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Potassium Availability to Plants - Utility of Different Soil Test Values

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The present study was aimed at finding out the validity of a number of soil tests for K. using different extractants by relating them to uptake. The experiments were conducted in red and black soils of Coimbatore, under field conditions, creating varying levels of soil potassium in mini-plots under natural agro-climatic conditions so as to be valid for field trials. Two crops, onion and maize were chosen as test crops to study the plant factors. Nine different methods besides the Neubauer test were used for assessing the availability. None of the soil test methods, tried in the present study, was universally suitable for all the crops and soils. Neubauer test was found to be not useful in black soil for both the crops although in red soil it was useful in the case of maize. From the study, it therefore appears that unless certain norms are evolved to include plant and soil characteristics the estimation and adoption of available K index to predict K availability and uptake have very little practical value.

The soil is a medium of considerable physical, chemical and biological complexity. Of the store of plant nutrient substances in the soil, only small amounts held on the surface of the solid particles and directly exposed to the soil solution will be the chief source of uptake by plant roots during their period of activity. A knowledge of K availability in soils is a pre-requisite for the soil fertility evaluation and the appropriate use of fertilizers. Heterogeneity of soil factors has led to the evaluation of a number of methods for potassium availability assessment. Comparison of many soil test methods on different types of soils showed that none of these methods is suitable for different types of soils (Tamhane *et al.*, 1958). Nelson *et al.*(1953) attributed these limitations to the heterogeneity of soil population, part of which is due to the differing colloidal characteristics of the various soils. The present study is aimed at finding out the utility of various soil test values in relation to K availability to plants.

MATERIALS AND METHODS

Field trial utilizing the mini-plot technique was taken up in two soil series *viz.*, Perianaickenpalayam and Palathurai representing the black and red soils respectively. Mini-plots were isolated from each other by erecting cylindrical rings of 30 cm diameter and 30 cm height, made of mud and provid-

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ed with a thick cement coating around the inner surface to prevent lateral mobility of nutrients. The rings were inserted without disturbing the central core and thus the physical condition was not disturbed.

Eleven levels of potassium were created by treating the soil with various levels of potassium and equilibrium was allowed to take place for 60 days. Onion (*Allium cepa* L.) bulbs, (variety C.S.659) and maize (*Zea mays* L.) seeds (variety Ganga 5) were sown separately in the cylinders. The nitrogen and phosphorus were applied as ammonium sulphate and super phosphate respectively as per the recommendations followed in the Soil Testing Laboratory. The plants were grown under naturale environment so that the results could be applied to field conditions.

The fractions of potassium in each plot were estimated with nine different methods using EEL flame photometer *viz.*, (1) Saturation paste; (2) 0.5N nitric acid (Attoe and Truog, 1945); (3) normal neutral ammonium acetate (Jackson, 1958); (4) 0.01N calcium chloride (Woodruff and McIntosch, 1960); (5) Morgan's universal extractant (Jackson, 1958); (6) sodium tetraphenyl boron (NaTPB) (Scott and Reed, 1962); (7) boiling 1N nitric acid (Wood and Turk, 1941); (8) ethyl alcohol and (9) chemical potential (Beckett, 1964). Besides this, Neubauer test utilizing *ragi* (*Eleusine coracana* Gaertn.) was also carried out.

The plant analysis was carried out to find out the uptake of potassium.

RESULTS AND DISCUSSION

The aim of the present experiment, was fo find out the relation between soil test values and uptake of potassium utilizing mini-plot technique under natural environment since the pot culture experiments do not reflect field conditions.

The level of available potassium in each plot was estimated by different methods. Each of the methods used involved solubility factor and exchange reactions. Naturally, the different methods extracted different amounts. Ammonium acetate was supposed to extract the potassium in the exchange phase. But NH_4+, because of similarity in size could interact with interlayer K in certain minerals like illite and hence might give a higher value than the actual exchangeable K. The amount of K+ extracted might not be a true estimate, depending on the clay type. Ethyl alcohol extraction was supposed to represent the soil solution as it existed in double layer, since alcohol could displace the soil water without entering into interactions with the soil-colloid system. The use of 0.01N calcium chloride solution, involved the principle of exchange between divalent calcium and monovalent potassium. The idea behind using saturation paste was that the moisture content was near to the field capacity and the extracted solution at such moisture represented levels of the soil water condition of the colloids under field level. Treatment with mild acids extracted more of K than the range usually found in soil solution, but might be representing the amount of

TABLE I. Available K extracted by different methods

Method	Black soil				Red soil			
	Onion		Maize		Onion		Maize	
	Range	Average	Range	Average	Range	Average	Range	Average
Saturation paste (ppm)	2.2-5.6	3.6	1.6-4.4	2.72	3.0-9.0	5.33	3.0-9.0	4.18
0.5N nitric acid(ppm)	275-600	385	275-600	429.1	350-525	435.4	350-1125	479.1
Neutral 1N NH_4OAC (ppm)	195-405	295.4	190-415	305	250-405	302	205-365	278 7
0.01N $CaCl_2$(ppm)	60-130	78	40-130	77.5	110-210	144.1	70-230	117.5
Morgan's extractant (ppm)	120-230	161.6	100-290	193.4	260-390	303	190-430	247 5
NaTPB (ppm)	200-400	266.6	300-800	542	400-550	479.1	200-500	356.3
Boiling 1N nitric acid (ppm)	123-178	147.8	94-156	122	156-198	174.7	144-188	175.8
Ethyl alcohol (ppm)	13-40	26.1	5-38	15.7	5-50	14.1	5-20.0	13.1
Chemical potential (calories) $-\triangle F$ values	5200-7825	6843	6200-7680	6918	4960-6240	5731.3	4800-5120	5298.8
Neubauer test (mg/100g soil)	3.50-5.00	4.29	4.00-8.00	5.87	2.25-5.00	3.41	4.00-8.00	5.12

mobile pool which supplied the needed K during the entire growth period of the plant. The use of sodium tetraphenyl boron (NaTPB) was based on the assumption that the organic complex molecule chelated the metal ion K just like the organic exchange complex of the root system. The complex salt might reveal the nutrient that might possibly be adsorbed by the root system, depicting an exchange model. Neubauer test represented plant-soil intact system, as a whole, and this involved the estimation including the active transport due to metabolic changes. Thus one way or other, each extractant had its own model of plant nutrient availability.

The amounts of available K estimated by various methods are presented in Table I. The significant correlation coefficients obtained between values for methods of estimation of available K and uptake of K are presented in Table II. The statistical analysis for correlation pertaining to onion and maize are based on smaller observations.

In the case of onion crop, none of the methods other than chemical potential showed significant correlation with uptake. In the case of maize in black soil there was significant correlation between K factors as determined by the methods saturation paste, nor-

TABLE II. Correlation coefficients between soil test method and uptake-soil typewise and cropwise

Soil type	Crop	Method		n-2
Black	Pooled	Morgan	0.4784*	22
		NaTPB	0.7979**	22
		Boiling 1N nitric acid	0.5046*	22
		Neubauer test	0.5768**	22
Red	Pooled	NaTPB	-0.5535**	22
		Chemical potential	0.4990*	22
		Neubauer test	0.7340**	22
Black	Onion	Chemical potential	-0.6479*	10
	Maize	Saturation paste	0.8598**	10
		1N NH_4OAC	0.5939*	10
		0.01N $CaCl_2$	0.5954*	10
		Morgan	0.6933*	10
		Chemical potential	-0.8378**	10
Red	Maize	Neubauer test	0.6048*	10

* Significant at 5% level ** Significant at 1% level

mal neutral NH_4OAC, 0.01N $CaCl_2$, Morgan's extractant and chemical potential and uptake of K. In red soil, however, Neubauer test alone had correlation with the uptake of maize. The above facts stress the need to include the plant characteristic also in the mineral nutrition. In the above case, onion is shallow rooted crop with a root CEC of 29.5 meq 100 g^{-1} while maize root system is comparatively more extensive and deep rooted with a root CEC of 16.8 meq 100 g^{-1}. In a shallow rooted and short duration crop which explore a thin layer of soil, it is obvious that intensity factor and rate factor are important to meet the crop requirements within a short period of growth phase and it is probable that none of the methods tried includes both the factors.

When the soils and crops are pooled, significant relations are obtained with some combination as given below in Table III, but this may be due to the predominance of significant relation obtained in maize and may not have any significance except the results are the outcome of the averaging effect.

Neubauer test was found to be not very useful in black soil for both the crops, although in red soils it was useful in the case of maize. In the case of maize, the roots which explore deeper layers and more extensively, the rate factor became less important and the intensity factors as measured by exchangeable methods and chemical potential were found to be of some use in predicting the availability and uptake of K. From the study it, therefore, appears that unless certain norms are evolved to include plant and soil characteristics, the estimation and adoption of available K index to