Journal of Experimental Agriculture International

43(6): 91-97, 2021; Article no.JEAI.71549
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Effect of Different Levels of Potassium on Soil Potassium Fractions and on Sugarcane Yield and Quality

A. Sireesha[1*], CH. S. Ramalakshmi[1] and T. Sreelatha[1]

[1]*Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, 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/JEAI/2021/v43i630706
Editor(s):
(1) Dr. Hab. Mariusz Cycoń, Medical University of Silesia, Poland.
Reviewers:
(1) Zaochang Liu, Shanghai Academy of Agricultural Sciences, China.
(2) Kaouther Ardhaoui, Gabes University, Tunisia.
Complete Peer review History: https://www.sdiarticle4.com/review-history/71549

Original Research Article

Received 01 June 2021
Accepted 05 August 2021
Published 10 August 2021

ABSTRACT

A Field experiment was conducted on effect of various levels of potassium application on soil potassium fractions and sugarcane yield at Regional Agricultural research station, Anakapalle, Andhra Pradesh. The experiment comprised six treatments and four replications in Randomized Block Design. The treatments comprised of T1:Control (0 K), T2:50% Recommended dose of Potassium (60 kg K/ha),T3:75% Recommended dose of Potassium (90 kg K/ha),T4:100% Recommended dose of Potassium (120 kg K/ha),T5:125% Recommended dose of Potassium (150 kg K/ha) and T6:150% Recommended dose of Potassium (180 kg K/ha). Results revealed that number of milliable cane, cane yield (t/ha) and sugar yield (t/ha) was found to be significantly high with treatment receiving 150% recommended dose of fertilizers (79855, 82.12 t/ha and 12.04 t/ha respectively), however, it was statistically on par with the treatments receiving 125% recommended dose of potassium fertilizers(79855,82.12 t/ha and 12.04 t/ha respectively) and 100% recommended dose of potassium fertilizers application (79315,81.86 t/ha and 11.57 t/ha respectively). Increasing levels of K significantly increased all the K fractions. However, highest value of water soluble K (29.5 mg kg^{-1} at 0-15 cm depth and 31.6 mg kg^{-1} at 15-30 cm) exchangeable K (205 mg kg-1 at 0-15 cm depth and 228 mg kg^{-1} at 15-30 cm depth) non-exchangeable K (854 mg kg^{-1} at 0-15 cm depth and 971 mg kg^{-1} at 15-30 cm depth), lattice K (2110and 2381 mg kg^{-1} at 0-15 and 15-30 cm) and total K

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

(3267 and 3718 mg kg^{-1}) were recorded with the application of with the application of 150% recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125% recommended dose of potassium application (150 kg ha^{-1}) . The sequential order of dominance of different fractions of K were lattice K>nonexchangeable K> exchangeable K and water soluble K. The per cent contribution of different fractions of K to total K were followed in the order of lattice K (64.02 to 74.94% at 0-15 and 15-30 cm depth), non-exchangeabl K (15.46 to 17.79% at 0-15 and 26.4 to 27.43 % 15-30 cm depth), exchangeable K (6.32 to 8.39% and 5.60 to 7.69% at 0-15 and 15-30 cm depth), and water soluble K (0.81-0.90% and 0.69 to 0.85% at 0-15 and 15-30 cm depth) There exists positive and significant correlation among various K fractions indicating dynamic equilibrium.

Keywords: Sugarcane; soil potassium; exchangeable k; lattice k; non-exchangeable k.

1. INTRODUCTION

Potassium is the third important essential major plant nutrient with numerous functions. It plays vital roles in enzyme activation, water relations (osmotic regulation), energy relations, translocation of assimilates, photosynthesis, protein and starch synthesis and underpinning agronomic productivity and sustainability [1]. Availability of soil K to plant is controlled by dynamic interactions among its different chemical forms [2]. K exists in four forms in soil. The forms of potassium in soil in the order of their availability to plants and microbes are soil solution K, exchangeable K, non-exchangeable K and mineral K [3,4]. All these forms are in dynamic equilibrium with each other that affect the level of soil solution K for plants. Soil solution K is generally low in quantity and ranges between 2 to 5 µg ml^{-1}. Exchangeable K and non exchangeable K levels comprise a small portion of the total K. The bulk of the total K is in mineral fractions.The components of dynamic interactions are: water soluble K, which is taken up directly by plants; exchangeable K, held by negatively charged sites of clay particles; nonexchangeable K, which is trapped between layers of expanding lattice clays; and lattice K, an integral part of the primary minerals (Srinivasa Rao et al., [5].

As sugarcane growing farmers are not applying recommended dose of potassium as like nitrogen, which is used as over above recommended dose. Apart from this, relatively low cost per unit of nitrogen, its widespread availability, and quick and evident response of the plant has further accentuated such an imbalance [6] In this scenario of potassium depletion, parallel to the continued cropping with only nitrogen and phosphate, along with no or inadequate potash application, K requirement of crops is met from the inherent potassium reserve (the non exchangeable potassium pool) of soil. Such depletion may denude the interlayer potassium of the illitic clay minerals of soils which are sufficient for the clay lattice to collapse [6] However, soils of North Coasta Zone of Andhra Pradesh are medium to high in soil available potassium content, eventhen sugarcane exhibits potash deficiency in some situations. Hence, present study was initiated to find out the potassium fractions in soils and also to know the dynamics of potassium fractiosn at different levels of application of potassium to soil.

2. MATERIALS AND METHODS

A Field experiment was conducted on effect of various levels of potassium application on soil potassium fractions and sugarcane yield at Regional Agricultural research station, Anakapalle, Andhra Pradesh. The experiment comprised six treatments and four replications in Randomized Block Design. The treatments comprised of T1:Control (0 K), T2:50% Recommended dose of Potassium (60 kg K/ha),T3:75% Recommended dose of Potassium (90 kg K/ha),T4:100% Recommended dose of Potassium (120 kg K/ha),T5:125% Recommended dose of Potassium (150 kg K/ha) and T6:150% Recommended dose of Potassium (180 kg K/ha). The recommended dose of fertilizers for sugarcane in North Coastal Zone is 112-100-120 kg NPK per ha. In this experiment all the treatments received recommended dose of nitrogen and phosphorus. Nitrogen applied as urea in three splits at 30,60,90 days after planting and phosphorus in single application as SSP in basal. Potassium was applied in two splits at 30 and 90 days after planting as Muriate of Potash. Soil samples were collected after harvest of the crop at two different depth of 0-15 cm and 15-30 cm from all the treatment plots. The samples were shade dried pounded and sieved under 2mm sieve. The processed samples were well mixed and stored in clean cloth bags with proper labels for subsequent analysis. Various forms of potassium were determined by flame photometer. Water soluble K Extracted by shaking soil and water suspension (1:5) for 1 hour and K determined on Flame Photometer [7] Exchangeable K extracted by using 1N neutral ammonium acetate, K on exchangeable complex determined with flame photometer [8] Non-exchangeable K determined by treating with 1 N HNO_3 in 1: 10 ratio and boiling for 10 minutes and K estimated with the help of flame photometer as described by Wood and Deturk, [9] Lattice K was calculated by subtracting the sum of above three fractions from the total potassium content [10] Total K extracted by HF digestion method [11] Before harvest sugarcane samples were collected for juice quality analysis.

3. RESULTS AND DISCUSSION

Data from Table 1 revealed that number of milliable cane (NMC), cane yield (t/ha) and sugar yield (t/ha) was found to be significantly high with treatment receiving 150% recommended dose of fertilizers (79855, 82.12 t/ha and 12.04 t/ha respectively), however, it was statistically on par with the treatments receiving 125% recommended dose of potassium fertilizers (79855, 82.12 t/ha and 12.04 t/ha respectively) and 100% recommended dose of potassium fertilizers(79315,81.86 t/ha and 11.57 t/ha respectively). However as compared to control, where no potassium fertilizers were applied the cane yield was reduced by nearly 25% of the recommended dose of fertilizers. Similar results were also found by Prasad et al. (1996), on the other hand, found in a sandy loam calcareous soil of North Bihar that cane yield was increased from 50 t ha^{-1} without K fertilization to 74.5 t ha^{-1} with only 60 kg K ha^{-1}.

Observed increase in the cane yield is in accordance with the essential role played by K in the processes namely, photosynthesis, water relationships and requirements for K in at least 60 different enzyme systems within the plant. Results showing the benefits of K on crop yield have also been reported by Khosa[12] and Singh et al. [13].

The increase in NMC over control was high in treatment with 50% Potassium application, however the yield increase was only 7.15%. It may be due to the insufficiency of potassium to increase cane weight after formative stage. However, there after 25% increase in potassium application improved cane yield only up to 100 % recommended dose, there after the increase in cane yield was marginal. Hence, over and above application of recommended dose of potassium may not be economical for sugarcane crop.

3.1 Cane Quality Parameters

Cane Quality Parameters like purity, CCS (%) and per cent sucrose content are used for evaluation of the juice quality of the sugarcane. The sucrose percent is the concentration (in g of solute per 100 g of solution) of a solution of pure sucrose in water having the same optical rotation as the sample at a specified temperature. purity, CCS (%) and per cent sucrose content increased with increase in levels of potassium over

Table1. Effect of Potassium fertilization on cane yield and sugar yield of sugarcane

Treatments	NMC per Ha	Cane Yield(t/ha)	Sugar Yield (t/ha)
T1:Control	59209	62.94	7.71
T2:50% Recommended dose of Potassium	65938	67.44	9.05
T3:75% Recommended dose of Potassium	71411	73.31	10.78
T4:100% Recommended dose of Potassium	76094	79.59	11.01
T5:125% Recommended dose of Potassium	79315	81.86	11.57
T6:150% Recommended dose of Potassium	79855	82.12	12.04
Mean	72637	75.04	10.55
C.D (0.05)	6892	6.81	1.07
C.V (%)	12.25	11.18	8.26

- **Number of Milliable Cane**

	% Increase in NMC with difference in Potassium application	% Increase in Cane Yield with difference in Potassium in Potassium application	Incremental Cost Benefit Ratio
T1:Control			
T2:50% Recommended dose of Potassium	11.36	7.15	8.68
T3:75% Recommended dose of Potassium	8.30	8.70	22.66
T4:100% Recommended dose of Potassium	6.56	8.57	24.24
T5:125% Recommended dose of Potassium	4.23	2.85	8.76
T6:150% Recommended dose of Potassium	0.68	0.32	1.00

Table2. Effect of Potassium fertilization on cane juice quality parameters

Treatments	Sucrose (%)	CCS (%)	Purity (%)
T1:Control	18.04	12.25	84.63
T2:50% Recommended dose of Potassium	18.30	13.42	85.82
T3:75% Recommended dose of Potassium	18.58	13.72	86.29
T4:100% Recommended dose of Potassium	18.69	13.83	86.54
T5:125% Recommended dose of Potassium	19.11	14.13	86.84
T6:150% Recommended dose of Potassium	19.62	14.66	87.11
	18.72	13.67	86.21

respective lower doses. While, analyzing the juice quality parameters of sugarcane juice, it was found that, the juice sucrose per cent and purity was found to be high with the treatment receiving 150% Recommended dose of Potassium (19.62% and 87.11% respectively). However, there was no statistically difference between the treatments receiving levels of potassium fertilizers on juice sucrose content and juice purity (%).

3.2 Water Soluble K

Water soluble K content at harvest ranged between 16.5 to 29.5 mg kg^{-1} at 0-15 cm depth and 17.9 to 31.6 mg kg^{-1} at 15-30 cm depth. Water soluble K increased with the increase in the rate of potassium application. The higher content of water soluble K (29.5 and 31.6 mg kg^{-1} at 0-15 and 15-30 cm) was noted with the application of 150% recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125% recommended dose of potassium application (150 kg ha^{-1}) which was 24.9 and 26.7 mg kg^{-1} at 0-15 and 15-30 cm and 22.4 and 24.5 mg kg^{-1} at 0-15 and 15-30 cm. The lowest value of water soluble K (16.5 and 17.9 mg kg^{-1}at 0-15 and 15-30 cm) was recorded with the treatment of Control (0 K). Increase in water soluble K might be due to increase in concentration of K in solution due to increased rate of potassium application. The contribution of water soluble K to total K ranged between 0.81 to 0.90% and 0.69 to 0.85% at 0-15 and 15-30 cm respectively indicating almost least contribution in comparison with other K fractions. Similar results were reported by Gajbhiye [14], Shrinivas Rao *et al*. [5] and Jadhao et al. [15] they reported that various fertilizer treatments comprising K levels significantly increased the various forms of potassium.

3.3 Exchangeable K

Exchangeable K content at harvest ranged between 168-205 mg kg^{-1} at 0-15 cm depth and 176 to 228 mg kg^{-1} at 15-30 cm depth. Exchangeable K increased with the increase in the rate of potassium application. The higher content of water soluble K (205 and 228 mg kg^{-1} at 0-15 and 15-30 cm) was noted with the application of 150% recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125% recommended dose of

Table 3. Effect of Potassium fertilization on different fractions of potassium at harvest stage of sugarcane crop

Treatments	Depth (cm)	Water Soluble K (ppm)	Exchangeable K (ppm)	Avaialble K (ppm)	Non-Exchangeable K (ppm)	Fixed K (ppm)	Total K (ppm)
Control	0-15	16.5	129	146	315	1377	1838
	15-30	17.9	145	163	461	1654	2591
50% RDK	0-15	19.3	174	194	514	1468	2175
	15-30	20.5	184	205	674	1951	2829
75% RDK	0-15	20.7	186	208	580	1511	2298
	15-30	21.6	221	243	756	2037	3036
100% RDK	0-15	22.4	220	242	692	1731	2666
	15-30	24.5	241	266	825	2207	3297
125% RDK	0-15	24.9	257	282	722	2097	3101
	15-30	26.7	269	296	963	2137	3396
150 % RDK	0-15	29.5	274	304	854	2110	3267
	15-30	31.6	286	318	1020	2381	3718

potassium application (150 kg ha^{-1}) which was 198 and 225 mg kg^{-1} at 0-15 and 15-30 cm and 194 and 213 mg kg^{-1} at 0-15 and 15-30 cm. The lowest value of Exchangeable K (168 and 172 mg kg^{-1} at 0-15 and 15-30 cm) was recorded with the treatment of Control (0 K).The increasing levels of K application might have been the reason for the higher concentration of exchangeable K. The contribution of exchangeable K to total K ranged between 6.32% to 8.39% and 5.60 to 7.69 % at0-15 and 15-30 cm which was slightly higher as compared to water soluble K. Similar results were reported by Kadrekar[16], More and Gawali[17],Jawanjal[18] [12] and Jadhao et al. [15] they reported that various fertilizer treatments significantly increased exchangeable K.

3.4 Non-exchangeable K

Non-exchangeable K content ranged between 459 to 854 mg kg^{-1} at 0-15 cm depth and 568 to 971 mg kg^{-1} at 15-30 cm depth. Non-exchangeable K increased with the increased rate of potassium application. The higher content of nonexchangeable K (854 and 971 mg kg^{-1}at 0-15 and 15-30 cm) was with the application of 150 % recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125% recommended dose of potassium application (150 kg ha-1) which was 722 and 963 mg kg^{-1} at 0-15 and 15-30 cm and 692 and 825 mg kg^{-1} at 0-15 and 15-30 cm.The lowest value of Non Exchangeable K (459 and 568 mg kg^{-1} at 0-15 and 15-30 cm) was recorded with the treatment of Control (0 K) .The increasing levels of K application might have been the reason for the higher concentration of non exchangeable K. The contribution of non-exchangeable K to total K indicate that, this form of K appreciably contributed to total pool indicating fixation of K in the interlayer, which suggest need of application of organics, which helps in release of K. Similar results were also observed by Bhalerao and Pharande[19],Talashikar et al. [20] and Jadhao et al. [15] they reported that various fertilizer treatments significantly increased non-exchangeable K.

3.5 Lattice K

Lattice K content at harvest ranged between 1377 to 2110 and 1654 to 2381 mg kg-1 at 0-15 and 15-30 cm. Lattice K increased with the increase in the rate of potassium application. However, The higher content of lattice K (2110 and 2381 mg kg^{-1}at 0-15 and 15-30 cm) was with the application of 150 % recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125 % recommended dose of potassium application (150 kg ha^{-1}) which was 2097 and 2137 mg kg^{-1} at 0-15 and 15-30 cm and 1731 and 2207 mg kg^{-1} at 0-15 and 15-30 cm. The lowest value of lattice K (1377 and 1654 mg kg^{-1} at 0-15 and 15-30 cm) was recorded with the treatment of Control (0 K) .The contribution of lattice K to total K was found to be 64.02 to 74.94 % indicating lattice or mineral K is the dominant K fractions, which contributed substantially to total K. Similar results were also observed by Bhalerao and Pharande[19], Talashikar et al. [20] and Jadhao et al. [15] who reported that various fertilizer treatments significantly increased lattice K.

3.6 Total K

Total K content ranged between 1838 to 3267 and 2591 to 3718 mg kg-1 at 0-15 and 15-30 cm. Total K increased with the increase in the rate of potassium application. The higher content of total K (3267 and 3718 mg kg-1 at 0-15 and 15-30 cm) was with the application of 150 % recommended dose of potassium application (180 kg ha^{-1}) followed by application of 125% recommended dose of potassium application (150 kg ha^{-1}) which was 3396 and 3701 mg kg^{-1} at 0-15 and 15-30 cm and 3297 and 2666 mg kg^{-1} at 0-15 and 15-30 cm. The lowest value of total K (1838 and 2591 mg kg^{-1} at 0-15 and 15-30 cm) was recorded with the treatment of Control (0 K).Similar results were also observed by Bhalerao and Pharande[19],Talashikar et al. [20] and Jadhao et al. [15] who reported that various fertilizer treatments significantly increased total K.

However, the sequential order of dominance of different fractions of K were

3.7 Lattice K>Nonexchangeable K>Exchangeable K and Water Soluble K

Relationship among soil K fractions Different K fractions were positively and significantly correlated with each other indicating dynamic equilibrium among various fractions of K [21] Higher degree of correlation of was noted among lattice-K and total K (r=0.983**) followed by non-exchangeable K and total K (r=0.951**) indicating lattice K and non-exchangeable K is that pool, which is closely associated with total K.[22,23].

4. CONCLUSION

From the present study, it can be concluded that, application of 150 % recommended dose of potassium application (150 kg/ha) increase all the K fractions, over rest of the treatments. Thus, the sequential order of dominance of different fractions of K were lattice K (LK) > non-exchangeable K (NEK) > exchangeable K (Ex. K) > water soluble K (WS K). There exists a significant and positive correlation among different forms of K. The cane and sugar yield also increased with increase in level of potassium application.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. MengelK. Dynamics and availability of major nutrients in soils. Adv. Soil Sci. 1985;2:65-131.
2. WangJJ, HarrellDL, BellPF. Potassium buffering characteristics of three soils low in exchangeable potassium. Soil Sci. Soc. Am. J. 2004;68:654-661.
3. Martin HW, Sparks DL. On the behavior of nonexchangeable potassium in soils. Commun Soil Sci. Plant Anal. 1985;16:133–162.
4. Srinivasa Rao, Subba Rao A, Bansal SK. Relationship of some forms of potassium with neutral normal ammonium acetate extractable K in mineralogically different benchmark soil series ofIndia. J Indian Soc. Soil Sci. 2002;48(1):27-32.
5. Sparks DL, Huang PM. Physical chemistry of soil potassium In: R.D. Munson (ed) Potassium in Agriculture. American Society of Agronomy, Crop Science Society of America and Soil Science Society of America, Madison, Wi. 1985:201-276.
6. Sanyal SK, Majumdar K, Singh VK. Nutrient management in Indian agriculture with special reference to nutrient mining - a relook. Journal of the Indian Society of Soil Science. 2014;62:307-325.
7. Pratt PF. Potassium. In: Black CA, Evans DD, White JL, Ensminger LE, Clark FE. (Eds) Methods of soil analysis, part 2: Chemical and Microbiological properties. American Society of Agronomy, Inc., Publisher Madison, Wisconsin, USA. 1965;1019-1030.
8. Knudsen DVA. Peterson and PF Pratt. Lithium, Sodium and Potassium method, chemical and microbiological properties. Agronomy Monograph. 1982:225-238
9. Wood HS, Deturk EE. The absorption of potassium in soil in non-replaceable forms. Proc. Soil Sci. Soc. Amer. 1941;5:152–161.
10. Ranganathan A, Satyanarayana T. Studies on potassium status of soil of Karnataka. J Indian. Soc. Soil. Sci. 1980;28(2): 148-153.
11. Jackson ML. Soil Chemical Analysis Advanced Course 2nd Edition published by

Author Univ. of Wisconsin, Medison, USA; 1967.
12. Khosa TM. Sources of potassium on growth, yield and quality of sugarcane. Better Crops International. 2002;16(1):14-15.
13. Singh VK, Shukla AK, Gill MS, Sharma SK, Tiwari KN. Improving sugarcane productivity through balanced nutrition with potassium, sulphur and magnesium. Better crops – India. 2008;12-14.
14. Gajbhiye KS. Forms of Potassium in some Inceptisols and Entisols. Journal of the Indian Society of Soil Science. 1985;33:412-415.
15. Jadhao SD, Bajpal RK, Tiwari A, Bachkaiya V, Tedia K, Kumar R. Potassium dynamics as influenced by long term manuring and fertilization under rice-wheat cropping sequence in vertisols. Ann. Plant Physiol. 2015;29(2):29-35.
16. Kadrekar SB. Soil of Maharashtra state with reference to the forms and behaviours of potassium. J Indian Soc. Soil Sci. 1976;10:28-29.
17. More SD, Gavali SG. Potassium fractions in relation to soil properties in Vertisol. Journal of Maharashtra Agriculture Universities. 1999;25(3):299-300
18. Jawanjal, SG. Dynamics of potassium fractions under long –term fertilization to sorghum – wheat sequence in Vertisol. Thesis, (Unpub) Dr. PDKV, Akola; 2002.
19. Bhalerao VP, Pharande AL. Potassium behaviour in salt affected swell-shrink soils: Forms, fixation and release of potassium. Journal of Maharashtra Agriculture Universities. 2003;28(1): 17-21.
20. Talashikar SC, Mehta VB, Dosani AAK, Dhopavkar RV, Dhekale JS. Influence of soil reaction on acidity and fractions of organic matter, nitrogen, phosphorous and potassium in lateritic soils of Kokan. J Indian Soc. Soil. Sci. 2006;54(2):174–178.
21. Sparks, D.L. and Huang, P.M. (1985) Physical Chemistry of Soil Potassium. In: Munson, R.D., Ed., Potassium in Agriculture, ASA, CSSA and SSSA, Madison, 201-265.
22. Ashok Kumar, Lokesh Babar, Narendra Mohan and Surinder Kumar Bansal. Effect of Potassium Application on Yield, Nutrient Uptake and Quality of Sugarcane and Soil Health. Indian Journal of Fertilisers. 2019;15(7):782-786.
23. TupakiLokya, MaliDV, GabhaneVV, KaduPR, PaslaweAN. Different levels of potassium effect on potassium fractions under soybean grown on farmer's field in vertisols. International Journal of Chemical Studies. 2018;6(2):2428-2431.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/71549