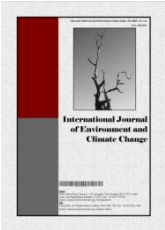

International Journal of Environment and Climate Change

11(10): 178-184, 2021; Article no.IJECC.76203
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Integrated Potassium Application on Growth, Yield and Micronutrient Uptake by Forage Maize (*Zea mays L.*)

Nisha Chaudhary[1], J. K. Parmar[1], Drashti Chaudhari[1] and Manish Yadav[2*]

[1]Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand, Gujarat-388110, India.
[2]Department of Soil Science, Punjab Agricultural University, Ludhiana, Punjab- 141004, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2021/v11i1030505
Editor(s):
(1) Dr. Wen-Cheng Liu, National United University, Taiwan.
Reviewers:
(1) Ifra Saleem, Ayub Agricultural Research Institute, Pakistan.
(2) V. Vasanthabhrathi, Annamalai University , India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/76203

Original Research Article

Received 13 August 2021
Accepted 26 October 2021
Published 27 October 2021

ABSTRACT

A pot experiment was conducted during *kharif* season of 2019 to carry out the study on "Interactive effect of potash (K_2O), potassium mobilizing bacteria (KMB) and FYM on forage yield, nutrient uptake by forage maize and soil fertility in a loamy sand soil of middle Gujarat". Application of K_2O @ 60 kg ha^{-1}, KMB and FYM recorded significantly the highest plant height of forage maize at harvest over respective control. Crop fertilized with K_2O @ 60 kg ha^{-1} and KMB gave significantly the highest green forage and dry matter yield. The results indicated that application of K_2O @ 60 kg ha^{-1}, potassium mobilizing bacteria recorded significantly the highest uptake of N, P, K, Fe and Zn by crop at harvest. Significantly the highest uptake of N, K and Cu were found with application of FYM @10 t ha^{-1}. Significantly the highest K uptake by maize as well as higher P and Zn uptake by maize were observed due to interaction effect of K × KMB (60 kg K_2O ha^{-1} with KMB). In case of N and Cu uptake by maize were noted the Significantly higher due to interaction effect of K × KMB (30 kg K_2O ha^{-1} with KMB) and K × KMB × FYM (60 kg K_2O ha^{-1} with KMB and FYM), respectively. The integrated use of potassium fertilizers along with KBM or in combination with FYM significantly improved the maize grain and nutrient uptake

**Corresponding author: E-mail: manish.soil017@gmail.com;*

Keywords: Farmyard manure; forage yield; nutrient uptake; potassium mobilizing bacteria.

1. INTRODUCTION

In India, maize ranks fifth in area and third in production and productivity among cereal crops. The area under maize crop in Gujarat is about 7800 ha. The average yield of green fodder maize is about 40 to 50 t ha^{-1} [1]. Maize is an excellent crop in terms of biomass production. Maize straw is used as animal fodder since the ancient times.Maize crop has an important place in the food grain basket of our country due to its importance in food, feed, specialty corn, starch etc.It plays important role in human diet, animal feed and provides a large amount of energy and protein. Potassium has been recognized as an essential element and a major nutrient for plant growth and required in large quantities.Potassium is considered second only to nitrogen when it comes to nutrients needed by plants and is commonly considered as the "quality nutrient". Potassium plays an important role in regulates photosynthesis, protein synthesis and stomatal movement. It acts as a major cation for the maintenance of cation-anion balance. Potassium is important for corn growth because it helps increase disease resistance and water stress tolerance. Adequate K increases the ability of corn plants to efficiently uptake other nutrients. Its beneficial action on crop quality shows better utilization of nitrogen and increased protein formation. Most of the K in soil exists in various insoluble rocks, minerals and sedimentary materials.The bulk of soil potassium (about 98% of total K) usually exists in unavailable form in primary (micas and feldspars) and secondary (illite group) clay minerals [2]. The K- mobilizing bacteria are able to release potassium from insoluble minerals of soil. It is known that potassium solubilizing bacteria (KSB) can solubilize K-bearing minerals and convert the insoluble K to soluble forms of K available to plant uptake. Many bacteria such as *Acidothiobacillus ferrooxidans, Paenibacillus* spp., *Bacillus mucilaginosus, B. edaphicus,* and *B. circulans* have capacity to solubilize K minerals (e.g., biotite, feldspar, illite, muscovite, orthoclase, and mica). KSB are usually present in all soils, although their number, diversity and ability for K solubilization vary depending upon the soil and climatic conditions. KSB can dissolve silicate minerals and release K through the production of organic and inorganic acids, acidolysis, polysaccharides, complexolysis, chelation, and exchange reactions. Hence, the production and management of biological fertilizers containing KSB can be an effective alternative to chemical fertilizers.

Among the microorganisms, K mobilizing bacteria (KMB) have attracted the attention of agriculturists as soil inoculums to promote the plant growth and yield.FYM is the source of primary, secondary and micronutrients to the plant growth. The entire amount of nutrients present in farm yard manure is not available immediately. The application of FYM increased the organic carbon, organic matter, total soil porosity, water holding capacity and decreased soil bulk density [3]. Most agricultural soils have large amounts of K but, are mostly unavailable to crop plants due to immobilization. Hence, very limited concentration of K available to plants results K deficiency in soils. Further, intensive cropping system also results potash deficiency in soil.These necessitate to find an alternate indigenous source of K for plant needs and maintain K status in soils for sustaining crop production [4]. The judicious use of potassium and KMB fertilizer in crop land promises increase in growth, yield, nutrient uptake capacity and soil fertility.In view of these facts, the investigation entitled "Effect of potash, potassium mobilizing bacteria (KMB) and FYM on forage yield and nutrient uptake by forage maize (*Zea mays L*.) in a loamy sand soil of middle Gujarat" was planned and conducted.

2. MATERIALS AND METHODS

A pot experiment entitled, "effect of levels of potash, potassium mobilizing bacteria (KMB) and FYM on forage yield and nutrient uptake by forage maize (*Zea mays L*.) In a loamy sand soil of middle Gujarat**"** was carried out during *khari f*season of 2019 in the pot house of the Department of Soil Science and Agricultural Chemistry, Anand Agricultural University, Anand. The experiment was laid out in a completely randomized design (factorial) with three repetitions. The experiment comprised of twelve treatment combinations with three levels of K_2O (0, 30 and 60 kg ha^{-1}), two levels of KMB (with potassium mobilizing bacteria and without potassium mobilizing bacteria) and two levels of FYM (0 and 10 t ha^{-1}). The soil was collected from Agriculture Research Station, Khambhodaj, AAU, Anand was of *Typic Ustochrepts*, having loamy sand soil texture, slightly alkaline in reaction (pH-8.05). The polythene lined earthen pots were filled with 15 kg composite soil. Soil

was mixed with the FYM and potassium mobilizing bacteria (*Enterobacter asburiae*) as per treatments before transferring the soil to the pots. While half dose of nitrogen was applied at the time of sowing and remaining half recommended dose of nitrogen was applied at 30 DAS. The P_2O_5 and K_2O were applied in the form of di-ammonium phosphate (DAP) and muriate of potash at the time of sowing. The pots were brought to field capacity by proper watering; eight seeds of maize were sown in each pot. After germination, maize plants were thinned to five plants per pot. Pots were regularly watered and weed free condition was maintained till achieved tasseling stage of maize crop. The observations like plant height at 30 DAS and at harvest were taken in accordance with the crop growth in pots. Top dressing of 50 % N in the form of urea was done at 30 DAS. When the maize was at tasseling stage (60 DAS), the plants were uprooted carefully. The fresh and oven dry weight of plant were recorded from each pot. All the data recorded during the study period were statistically analyzed by using standard methods as suggested by Steel and Torrie [5].

3. RESULT AND DISCUSSION

3.1 Effect on Growth and Yield

Application of K_2O @ 60 kg ha^{-1}recorded significantly higher plant height (79.09 cm) at 30 DAS, which was at par with K_2O @ 30 kg ha^{-1}while significantly the highest plant height (154 cm) of forage maize was recorded at harvest over control was also noted with the application of K_2O @ 60 kg ha^{-1}. The application of KMB and FYM recorded significantly the highest plant height at harvest over respective control. The results were conformity with finding of Chaudhary *et al.* [10] and Jha [11] Crop fertilized with K_2O @ 60 kg ha^{-1}, potassium mobilizing bacteria and FYM @ 10 t ha^{-1} gave significantly the highest green forage (354, 330 and 326g pot^{-1}), respectively.Similarly, the application of K_2O @ 60 kg ha^{-1} and KMB recorded significantly the highest dry matteryield (69.95 and 64.29 g pot^{-1}) of maize (Table 2). The findings corroborate the reports of Yadav *et al.* [12-13] and Jha [11]. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of photosynthesis and ultimately increased in the green and dry matter yield [14]. The findings corroborate the reports of Ahmad *et al.* [15] Yadav *et al.* [12-13] and Chaudhary *et al.* [10] in maize crop.

3.2 Effect on Nutrient uptake

In uptake study, application of K_2O @ 60 kg ha^{-1}, potassium mobilizing bacteriarecorded significantly the highest uptake of N, P, K, Fe and Zn by crop at harvest but in case of nitrogen it was at par with K_2O @ 30 kg ha^{-1}except potassium mobilizing application not found significant on Mn and Cu uptake by plant at harvest.Significantly the highest uptake of N, K and Cu were found with application of FYM @10 t ha^{-1}. While P, Fe, Mn and Zn uptake by forage maize recorded was non-significant due to FYM application (Table 3). This result was also concealed by Ravindra *et al.* [16], Singh *et al.* [17] and Chaudhary *et al.* (2017). The significantly higher uptake of Cu (0.34 mg pot^{-1}) was found with FYM application over the no application of FYM. Thus application of FYM has resulted in an overall significant increase in uptake of nutrients. These observations are conformity with the reported by some earlier worker Chaudhary *et al.* [10] and Chaudhary *et al.* [18] and Hussain *et al.* [19].

3.3 Interaction Effect

The interaction effect of K × KMB (K_2O @ 60 kg ha^{-1} with KMB application) gave significantly the highest plant height (164 cm) of maize and significantly the higher green forage yield (356 g pot^{-1}) and dry matter yield (69.94 g pot^{-1}) were also noted with interaction effect of K × KMB (K_2O @ 60 kg ha^{-1} with KMB application (Table 4). These results were in close conformity with finding of Ghetiya *et al.* [20].

Significantly the highest K uptake by maize as well as higher P and Zn uptake by maize were noted due to interaction effect of K × KMB (60 kg K_2O ha^{-1} with KMB). The N uptake by maize were noted significantly higher due to interactive effect of K × KMB (30 kg K_2O ha^{-1} with KMB). Similar result was supported by Meena and Maurya, [21] Basak and Bisvas [4] and Patel and Yadav (2014). Similarly, higher Cu uptake by maize was found due to interaction effect of K × KMB × FYM (60 kg K_2O ha^{-1} with KMB and FYM). This result close confirms of Patel and Yadav (2014).

Table 1. Initial physico - chemical properties of the soil used for pot study

Sr. No	Characteristics		Method
1	pH (1:2.5)	8.05	pH meter [6]
2	EC (1:2.5) dS m^{-1}	0.18	Conductivity meter [6]
3	Organic carbon (%)	0.39	Chromic acid wet oxidation method [6]
4	Available N (kg ha^{-1})	198	Alkaline permanganate method [7]
5	Available P_2O_5 (kg ha^{-1})	39	Olsen *et al.* [8]
6	Available K_2O (kg ha^{-1})	107	Neutral Normal Ammonium acetate [6]
7	DTPA- Zn (mg kg^{-1})	0.92	Atomic Adsorption Spectrophotometric
8	DTPA- Fe (mg kg^{-1})	2.77	method [9]
9	DTPA- Mn (mg kg^{-1})	7.82	
10	DTPA- Cu (mg kg^{-1})	0.79	

Table 2. Effect of potash, potassium mobilizing bacteria (KMB) and FYM on plant height and yield of forage maize

Treatments	Plant height (cm)		Yield (g pot^{-1})	
	30 DAS	At harvest	Green forage	Dry matter
K_2O levels				
K_0 : 0 kg ha^{-1}	72.57	139	289	55.94
K_1: 30 kg ha^{-1}	77.35	143	312	61.15
K_2 : 60 kg ha^{-1}	79.09	154	354	69.95
S.Em ±	1.36	3.2	5.1	1.47
C.D. (P = 0.05)	3.96	7.5	15.4	4.28
KMB levels				
KMB_0: without KMB	75.88	140	306	60.40
KMB_1: with KMB	76.79	151	330	64.29
S.Em ±	1.10	2.01	3.99	1.20
C.D. (P = 0.05)	NS	6.1	12	3.49
FYM levels:				
F_0 : 0 t FYM ha^{-1}	74.80	142	310	60.99
F_1 : 10 t FYM ha^{-1}	77.87	148	326	63.71
S.Em ±	1.10	2.3	4.1	1.20
C.D. (P = 0.05)	NS	6.8	12.3	NS
Interaction				
K×KMB	NS	Sig.	Sig.	Sig.
K×F	NS	NS	NS	NS
KMB×F	NS	NS	NS	NS
K×KMB×F	NS	NS	NS	NS
C.V. %	6.16	5.81	5.53	8.15

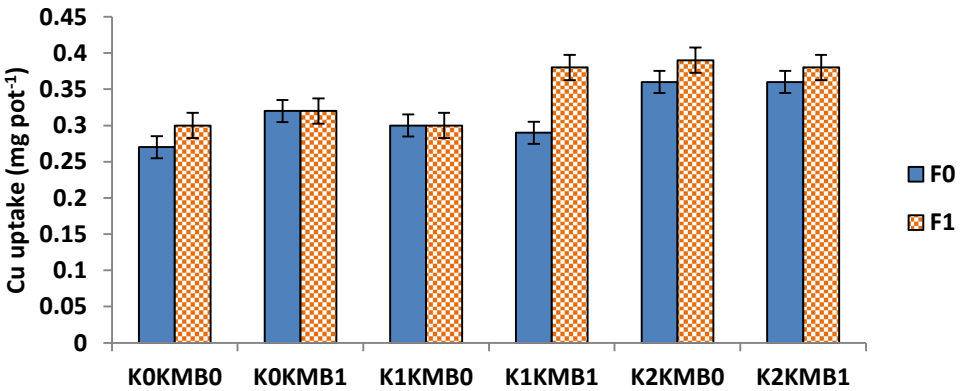

Fig. 1. Interaction effect of Potash, KMB and FYM on Cu uptake (mg pot^{-1}) by forage maize at harvest

Table 3. Effect of potash, potassium mobilizing bacteria (KMB) and FYM on major and micronutrients uptake by forage maize at harvest

Treatments	Nutrients Uptake (mg pot^{-1})						
	N	P	K	Fe	Mn	Zn	Cu
K_2O levels:							
K_0 : 0 kg ha^{-1}	750	121	707	14.69	0.97	1.74	0.30
K_1: 30 kg ha^{-1}	909	136	804	15.71	1.08	2.09	0.32
K_2 : 60 kg ha^{-1}	983	158	998	18.60	1.23	2.40	0.37
S.Em ±	31	4	21	0.45	0.04	0.08	0.01
C.D. (P = 0.05)	91	12	61	1.30	0.12	0.23	0.02
KMB levels:							
KMB_0: without KMB	833	133	780	15.69	1.06	1.94	0.32
KMB_1: with KMB	927	144	892	16.98	1.13	2.21	0.34
S.Em ±	26	3	17	0.36	0.03	0.07	0.01
C.D. (P = 0.05)	75	10	50	1.06	NS	0.19	NS
FYM levels:							
F_0 : 0 t FYM ha^{-1}	837	136	799	15.84	1.07	2.03	0.32
F_1 : 10 t FYM ha^{-1}	924	141	873	16.82	1.11	2.13	0.34
S.Em ±	26	3	17	0.36	0.03	0.07	0.01
C.D. (P = 0.05)	75	NS	50	NS	NS	NS	0.02
Interaction							
K×KMB	Sig.	Sig.	Sig.	NS	NS	Sig.	NS
K×F	NS	NS	NS	NS	NS	NS	NS
KMB×F	NS	NS	NS	NS	NS	NS	NS
K×KMB×F	NS	NS	NS	NS	NS	NS	Sig.
C.V. %	12.31	10.54	8.72	9.44	13.25	13.36	8.32

Table 4. Interaction effect of potash and potassium mobilizing bacteria (KMB) on growth, yield and nutrient uptake by forage maize

Treatments	Plant height * (cm)	GFY (g pot^{-1})	DMY (g pot^{-1})	N uptake (mg pot^{-1})	P uptake (mg pot^{-1})	K uptake (mg pot^{-1})	Zn uptake (mg pot^{-1})
K_0 × KMB0	138	281	55.40	777	121	699	1.74
K_0 × KMB_1	141	298	56.49	723	121	715	1.74
K_1 × KMB_0	139	287	55.85	784	121	726	1.75
K_1 × KMB_1	146	336	66.45	1033	151	881	2.43
K_2 × KMB_0	144	351	69.97	940	156	916	2.32
K_2 × KMB_1	164	356	69.94	1026	160	1080	2.47
S.Em ±	3.10	7.10	2.07	44.1	6.2	30.2	0.11
C.D. (P = 0.05)	10.0	21.3	6.05	129.2	17.5	87.6	0.33

**at harvest, GFY- Green forage yield, DMY- Dry matter yield*

4. CONCLUSION

Among the fertilizer treatments in the present experiment, the application of potassium @ 60 kg ha^{-1} along with KMB application resulted in increased green forage yield, dry matter yield, potassium uptake by forage maize. The interaction effect on potassium and KMB was found significant in case of plant height at harvest, green and dry yield of fodder maize. This study demonstrated that integrated use of potassium fertilizers along with KBM or in combination with FYM significantly improved the maize grain and nutrient uptake.

ACKNOWLEDGEMENTS

The authors are thankful to the Department of Soil Science and Agricultural Chemistry, Anand Agriculture University, Anand (Gujarat) for providing all necessary facilities and support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rathod P, Dixit S. Green fodder production: A manual or field functionaries. Patancheru, Telangana, India, ICRISAT. 2019;56.
2. Attoe OJ, Truog E. Exchangeable and Acid-Soluble Potassium as Regards Availability and Reciprocal Relationships. Soil Science Society of America Journal. 1946;10(C):81-86.
3. Rasool R, Kukal SS, Hira GS. Soil fertility and crop performance as affected by long term application of FYM and inorganic fertilizer in rice-wheat system. Soil Til. Res. 2007;96:64-72.
4. Basak BB, Biswas DR. Influence of potassium solubilizing microorganism (*Bacillus mucilaginosus*) and waste mica on potassium uptake dynamics by sudan grass (Sorghum vulgare Pers.) grown under two Alfisols. Plant and Soil. 2009;317(1):235-55.
5. Steel GD, Torrie JH. Principles and procedures of statistics. McGraw Hill Book Co. Inc. New York; 1982.
6. Jackson ML. Soil Chemical Analysis Advanced Course. 11th Printing. Published by author, Madison, WI; 1979.
7. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soil, Current Science. 1956;25:259-260.
8. Olsen SR, Colde GV, Wantanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S.D.A. 1954;939:19.
9. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper, Soil Science Society of American Journal. 1978;42:421– 428.
10. Chaudhary DG, Chaudhary SR, Chaudhary MM, Mor VB. Interaction effect of potassium and zinc on yield and nutrient uptake of forage maize (*Zea mays L*.) grown on loamy sand soil. Int J Chem Stud. 2017;5(4):1737-9.
11. Jha Y. Potassium mobilizing bacteria: Enhance potassium intake in paddy to regulates membrane permeability and accumulate carbohydrates under salinity stress. Brazilian Journal of Biological Sciences. 2017;4(8):333-344.
12. Yadav NK. Effect of type of biochar on growth, dry matter yield and nutrition of maize (*Zea mays L*.) grown on sandy loam soils of middle Gujarat (Doctoral dissertation, Anand Agricultural University, Anand).
13. Yadav R, Nanwal RK, Kumar A. Effect of potash, zinc and biofertilizer application on productivity and quality of pearlmillet. Environment & Ecology. 2014;32(3):980-983.
14. Kaiser, Rosen. Cultivar and phosphorus effects on switchgrass yield and rhizosphere microbial diversity.Applied microbiology and Biotechnology. 2018;103:1973–1987.
15. Ahmad M, Ahmad R, Ishaque M, Malik AU. Response of maize hybrids to varying potassium application in Pakistan.Pakistan Journal of Agriculture Science. 2009;46(3):179-184.
16. Ravindra VM, Math KK, Ramya SH, Prashanth KM. Effect of application of spent wash as a source of potassium on the uptake of NPK and S by maize. Environment & Ecology. 2014;32 (4B):1784 -1787.
17. Singh G, Biswas DR, Marwaha TS. Mobilization of potassium from waste mica by plant growth promoting rhizobacteria and its assimilation by maize (*Zea mays L*.) and wheat (*Triticumaestivum* L.): A hydroponics study under phytotron growth chamber. Journal of plant nutrition. 2010;33(8):1236-1251.
18. Chaudhary KV, Parmar, JK, Rathod TK, Viradia MB. Influence of phosphorus, sulphur and FYM on growth and yield of forage maize (*Zea mays L*.) grown on loamy sand soil.International Journal of Chemical Studies, 2019;7(2):943-947.
19. Hussain MZ, Kumar M, Singh R, Kumari S, Mandal D. Effect of different levels of potassium on nutrient content and uptake by Kharif maize (*Zea mays L*.) International Journal of Chemical Studies. 2019;7(6):2118-2122.
20. Gheliya KP, Bhalu VB, Mathukia RK, Hadavani JK, Kamani MD. Effect of phosphate and potash solubilizing bacteria on growth and yield of popcorn (*Zea mays L*. var. Everta).Int J Pure ApplBiosci. 2018;6:167-74.
21. Meena G, Maurya BR. Potentiality of potassium solubilizing bacteria on

enhancing the growth, yield and nutrient acquisition on wheat (*Triticumaestivum* L.). International Journal of Current Microbiology and Applied Sciences. 2017; 6(4):2443-2450.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/76203