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Potassium Supplying Power of a Black Soil Amended with Spent Wash and Post – Methanation Effluent

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Abstract

A study was conducted to assess the Potassium supplying power of a black soil amended with spent wash (SW) and Post Methanation effluent (PME) at Indian Institute of Soil Science, Bhopal. The water-soluble K content ranged from 0.17 to 3.95 $cmolkg^{-1}$, Exchangeable K content, ranged from 0.68 to 8.56 $cmolkg^{-1}$, non Exchangeable ranged from 0.68 to 8.56 $cmolkg^{-1}$ and mineral-K varied between 29.3 and 33.64 $cmolkg^{-1}$ soil. As compared to other forms of K in soil, mineral-K was more or less stable and was not affected by various treatments. Total K content of soil varied 32.13 to 51.37 $cmolkg^{-1}$ increased tremendously with the application of PME and SW. Step-K, was maximum in the first extraction and varied from 0.7 to 2.1 $cmolkg^{-1}$.Consant rate K(CR-K) varied from 0.01 to 0.03 $cmolkg^{-1}$ .Total extractable K and step K had positive correlation with each other. This indicated that the more the amount of step K the more will be the plant utilizable non-exchangeable K from micaceous minerals. The study suggests that both the distillery effluents Post Methanation effluent (PME) and Spent Wash (SW), had great potential of supplying K and other plant nutrients to the soil and might be treated as a substitute to chemical fertilizers, if applied up to a safe prescription limit.

Introduction

Potassium being one of the most dynamic nutrient, its availability in different forms and combinations depends upon the equilibrium and kinetics reaction between forms of soil K, soil moisture contents, temperature and the concentrations of bivalent cations in solution and on the exchanger phase (Sparks and Huang, 1985) and the various intrinsic and extrinsic components of soils such as mineralogy, texture, cation exchange capacity(CEC),clay content , organic matter etc.Various attempts has been made to assess the status of potassium (Pati-Ram and Prasad 1984, Bhaskar *et al.,* 2001, Singh and Datta 1986, Singh *et al*., 1999 , Basumertary and Borodoloi 1992) and its availability in different forms in the soils. The capacity of soils to supply potassium from exchangeable and non-exchangeable from is not easy determined because of the reversible transformation from one form to the other form that is assumed to occur in the soil. Owing to the complexity that existed in the soil system, none of the methods are universally applicable for all the soil. Haylock (1956) introduced the step-K and contest rate—K (CR-K) as a measure plant utilizable non-exchangeable—K reserves in soil. Several workers (Patra and Khera, 1982; Subba Rao *et al*., 1983) have adopted step—K as a measure of K supplying capacity of soil. With this background information, the present investigation was taken up to study the K supplying power of black soil amended with spent wash and post-methanation effluent.

Materials and Methods

Surface (0-15 cm) soil sample were collected from a field experiment with soybean-wheat system, which received continuous application of different dosages of spent wash (SW) and post-methanation effluent (PME) for five cropping cycles from Indian Institute of Soil Science, Bhopal. The following treatments were selected for the study:- Control, NPK+FYM, 2.5 cm PME, 5.0 cm, PME, 10 cm, 15cm PME 2.5 cm SW and 5.0 cm SW.

Different extracting forms of K, viz, water-soluble and exchangeable K (Shaking and centrifugation method—Knudsen *et al.,* 1982) Non-exchangeable K was estimated by boiling the soil with 1N HNO_3. Total K was determined by digesting the soil sample with H_2O_2, 40% HF, H_2SO_4, HNO_3, 60% $HCLO_4$. After evaporating to dryness the contents were added 10 ml 1N HCL & kept at 70^0C for 1 hour. The K-release characteristics, step K and constant rate K (CR-K) were determined by repeated boiling with 1N HNO_3 for ten times at 1:10 soil solution ratio at ever tem minutes interval (Haylock 1956 as modified by Maclean 1961). The amount of K supply gradually attained a content value termed as ẍ constant rate K (CR-K). Step K in each extraction was computed from difference between the K extracted in the particular extraction and CR-K. The sum of the step-K in all the extraction was termed as total step K where as the total amount of K released at the end of ten extractions was termed as total extractable K.

Results and Discussion

Soil texture varied from sandy loam to sandy clay with organic carbon content 4.1 gkg^{-1} Calcium Carbonate content 21.3 gkg^{-1}. The soil is alkaline with pH 7.9.

Water soluble Potassium (WS-K)

Water soluble K content ranged from 0.17 to 3.95 cmol kg^{-1} in the surface layer (-0-15) of soil (Table 1.). The higher the level of PME or SW addition, the higher was the water-soluble K content, the highest being 3.95 cmol kg^{-1} amended with 15cm post Methanation effluent. The lower value of water-soluble K content was found 0.17 cmol kg^{-1} in control. Both PME and SW are rich in K and hence application of both results in ẍ higher level of K enrichment in soil.

Exchangeable-Potassium (EX-K)

Exchangeable K content, in the present investigation ranged from 0.86 to 8.56 cmol kg^{-1} in the surface layer (0-15Cm) (Table-1), being lowest in control and highest at 15 cm PME application, like water soluble K exchangeable K content increased with the level of PME and SW addition. Among various forms, the highest improvement took place in exchangeable K due to continuous application of PME and SW over five years.

Non-Exchangeable Potassium (NEX-K)

Added K through PME and SW also contributes significantly in increasing the non-exchangeable K pool of the soil indicated by boiling 1 N HNO_3 extractable K. Non-exchangeable K increased from 1.95 cmol kg^{-1} in control to 5.32 cmol kg^{-1} in plots receiving 15 cm PME, and to 2.83 cmol kg^{-1} in plots receiving 5cm (Table-1).

Mineral Potassium (M-K)

Mineral K as estimated different between total K and water-soluble plus exchangeable plus non-exchangeable K varied between 29.3 and 33.6 cmol kg^{-1} soil (Table-1). As compared to other forms of K in soil, mineral-K was more or less stable and was not affected by various treatments. This clearly indicated that mineral-K content of soil was not much influence by application K-bearing distillery effluents.

Total Potassium (T-K)

A perusal of data in (Table -1) clearly indicates that total L contents of soil increased tremendously with the application of PME and SW, and the increase was higher with high level of application. Total K increased from 32.13 cmol kg^{-1} in control 51.37 cmol kg^{-1} in 15 cm PME treatment and 42.19 cmol kg^{-1} 15 cm PME treatment and to 42.19 cmol kg^{-1} in 5 cm SW treatment. Very high content of K in both PME and SW might have resulted such as enrichment of total K and other forms of K in soil. Because of K enrichment in soil due to application of Pme and Sw, fertilizer K application to any crop may be avoided.

Step K and constant rate K

Step K provides estimation of mineral K that is potentially available in due course of time under long term cropping; where as constant rate K indicates inter layer K release from clay structure (Haylock 1956). Step K was maximum in the first extraction and varied from 0.72 to 2.1 cmol kg^{-1} in control and in 10 cm PME treatment. The maximum value of step K was 4, 15 cmol kg^{-1} in 5.0 cm SW, NPK+FYM, it 1.87 cmol kg^{-1}. The respective values of step K plus 0.1 M HNO_3 extracted K were 9.73, 2.7 and 2.81 cmol kg^{-1} in 10 cm PME, control and NPK+FYM (Table 2 and 3). The values of constant rate K (CR-K) varied 0.01 to 0.03 cmol kg^{-1}. Maximum value of Cr-K was found 0.03 cmol kg^{-1} in both 2,5 cm PME and 10 cm PME treatment. Minimum value of CR-K were found 0.01 cmol kg^{-1} in 2,5 cm SW and 5.0 cm PME treatments. In PMK+FMY it was found 0.02 cmol kg^{-1} (Table 3). It indicates that with the application of PME and SW the potential of soil to release K increased tremendously.

Table-1: Different forms of K in soil as influenced by PME and SW addition (cmol/kg)

Treatment	Water soluble	Exchangeable	Non-Exchangeable	Mineral	Total
Control	0.17	0.73	1.95	29.28	32.13
NPK + FYM	0.25	0.68	1.16	29.9	32.99
2.5 CM PME	0.63	2.65	2.93	32.59	38.8
5 cm PME	0.93	3.64	3.07	32.64	40.28
10 cm PME	2.02	6.64	4.19	33.64	46.49
15 cm PME	3.95	8.56	5.32	33.54	51.37
2.5 cm PME	1.02	2.68	2.14	31.05	36.89
5 cm PME	2.01	6.93	2.83	30.42	42.19

Table - 2: *Release of K at different extractions by boiling 1N HNO_3.*

Treatment	1N HNO3	Ist	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Control	0.85	0.7	0.69	2.0	0.07	0.05	0.03	0.02	0.02	0.02	0.02
NPK + FYM	0.94	0.8	0.37	0.33	0.11	0.1	0.05	003	0.02	0.02	0.02
2.5 cm PME	2.47	1.4	1.01	0.62	0.23	0.12	0.14	0.07	0.03	0.03	0.03
5.0 cm PME	2.29	0.8	0.74	0.47	0.15	0.12	0.05	0.03	0.01	0.01	0.01
10 cm PME	5.58	2.1	1.07	0.37	0.17	0.16	0.12	0.05	0.03	0.03	0.03
15 cm PME	6	1.76	0.74	0.46	0.32	0.08	0.07	0.03	0.02	0.02	0.02
2.5 cm PME	2.19	1.1	0.5	0.38	0.16	0.14	0.03	0.01	0.01	0.01	0.01
5.0 cm PME	4.24	0.8	0.33	0.19	0.07	0.06	0.03	0.02	0.01	0.01	0.01

Table – 3: Non- exchangeable soil K removed in successive extraction of soil sample with *1N HNO_3.*

Treatment	0.1N HNO3	CR-K Constant Rate	Total extractable K	0.1NHNO3+Total extractable K
Control	0.85	0.02	1.85	2.7
NPK + FYM	0.94	0.02	1.87	2.81
2.5 cm PME	2.47	0.03	3.65	6.21
5.0 cm PME	2.29	0.01	2.38	4.67
10 cm PME	5.58	0.03	4.15	9.73
15 cm PME	6	0.02	3.52	9.52
2.5 cm PME	2.19	0.01	2.35	4.54
5.0 cm PME	4.24	0.01	1.51	5.75

The study clearly indicates that due to application of Post Methanation effluent (PME) and Spent Wash (SW), potassium content of soil in all forms except mineral form got enriched. Due to this enrichment, the potassium supplying power of the soil was improved and hence application of potassic fertilizers in such fields may not be required. The study suggests that both the distillery effluents Post Methanation effluent (PME) and Spent Wash (SW),had great potential of supplying K and other plant nutrients to the soil and might be treated as a substitute to chemical fertilizers, if applied up to a safe prescription limit.

Authors' contributions: *Rouf ur Rafiq (Research Scholar), corresponding author, designed the research, generated and interpretated the data and worte manuscript and Dr A K Biswas (Principal Scientist & Head), helped in designing the research and manuscript writing, supervised the data collection.*

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