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Influence of fertilizer regime on potassium dynamics in a red sandy loam soil

A. K. Upadhyay, C. Palaniswami*, H. Hameed Khan and J. Balamurugan

Division of Crop Production, Central Plantation Crops Research Institute, Kasaragod - 671 124, Kerala (India)

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Abstract

Potassium adsorption studies were carried out in a red sandy loam soil (*Arenic Paleustult*) under various fertilizer regimes in coconut under coconut based cropping system at Kasaragod. The soil samples were collected from the basin of the coconut palms. Adsorption studies are carried out using batch technique with five K levels viz. 0, 250, 500, 750 and 1000 ppm K. In the treatments, no fertilizer, one-fifth and one-fourth of the recommended dose, the adsorbed K increased up to 750 ppm K level, and there upon it showed a decline at 1000 ppm K level. However, in case of other three fertilizer regimes, the adsorption of K increased to 500 ppm K level, beyond which there was decline in K adsorption. Within the K levels, K adsorption declined from no fertilizer upto one-fourth of the recommended dose and after which the K adsorption increased with increasing fertilizer levels. The optimum K application to maximize the soil solution K for optimum plant nutrition at each treatment level ranged from 662 ppm (full dose) to 692 ppm (No fertilizer). The quantity of K fertilizer required to optimize the soil solution K concentration in red sandy loam soil is 1150g K_2O palm^{-1}year^{-1}, which very well matches with the general K recommendation (1200g K_2O palm^{-1}year^{-1}) for the crop in India.

Key words: Potassium adsorption, red sandy loam, soil solution K level, coconut, potassium requirement

Introduction

The role of potassium in the soil and thereby in the crop nutrition is very important and complex. In the Indian agriculture, potassium is second or comparable to nitrogen in its importance. It is one of the three major nutrients removed in appreciable amounts from the soil and has to be replenished quickly to the soil nutrient pool to offset any yield decline. The major area of the coconut being in South India suffers from prolonged spell of high temperature and high rainfall leading mainly to leaching losses of silica and bases from parent material with concurrent accumulation of oxides of Fe and Al. Based on the ratings of Muhr *et al.* (1963), Pillai (1975) has reported that all the soil groups of Kerala under coconut are generally deficient in available K and no soil group come under high ratings. Nevertheless, potash requirement of coconut is also very high as indicated by the amount of nutrients removed annually by the palm. The nutrient removal ratio of N: K of 1: 1.2 – 1.75 themselves is indicative of its influence being exerted on the crop (Khan *et. al.*, 2000).

Critical studies on soil potassium in relation to coconut nutrition are lacking except for some manurial experiments with potassium as one of the factorial component (Biddappa *et al.*, 1993). Khan *et al.* (1982) found that K adsorption was comparatively more and uniform in laterite soils than in red sandy loam, river alluvium and coastal sands cultivated to coconut. As K is likely to get depleted more easily from the feeding zone and the K pool also cannot restore much K needed by the coconut palm, which has a heavy demand for potassium, there is a need for evolving a more suitable way of K management.

In light of above, objectives of the study were: to study the impact of fertilizer regime on the K adsorption behaviour in the soil of coconut basin and extent of K required to maximize the soil solution K for optimum plant nutrition.

* Corresponding author. E-mail: darsanpalaniswami@yahoo.co.uk

Materials and Methods

Location of the experiment: The present study was conducted in an existing 35 year old coconut garden intercropped with clove, banana and pineapple in the research farm of Central Plantation Crops Research Institute, Kasaragod, Kerala, India. The coconut palms are spaced 8 m apart and arranged in square system of planting. Clove, banana and pineapple were grown as intercrops. The experiment was laid out in 1.2 ha area. The soil is red sandy loam (*Arenic Paleustult*). The soil had pH 5.3, clay 22 %, 0.48 % organic carbon and CEC 4.7 cmol kg^{-1} soil. Initially (1983), the experimental plot had three treatments *i.e.* full, two-third and one-third of the recommended fertilizer dose. Later, based on the results of ten years wherein one-third was found sufficient for maintaining the optimum crop nutrition, the experiment was modified by including three more additional treatments from the year 1994. The treatment details are given in Table 1. The experiment is divided into six blocks and not replicated. The N, P and K were applied in the form of urea, Mussoorie-phos and muriate of potash respectively, in two splits *viz.* one-third (33 %) in May-June (beginning of monsoon) and two-third (66 %) in September- October (receding monsoon). Fertilizers were applied as broadcast in circular basins of 1.8 m around the palm. In the irrigation treatment, palms were irrigated at 100 % open pan evaporation (Eo) through perfo-irrigation system.

Table 1. Details of treatment

Plot	Treatment	Plot size (ha)
I	Full recommended dose	0.2
II	2/3rd of recommended dose	0.2
III	1/3rd of recommended dose	0.2
IV	1/4th of recommended dose	0.2
V	1/5th of recommended dose	0.2
VI	No fertilizer	0.2

Note: Recommended fertilizer dose for coconut, clove, banana and pineapple is 500: 320: 1200, 300: 250: 750, 200:200:400 and 8: 4: 8 g N, P_2O_5, and K_2O $plant^{-1}$ $year^{-1}$ respectively

Methodology

The soil samples were collected up to 30 cm depth from the coconut basin 1m away from the bole. From each treatment, samples were collected from the basin of four palms each and pooled together for this experiment. The soil samples were air dried in shade, ground to pass through 2 mm sieve and analysed for available potassium status. The available potassium was determined in the 1N NH_4OAc (Hanway and Heidel, 1952) flame photometrically. In a sample vial, 2.5 gm soil was weighed and incubated for 24 hours with 25 ml K solution containing various amounts of K (0, 250ppm, 500ppm, 750ppm and 1000ppm K added as a solution of KCl). The experiment was conducted in three replications. After the incubation period, the sample vials were shaken for 1 hour and the suspension was allowed to equilibrate for the same time at the room temperature. The supernatant was filtered through Whatman filter paper no. 1 and the K content in the solution was determined flame photometrically. The adsorption or desorption of K was determined by taking the difference in the concentration of K in the initial and final reading. Adsorption data was fitted with different models (Freundlich, Langmuir and different polynomial model) and the best fit was used for calculation of adsorption maxima and global minimum.

Results and Discussion

The potassium adsorption varied with the fertilizer regimes (Table 2). The adsorption of K declined with increasing fertilizer levels. The adsorption was more in the fertilizer treatment, No Fertilizer at 250 ppm of applied K (221.05 ppm) and this declined appreciably to 51.63 ppm at Full dose of recommended fertilizer levels. At 500 and 750 ppm K level, K adsorption was high at No fertilizer and One-fifth of the recommended dose but declined at one-fourth of the recommended dose, which increased at further increase in fertilizer regimes. But at 1000 ppm K level, no particular trend was observed. The fertilizer treatment, One-fourth of the recommended dose showed lower adsorbed K values in the treatments 500, 750 and 1000 ppm K level compared to the other treatments. In the case of treatments, No fertilizer, One-fifth and One-fourth of the recommended dose, the adsorbed K increased up to 750 ppm K level, and there upon it showed a decline at 1000 ppm K level. In the case of other three higher fertilizer regimes, the adsorption of K increased to 500 ppm K level, beyond which there was decline in K adsorption. Within the K levels, the potassium adsorption declined with increasing fertilizer level upto one- fourth of the recommended dose. However, beyond one-fourth level, the K adsorption increased with the increasing fertilizer level.

Table 2. Adsorption of potassium (ppm) in soil under different fertilizer regimes

Fertilizer regime	Levels of K added (ppm)				
	0	250	500	750	1000
No Fertilizer	0	221.05	1259.47	1298.89	861.28
1/5th Recommended dose	0	136.81	1259.47	1359.11	649.13
1/4th Recommended dose	0	94.45	1110.78	1118.25	578.11
1/3rd of recommended dose	0	93.98	1211.00	1178.46	791.18
2/3rd of recommended dose	0	94.45	1260.41	1218.26	791.18
Full Recommended dose	0	51.63	1260.41	1238.21	575.29

The perusal of Table 2 revealed that adsorption of K was more in the lower fertilizer regimes (No fertilizer, 1/5 and 1/4 of the recommended dose), which may be on account of lower K application rates. Variation was also observed in K adsorption between fertilizer regimes *vis a vis* K treatments, which could be attributed to the variation in saturation of exchange complex with K. Interestingly, within the K levels, the potassium adsorption declined with increasing fertilizer level upto one- fourth of the recommended dose. However, beyond one-fourth level, the K adsorption increased with the increasing fertilizer level. In the case of higher fertilizer regimes, the increased adsorption may be attributed to added phosphatic fertilizers, which contributes phosphate ions, which is capable of neutralizing positive charges of Fe hydroxides in the clay fraction generating electronegative sites that can be occupied by K^+ ions (Mekaru and Uehara, 1972; Uehara and Gilman, 1981). With the application of phosphatic fertilizer, there is buildup of available P in the soil. The P tends to accumulate, as the crop requirement for P is less. Infact, it has already been established that soil test values of 20 ppm of air dry soil available P is sufficient to maintain the P nutrition of coconut Khan *et al.* (1992). The available P status of the soil ranged between 98 ppm (No fertilizer level) and 343 ppm (Full dose of recommended fertilizer).

On fitting the adsorption versus equilibrium concentration values, quadratic function gave the best fit compared to Langmuir and Freundlich equations. Adsorption maxima were calculated from the quadratic function. Adsorption maxima varied with the fertilizer regime (Table 3). The adsorption maxima increased up to one-fifth of the recommended dose and there upon, it declined at one-fourth of the recommended dose, further, which it increased with the increasing fertilizer regimes. This variation can be attributed to the increased phosphorus application as stated above that contributes phosphate ions, which is capable of neutralizing positive charges of Fe hydroxides in the clay fraction generating electronegative sites that can be occupied by K^+ ions. The soil solution K level required for optimum K

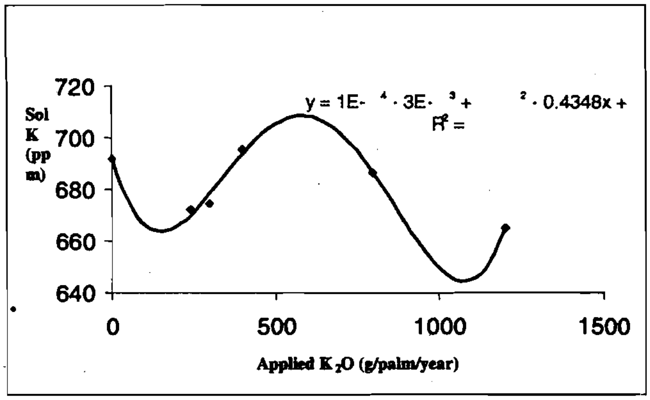

Fig. 1. Minimum soil solution K level as effected by fertilizer regime

nutrition of the coconut ranged between 651 to 697 ppm under various fertilizer regimes. This suggests that a minimum soil solution K level in the vicinity of 650ppm or above is required to meet the K demands of the crop. On plotting the fertilizer regime against soil solution K level, 4th degree polynomial curve gave the best fit (Fig. 1). The global minimum was calculated using the procedure given by Press *et. al.* (1992). To supply / maintain the required soil solution K level of 650 ppm, the required fertilizer K was found to be 1150 g K_2O/ palm/year which matches the K recommendation of 1200g K_2O/palm/year for coconut.

Table 3. Effect of fertilizer regime on adsorption K maxima and soil solution K level

Fertilizer regime	Adsorption K maxima (ppm)	Optimum soil solution K (ppm)
No Fertilizer	1399.50	691.65
1/5th of recommended dose	1452.20	665.71
1/4th of recommended dose	1237.17	687.86
1/3rd of recommended dose	1325.20	697.97
2/3rd of recommended dose	1352.01	686.27
Full recommended dose	1373.28	651.57

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