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Potassium Release Characteristics of Certain Soils of Tamil Nadu

By

K. M. RAMANATHAN.

ABSTRACT

It is quite common that soils differ markedly in their K releasing power. The dynamic equilibrium existing between different forms of K and the type of clay minerals present were responsible for such variations Based on the cumulative K release characteristics soils of different groups were classified into three categories with regard to their K releasing power. The cumulative K release curves were of the quadratic type and hence second degree equations were fitted by the least square principle. From these equations also it was possible to categorise the magnitude of the K releasing power of the soils. The cumulative values of K released by successive extraction with 0.01 N HCl gave a positive significant correlation for K uptake.

INTRODUCTION

Potassium presents a more complex problem in its availability to plants than N and P since K occurs in soils in different forms which are in a dynamic equilibrium with each other. As early as 1940 Wood and DeTurk proposed the following scheme of K forms in soil.

$$\text{Primary mineral K} \rightarrow \text{Field K} \underset{\leftarrow}{\rightarrow}$$

$$\text{Replaceable K} \underset{\leftarrow}{\rightarrow} \text{Water soluble K.}$$

This equilibrium is affected by the nature of clay minerals and primary minerals present, relative mobility of the different forms, the rate of replenishment of the different forms and concentration of added fertilizer K. Hence it is difficult to interpret the behaviour of K in any particular situation since fixed K partly diffuses into the exchangeable form and precise distinction between different forms is not possible (Welte and Niederbudde, 1965).

Owing to the complexity that exists in the soil system, numerous chemical and biological methods are being advocated for assessing the K availability. However, none of the methods advocated are universally applicable for all the soils owing to variations in soil characteristics which in turn fail to give a good relationship between estimated K and K uptake by plants (Ramamoorthy and Paliwal, 1960). Ekpete (1972) employing number of chemical extractants concluded that none of the

Assistant Professor, Soil Science, Tamil Nadu Agricultural University, Coimbatore-641003. The article has been selected for the award of Ramasastrulu Prize (1974) for the best account of original Research by MASU.

methods extracted the exact quantity of K equal to 'A' value. In practice the exchangeable K is widely employed as an index of K availability in soils. But this is an unsatisfactory measure of nutrient availability since its concentration at any one time is low and it gives little indication of the non-exchangeable reserve potential of the available K (Metson, 1968). Hence for better prediction of the K supplying power of a soil the measure of both the exchangeable and non-exchangeable K is necessary.

Generally the Neubauer technique has been found to be a very useful method, in predicting the K availability of soils (Stanton and Orchard, 1963; Chiriac, 1964). But such biolgical methods require a considerable time and hence the chemical methods are continued to be used. The cumulative release of K by successive extraction may indicate the K reserves in terms of the different forms in the soils. Hence an attempt was made to study the K release characteristics of certain soils of Tamil Nadu. A Neubauer test was also conducted to compare the efficiency of K release pattern in assessing the K availability in soils.

MATERIALS AND METHODS

Twelve surface soil samples representing three each for the different soil groups occurring in Tamil Nadu were considered for the study. The K release characteristics of these soils by sucessive extraction with 0.01 N HCl was determined employing the method given by Garman (1957) with suitable modifications as described below. Five grams soil was extracted successively with 50 ml lots of 0.01 N HCl for 15 times until almost a constancy of K release was reached for all the soils. Everytime the supernatant extract was used for K determination in the atomic absorption spectrophotometer. The cumulative K release values were plotted on a graph. The curves obtained were of the quadratic type and hence the second degree curves were fitted by the least square principle.

The same soil samples were tested by the modified Neubauer technique to assess the K avalability status. One hundred grams of soil mixed with 50 g of washed quartz was taken in 11 cm diameter petridishes. One hundred sprouted *Elucine coracana* (Ragi Co 7) seeds were sown and distilled water was added periodically. The seedlings were pulled out carefully 17 days after sowing. The roots were washed with distilled water, dried and the dry matter yield was recorded. The K content of the dry matter was determined after digestion with triple acid and the total K uptake was camputed. Simple correlations were worked out between the cumulative K release values and exchangeable K on the one hand and the weight of dry matter yield and total K uptake by Co 7 ragi on the other.

RESULTS AND DISCUSSION

The physical and chemical characteristics of the soils (Table-1) revealed a wide heterogenity in texture and cation exchange capacity of the soils not only between different soil groups but also within the same group.

TABLE-1 : Physical and chemical characteristics of soil groups.

Soil group and place of collection			Clay %	Silt %	Fine Sand %	Coarse Sand %	C. E. C. me/100 gm	Exchange-able K ppm	Organic Carbon %
Black	1	Coimbatore	34.7	8.8	23.4	23.7	32.2	298	0.20
Black	2	Dharmapuri	32.2	15.5	22.4	23.0	34.9	135	0.39
Black	3	Peelamedu	44.9	9.4	18.4	25.3	41.6	407	0.41
Red	1	Coimbatore	21.4	8.8	32.1	34.1	15.0	479	0 84
Red	2	Palladam	9.[illegible]	2.3	40.0	47.0	4.0	40	0.24
Red	3	Pollachi	17.2	3.8	47.6	27.3	13.6	81	0.30
Alluvial	1	Thanjavur	44.5	17.7	18.3	10.6	27.3	156	0.94
Alluvial	2	Coimbatore	34.4	14.3	21.7	22.5	28.2	394	0.60
Alluvial	3	Erode	30.2	17.8	27.8	17.6	19.8	122	1.41
Laterite	1	Thanjavur	24.9	2.5	26.0	47.9	2.8	65	0.48
Laterite	2	Nanjanad	36.4	30.5	9.6	21.8	15.0	482	1.72
Laterite	3	Aravancad	26.4	22.3	21.3	24.1	10.2	326	1.94

Potassium release by successive extraction:

The soils when successively extracted with 0.01 N HCl released a certain amount of K continuously. The amount of K released by every successive extraction gradually decreased and by the 14th extraction all the soils reached almost a constancy (Table 2). The quadratic curves (Fig.1) obtained for the cumulative K release values were distinctly different for the various soils.

The magnitude of the initial steepness of the curves vary quite markedly for different soils. Similarly the transitional parts as well as the flattening regions of the curves also depicted an interestingly different K release pattern of the soils. These three regions of the curves distinctly represented atleast three levels of K release from soils

Fig.1 CUMULATIVE K RELEASE CURVES BY SUCCESSIVE 0·01N Hcl EXTRACTIONS

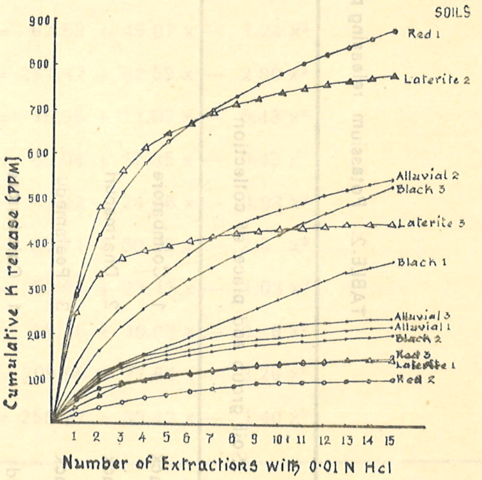

TABLE-2: Potassium releasing power of soils by successive extraction with 0.01 N HCl (K values in ppm).

Soil group and place of collection			Number of Extraction 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Black	1	Coimbatore	62.5	42.5	25.0	23.0	22.0	21.0	21.0	21.5	21.0	21.0	20.0	19.0	17.0	15.0	15.0
Black	2	Dharmapuri	52.5	40.0	22.5	17.5	12.0	10.0	8.0	6.5	5.8	5.0	5.0	4.0	3.5	3.5	3.5
Black	3	Peelamedu	92.5	70.0	52.5	42.5	35.0	30.0	26.5	26.5	25.0	25.0	23.0	23.0	22.0	20.0	20.0
Red	1	Coimbatore	285.0	137.5	92.5	62.5	47.5	40.0	33.2	29.2	27.5	24.0	22.0	20.0	18.0	18.0	18.0
Red	2	Palladam	22.0	17.5	10.0	8.5	7.5	6.5	6.5	5.8	4.0	3.0	2.0	2.0	2.0	2.0	2.0
Red	3	Pollachi	52.5	25.0	12.5	7.5	7.5	6.8	6.7	5.5	5.5	3.5	3.5	3.0	3.0	3.0	3.0
Alluvial	1	Thanjavur	52.5	42.5	30.0	17.5	12.5	10.2	10.0	9.0	6.5	6.0	5.0	5.0	4.5	4.0	4.0
Alluvial	2	Coimbatore	127.5	82.0	71.5	42.5	42.5	41.0	32.7	28.0	22.5	17.3	16.0	14.5	13.0	12.0	12.0
Alluvial	3	Erode	57.5	52.5	25.0	20.0	12.5	12.5	12.0	9.5	8.0	5.8	6.0	4.0	4.0	3.5	3.5
Laterite	1	Thanjavur	35.0	27.5	20.0	12.5	10.0	9.0	9.0	6.5	4.5	2.8	2.0	2.0	1.5	1.5	1.5
Laterite	2	Nanjanad	295.0	185.0	80.0	52.5	30.0	26.5	20.5	20.0	14.0	11.0	10.0	9.0	8.0	6.0	6.0
Laterite	3	Aravancad	247.5	82.5	37.5	17.5	12.5	13.0	9.5	8.0	6.5	4.2	4.0	4.0	3.0	3.0	3.0

(Garman, 1957). The first steep portion of the curves denoted the readily available water soluble and exchangeable forms of K. These forms of K probably were held with less tenacity and hence could be released with less energy and may be equated to the K adsorbed on the planar and to a certain extent of the edge positions of the clay minerals (Mengel, 1971). The K ions bound by planar positions were in a dynamic equilibrium with soil solution. The quadratic equations obtained (Table 3) for the curves with steep slopes recorded large values of the coefficient of X^2 which indicated that the release of K was high as seen from the graph with its latus rectum being small.

The transitional portion of the curves might be characterised by the strongly adsorbed K requiring more energy for K release. In general, the K held under interlayer position or fixed K might correspond to this form as its equilibrium with soil solution was very much limited (Mengel, 1971). It could be seen that for certain soils the transitional portions being not prominent (red 1, black 1 and 3 and alluvial 2) merged with the flattening portions almost with a gentle slope. The transitional portions of the curves for the laterite soils (2 and 3) were prominent which were followed by a flattening trend revealing that the K might be held strongly and thus very little K was released at this stage of extraction.

TABLE-3: Best fitting quadratic equations for the curves.

Soil group and place of collection			Equations
Black soil	1	Coimbatore	$y = 44.23 + 28.22\,x - 0.446\,x^2$
Black soil	2	Dharmapuri	$y = 48.36 + 22.21\,x - 0.84\,x^2$
Black soil	3	Peelamedu	$y = 67.53 + 49.07\,x - 1.24\,x^2$
Red soil	1	Coimbatore	$y = 261.47 + 82.69\,x - 2.90\,x^2$
Red soil	2	Palladam	$y = 15.56 + 11.97\,x - 0.43\,x^2$
Red soil	3	Pollachi	$y = 50.04 + 12.85\,x - 0.43\,x^2$
Alluvial soil	1	Thanjavur	$y = 47.22 + 24.86\,x - 0.93\,x^2$
Alluvial soil	2	Coimbatore	$y = 86.71 + 60.20\,x - 2.0\,x^2$
Alluvial soil	3	Erode	$y = 52.65 + 27.13\,x - 1.03\,x^2$
Laterite	1	Thanjavur	$y = 26.45 + 19.03\,x - 0.76\,x^2$
Laterite	2	Nanjanad	$y = 309.95 + 77.64\,x - 3.26\,x^2$
Laterite	3	Aravancad	$y = 256.27 + 33.42\,x - 1.40\,x^2$

The rate of release of K was rapid at the initial stages of extraction. The higher values of coefficient of X^2 obtained for these equations (Table 3) were also evident of the rapid and quick release of K. These soils with predominent amounts of Kaolinite and hydrated oxides of Fe and Al (Durairaj, 1961) might have less specific sites for K adsorption and therefore released K very rapidly in contrast to black soils.

The third and the flattening portions of the curves might denote that forms of K release which were very strongly held and ptobably represented the structural or primary mineral or interlattice K and are not likely to be available to the plants immediately. Such soils with gentle slope at this region (red 1, black 1 and 3 and alluvial 2) might be considered as specially important as they continued to release K almost steadily.

Based on the foregoing hypothesis the cumulative K release curves for different soils presented distinctly revealed three different categories of soils under examination with regard to their K release pattern. The soils red 1 and laterite 2 with a higher degree of steepness in the initial portions of the curves indicated that these soils were releasing K in a greater measure initially. This revealed that these soils may not respond to K applications till the greater reserves of the labile K were depleted. Further the coefficient of X^2 values obtained in the equations for these soils (Table 3) were high thus indicating the high and rapid release of K. The second category of the soils were alluvial 2, laterite 3 and to a certain extent black soil 3 wherein the initial slopes of the curves were of medium magnitude and naturally the amount of K released also might be moderate. This was also evident from the medium values of coefficients of X^2 obtained in the equations for these soils. It is likely that such soils may respond to K application only when K loving crops are grown.

The curves for the remaining soils showed comparatively a flattening trend even at the very initial stages of extraction without any pronounced steepness. This clearly revealed that these soils had very little reserve of labile K and therefore might respond to the K application. Garman (1957) reported similar characterisation of soils.

Further, it was apparent that the soils red 1, alluvial 2 and black 1 and 3 showed almost a gradual slope when the number of extractions advanced. This trend was especially true with black soils 1 and 3 and alluvial soil 2 wherein the initial steepness was almost absent and it appeared that there was a tendency for K release to take place in a gradual manner. Black soils with predominent amounts of montmorillonite and vermiculite appeared to release K in a regular way from the beginning to the later stages of extraction (Durairaj, 1961). Alexiades and Jackson (1965) reported that vermiculite and montmorillonite minerals retarded the leaching of K from soils. Gradual release of K from black soils could be considered as a distinct and characteristic index of the release of non-labile K that might eventually be converted into the labile forms under favourable conditions of plant growth. Such soils might be considered to have a good replenishment factor as the nonlabile K was released gradually.

Comparison of K removed by Neubauer crop and K release pattern of soils :

A comparison was made between K uptake by Neubauer crop with a couple of chemical methods beween the cumulative values of K released by 0.01 N HCl and NH_4OAc extractable K on the one hand and the dry matter yield of a Neubauer crop (Co 7 ragi) and K uptake (Table 4 and 5). The cumulative K release values gave a higher correlation coefficient for K uptake and lower value for dry matter production. The

TABLE 4. Weight of dry matter produced and K uptake by Co 7 ragi under Neubauer test.

Soil group and place of collection			Yield of dry matter mgm/100g soils.	K uptake mgm/100g soil
Black	1	Coimbatore	120	3.1
Black	2	Dharmapuri	100	2.3
Black	3	Peelamedu	124	3.0
Red	1	Coimbatore	133	4.1
Red	2	Palladam	66	1.4
Red	3	Pollachi	54	1.2
Alluvial	1	Thanjavur	75	2.0
Alluvial	2	Coimbatore	90	2.7
Alluvial	3	Erode	120	2.8
Laterite	1	Thanjavur	60	1.1
Laterite	2	Nanjanad	135	4.4
Laterite	3	Aravancad	110	3.2

TABLE 5. Correlation coefficients and regression equations of the statistical analysis of the data.

Variable x	Variable y	No. of obser-vations	Correlation coefficiant	Prediction equation
Cumulative K release	Dry matter yield	12	0.7688**	$\hat{y} = 68.22 + 0.08x$
Cumulative K release	K uptake by Ragi	12	0.9120**	$\hat{y} = 1.1905 + 0.0037x$
Exchangeable K	Dry matter yield	12	0.7820**	$\hat{y} = 64.83 + 0.1307x$
Exchangeable K	K uptake	12	0.8840**	$\hat{y} = 1.1922 + 0.0057x$
Cumulative K release	Exchangeable K	12	0.9658**	$\hat{y} = 8.27 + 0.6268x$

** Significant at 1 % level.

NH_4OAc extracted K behaved in the reverse pattern by recording higher correlation coefficient for dry matter production and lower values for K uptake. It might be possible that cumulative K release values of 0.01 N HCl extract accounted for both exchangeable and non-exchangeable K and thus gave higher correlation coefficient with K uptake than NH_4OAc extracted K. Chiriac (1964) in a study to assess the K availability employing certain chemical methods observed significant correlations between non-exchangeable K and K uptake by Neubauer test.

In any determination, the stress should be on the nutrient uptake by the plant rather than mere dry matter yield as an index of the nutrient availability. Likewise the K parameter which controls the yield responses is the actual K uptake of the plant rather than the yield (Mengel, 1971). Hence any chemical method which approaches more closely the actual amounts of K needed by the plants cannot be considered as a more reliable method.

It the light of this background in the present study, the cumulative K release values with 0.01 N HCl extract gave a higher correlation coefficient with K uptake by plants then NH_4 OAc extractable K. Garman (1957) and Maclean and Brydon (1961) reported significant correlations between 0.01 N HCl extracted K and K uptake by the plants.

The different soil groups (black, red, alluvial and laterite) occurring in Tamil Nadu which varied in their ability to supply K were distinctly differentiated into different categories based on their K release pattern. The cumulative K release pattern curves obtained possibly enabled to identify the magnitude of K releasing power of soils. This was also evident from the coefficient of X^2 values of the quadratic equations established for these soils. Based on this information the fertilization programmes could be modified for better utilization of the labile as well as non-labile K of the soil. The simple correlations worked out also indicated the suitability of the successive extraction with 0.01 N HCl method for better prediction of the K supplying power of the soils studied.

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