net Realization (Rs/ha) (4-5)	BCR 4÷5	Treatment cost
1	2	3	4	5	6	7	8
K_0 (0 K_{20} Kg/ha)	7668	12409	170860	35220	135640	4.85	0
K_1 (20 Kg K_{20}/ha)	7865	13451	178504	36420	142084	4.90	1200
K_2 (40 Kg K_{20}/ha)	8725	13617	192151	37620	154531	5.11	2400
K_3 (60 Kg K_{20}/ha)	8657	12303	185218	38820	146398	4.77	3600
K_4 (80 Kg K_{20}/ha)	7896	13028	177066	40020	137046	4.42	4800
B_0 (Without KMB)	7974	12312	175014	35220	139794	4.96	0
B_1 (With KMB)	8260	13611	185149	35620	149529	5.19	400

Maize grain price Rs. 15/kg Maize stover price Rs.4.50/kg Fix cost of cultivation Rs.35220/ha	K_0 = 0 kg K/ha K_1 = 20 kg K/ha K_2 = 40 kg K/ha K_3 = 60 kg K/ha K_4 = 80 kg K/ha	B_0 (Without KMB) B_1 (With KMB)

Conclusion

It is to be concluded from the results of grain yield achieved that the seed treatment of KMB @ 5 ml/kg seed along with soil application @ 1 lit/ha after 30 DAS gave significantly higher yield (7610 kg/ha.) with high net return (Rs. 1,40,898/ha.) with higher BCR 4.96.

References

1. Almeida HJ, Pancelli MA, Prado RM, Cavalcante VS, Cruz FJR. Effect of potassium on nutritional status and productivity of peanuts in succession with sugar cane. Journal of Soil Science and Plant Nutrition. 2015;15:1-10.
2. Almeida HJ, *et al*. The role of potassium in plant physiology and crop production. Journal of Plant Nutrition. 2015;38(10):1503-1521.
3. Csatho P. Variation in maize response to potassium across different soil types. Plant and Soil. 1992;145(1):47-55.
4. Hussain S, *et al*. The significance of potassium in enhancing crop resistance to environmental stresses. Environmental and Experimental Botany. 2016;127:12-19.
5. Kapur ML, *et al*. Availability of potassium in soils and its effect on crop yield. Indian Journal of Agricultural Sciences. 1984;54(1):28-34.
6. Manning DAC. Mineral sources of potassium for plant nutrition. A review. Agronomy for Sustainable Development. 2010;30(2):281-294.
7. Maurya BR, Meena VS, Meena OP. Influence of Inceptisol and Alfisol's potassium solubilising bacteria (KSB) isolates on release of K from waste mica. Vegetos. 2014;27:181-187.
8. Maurya BR, *et al*. Potassium solubilizing bacteria (KSB): Occurrence, mechanisms, and their role in plant growth promotion. International Journal of Agriculture and Biology. 2014;16(5):948-960.
9. Prasad R, Shrivastava A. Seasonal variations in maize response to potassium. Field Crops Research. 1992;30(2):123-134.
10. Romheld V, Kirkby EA. Research on potassium in agriculture: Needs and prospects. Plant and Soil. 2010;335(1-2):155-180.
11. Tisdale SL, Nelson WL. Soil Fertility and Fertilizers. Macmillan Publishing Co.; 1975. pp. 150-155.
12. Tisdale S, Nelson W. In: Soil fertility and fertilizers. Macmillan Company Inc.; 1975. New York.
13. White PJ, Karley AJ. Potassium in plants. Annals of Botany. 2010;105(3):513-525.
14. Yang X, *et al*. The interaction of potassium with other nutrients in crops. Frontiers in Plant Science. 2015;6:546.