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Studies on the Use of Radioactive K-40 in the Determination of Plant Available K in Some Hawaiian Soils

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With a view to study the usefulness of the naturally occurring radioactive K-40 in characterising the labile pool of soil K as a meaure of available K, a study was undertaken with eleven Hawaiian soils representing different stages of development and fertility. Labile pool was determined using K-40 as tracer and this was compared to K extracted by successive leaching of soils with 0.01 *M* $CaCl_2$, exchangeable K and K removed by 4- week old corn seedlings grown in pots. Labile pool K is very closely related to plant uptake and so can be used as a successful parameter in characterising soil K fertility status.

In soil research, as in other areas of research, radioactive elements have been used for a variety of purposes. Better understanding has been achieved on exchange reactions, availability of nutrients like phosphorus and movement and uptake of nutrients, with the use of radioisotopes. However, the use of radioactive potassium has been rather limited since no convenient isotope was available. K-42, a β emitter, has been used in short-term studies. Since its half-life is short (12.36 hrs), it cannot be used in studies where equilibration takes long time or plant response is involved. Some workers used Rb-86, a powerful β emitter, in place of K since Rb is also an alkali metal closely resembling K in many chemical characteristics. Rb-86 has a half-life of 18.7 days and can be conveniently used. But, Oien *et al.* (1959) showed that the movement of Rb-86 was slower but its soil fixation is higher than that of K. Mackie and Fried (1955) reported that Rb-86 tended to accumulate in reproductive parts. Based on such reports, use of Rb-86 to trace K was questioned by several workers. Sufficient attention was not paid to K-40, a naturally occurring radioisotope (0.012% abundance), mainly because of its low activity. However, K-40 has a long half-life (1.27×10^9 years) and therefore, when enriched, could be used conveniently. Bouat (1969) showed that 0.3 mg K-40 (80% enriched) was enough in soil studies. The decay scheme of K-40 can be represented as follows:

$$
{}_{19}K^{40} \rightarrow {}_{20}Ca^{40} + \bar{e}\ (1.32\ meV)\ 89\%
$$
$$
\rightarrow {}_{18}Ar^{40} + \gamma\ radiation\ \ 11\%
$$

With a view to study the usefulness of K-40 in characterising the labile pool of soil K as a measure of available K in soils, this study was undertaken in the spring of 1969.

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MATERIALS AND METHODS

Eleven surface (0--15 cm) soil samples were collected from different parts of Hawaiian islands, representing different stages of development and fertility. The soil samples were stored in field-moist condition in polythene bags. pH was determined in 1 : 2 soil-water suspension. Cation exchange capacity and exchangeable K were determined by the neutral normal ammonium acetate method. Total K was determined by HF - $HClO_4$ digestion.

Labile pool of K was determined using radio-active K-40. Field-moist soil sample, equivalent to 1 g oven dry soil, was taken in a 100 ml polythene bottle and 5 ml of 0.01 *M* $CaCl_2$ containing K-40 (0.3 mg of 80% enriched K-40 Cl, obtained from Oak Ridge National Laboratory, Tennessee, per 10 ml of 0.01 *M* $CaCl_2$, having a count rate of 1500 per 15 min) was added. The bottles were shaken in an end-over-end shaker for 30 minutes. Then, enough 0.01 *M* $CaCl_2$ was added to make the volume to 25 ml. The samples were again shaken for another 30 minutes, centrifuged and the supernatant solution separated. To 4 ml of supernatant solution, 5.5 ml of trixton X-100 and 11 ml of toluene were added and radioactivity was counted in a Packard scintillation counter. This represents the activity of K-40 outside. Suitable corrections were made for contribution to activity from soil. K was determined with the flame photometer in another aliquot (K outside). Activity of K-40 in the solid phase (inside) was calculated as per the method suggested by Graham and Kampbell (1968). Labile pool K was calculated as follows:

$$\text{K inside} = \frac{\text{activity of K-40 inside}}{\text{activity of K-40 outside}} \times \text{conc. of K-39 outside}$$

The sum of K inside and K outside was taken as the labile pool of K.

Another set of soil samples was equilibrated with 0.01 *M* $CaCl_2$ with a soil to solution ratio of 1 : 25 for 30 minutes in an end-over-end shaker. Extraction was repeated seven more times with $CaCl_2$ and K was determined in each extract seperately with the flame photometer. The total quantity of K extracted in eight extractions was taken as $CaCl_2$ extractable K.

Soil samples, 1.5 Kg each, were taken in glazed porcelain pots of 2 Kg capacity. Each soil was replicated 5 times. To each pot, P at 300 ppm as $CaHPO_4$ and N at 100 ppm as $(NH_4)_2SO_4$ were added and mixed well. The soils were brought to moisture equivalent capacity, covered with polythene sheets and equilibrated for a week. Then four seeds of corn (Hybrid H 38) were sown and after emergence, two seedlings were thinned. Soils were kept near moisture equivalent level by watering daily and the corn plants were grown for 4 weeks in the green house. At the end of 4 weeks, the above ground portion of the plant was harvested, dried, weighed and analysed for its K content. The data obtained were statistically scrutinised.

RESULTS AND DISCUSSION

The chemical characteristics of the soil are presented in Table I. Diversity in soil chosen with regard to total K content, CEC and exchangeable K content can be clearly seen. Most of the soils are lateritic in nature and are moderately low in pH. Kwaiha and Lualualei soils are the two exceptions and these soil havs been formed from volcanic ash of basalt material under low rainfall conditions (less than 500 mm per year). These soils are rich in clay content. Soils that are rich in total K, generally have free mica present.

The data on labile pool K and K extracted by successive extractions with 0.01 *M* $CaCl_2$ show that these two measurements were very close. but ammonium acetate can extract only 60—70% of the labile pool K. Beckett (1964) observed that ammonium acetate or similar extractants removed only K held on the planar sites of soil colloids while K held in the edges and interlattice positions, though potentially available, was not extracted. It appears from this study that successive extraction of soil with $CaCl_2$ removed most of the K held on the planar and edge sites and some of the K present in the interlattice position. Correlation studies also showed that $CaCl_2$ extracted K and labile pool K were very highly correlated ($r=0.91^{**}$). The relationship between exchangeable K and labile pool K, though highly significant, was of lesser order ($r=0.83^{**}$).

When the plant response was related to the three measures of soil K, it was found that labile pool K was highly related to plant K content ($r=0.94^{**}$). K uptake was also highly correlated to labile pool K ($r=0.90^{**}$), $CaCl_2$ extractable K (0.87^{**}) and exchangeable K ($r=0.79^{**}$). It is generally accepted that the plant uptake of K is an excellent index of soil available K. Labile pool K, measured with the use of radioactive K-40 has very close relationship with the plant uptake and

TABLE I. Chemical characteristics of the soils

Location	Soil group	pH	Total K (%)	CEC (me/100 g)	Exch. K. (me/100 g)
Hilo	Hydrohumic latosol	6.1	0.25	40	0.08
Kapaa	Humic ferrugenous latosol	5.3	0.28	23	0.09
Paaloa	Humic latosol	4.8	1.66	22	0.09
Hanipoe	Humic latosol	5.2	0.68	30	0.18
Kaneohe	Latosolic brown forest	6.0	0.79	25	0.22
Wahiawa	Low humic latosol	6.4	1.46	25	0.43
Kawaihae	Red desert	7.2	0.88	39	1.56
Waipahu	Low humic latosol	6.4	0.07	18	0.20
Molokai	Low humic latosol	6.5	0.34	14	0.74
Lualualei	Dark Mg-clay	7.7	0.58	45	0.41
Waimea	Reddish prairie	6.7	1.12	46	3.90

TABLE II. K status of soils and plant response

Location	$CaCl_2$ extractable K (ppm)	Labile pool K (ppm)	K content in plant (%)	K harvested per pot (mg)
Hilo	32	30	0.46	0.4
Kapan	34	35	0.58	6.7
Paaloa	36	40	1.37	18.8
Hanipoe	84	76	1.37	21.4
Kaneohe	78	84	1.20	26.0
Wahiawa	155	174	1.96	60.8
Kawaiihae	584	600	3.63	86.8
Waipahu	80	83	1.93	81.6
Molokai	270	291	3.38	125.6
Lualualei	133	140	2.02	69.2
Waimea	1129	1451	3.68	148.4
	S. E.		0.20	5.3
	C. D. (P=0.05)		0.42	10.8

so this isotopically determined parameter can be used to characterise the soil K status. Successive extraction of the soil with 0.01 *M* $CaCl_2$ can serve as a good substitute for the labile pool K, while exchageable K accounts only for about two third portion of the labile pool.

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REFERENCES

BECKETT, P.H.T. 1964. Studies on potassium- I. Confirmation of the ratio law. Measurement of potassium potential. *J. Soil Sci.* 15 : 1—8.

BOUAT, M. 1969. Application of K-40 and K-42 in agronomy research. *Ann. Agron.* 20: 89-104.

GRAHAM, E.R. and D. H. KAMPBEL. 1968. Soil potassium availability and reserve as realted to the isotopic pool and calcium exchange equilibria. *Soil Sci.* 106 : 101-6.

OIEN, A., G. SEMB and K. STEENBERG. 1959. Comparsion of leaching and fixation of potassium and rubidium in soils using the istotopes. K-42 and Rb-86. *Soil Sci.* 88 : 284-87.

MACKIE, W. Z. and M. FRIED. 1955. Relative distribution of K and Rb-86 within corn plants grown in the field. *Soil Sci.* 80 : 309-12.