Research Article *Journal of Plantation Crops, 2007, 35 (2) : 68-72*

Phosphorus and potassium distribution as influenced by fertigation in arecanut rhizosphere

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(Manuscript Received: 19-05-05; Revised: 06-03-06, Accepted: 26-04-07)

Abstract

As a part of long term study on fertigation in arecanut (*Areca catechu* L.) initiated in 1996 at Central Plantation Crops Research Institute, Regional Station, Vittal in Karnataka, an experiment was conducted in 1999 to study the effect of fertigation comprising of different fertilizer doses and frequencies of application on the distribution pattern of available phosphorus and potassium in soil. The available P and K distribution in soil was significantly affected by both depth and distance from dripping point. The concentration of both available P and K was maximum at the dripping point within 30 cm depth. The available P and K content were the highest at the dripping point and declined progressively with distance from dripping point. Nutrient distribution pattern showed that both 50 % and 100 % NPK levels maintained more or less same available phosphorus and potassium concentration in arecanut rhizosphere. This study gives scope for reducing the fertilizer dose if applied through drip irrigation on long term basis.

Keywords: Arecanut, fertigation, nutrient distribution, phosphorus, potassium.

Introduction

Arecanut (*Areca catechu* L.) is predominantly grown in laterite and red sandy loam soils, which have poor nutrient retention capacity due to low CEC (Tandon and Ranganathan, 1988). Besides, arecanut growing regions in West coast of India are characterized by heavy rainfall during monsoon season resulting in nutrient losses through run off, leaching etc. The annual nutrient mining by the arecanut palm is estimated as 79 kg N, 28 kg P_2O_5 and 79 kg K_2O per hectare (Rethinam, 1990). The nutrient use efficiency of arecanut is very low ranging from 25-30% for phosphorus and 20-25% for potassium. Studies indicated that fertigation places the nutrients in root zone in smaller quantities and thus increases nutrient use efficiency (Haynes, 1985; Bar Yosef, 1991; Patricia, 1999). For better management of nutrients, it is essential to know the nutrient distribution pattern from emitter. Earlier studies on fertigation in arecanut indicated the presence of higher root mass and more horizontal root spread along dripping plane (Sujatha and Haris, 2000). Based on growth and photosynthetic parameters, 50 % of standardized fertilizer dose was found sufficient for pre-bearing arecanut palms through fertigation. This resulted in saving of annual production cost to the tune of Rs. 14,450/ha (Sujatha *et al.*, 2000). Further studies on nutrient distribution in soil are required to ascertain the advantages reported from previous studies. With this background, an experiment was conducted to study the effect of fertigation comprising of different fertilizer doses and frequencies of application on distribution of available phosphorus and potassium in arecanut rhizosphere.

Materials and Methods

The experiment was laid out at the Experimental Farm of Central Plantation Crops Research Institute, Regional

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Station, Vittal in Karnataka, India. The place is located 58 m above MSL with an average rainfall of 3800 mm, and mean maximum and minimum temperatures of 36 °C and 21°C, respectively. The soil of the experimental site is laterite with a pH of 5.6 and available soil nutrient status of 143 ppm N, 10.1 ppm P and 53 ppm K at 0-25 cm. The experiment was initiated in 1996 with 14 treatment combinations laid out in 4x3+2 factorial RBD with three replications in two year old arecanut plantation (cv. Mohitnagar). The treatments included four levels of fertilizers *viz.*, 25, 50, 75 and 100 per cent of recommended fertilizer dose (100:40:140 g N: P_2O_5: K_2O/ palm/year) applied at three intervals *viz.*, 10, 20 and 30 days. Two controls *viz.*, absolute control (without fertilizer application) and normal fertilizer application were included for better appraisal of the results. The sources of fertilizers used were urea, diammonium phosphate and muriate of potash. The arecanut was planted with a spacing of 2.7 m x 2.7 m. The crop was drip irrigated at 100 % ET during post monsoon season and the fertilizer was applied from December to May. Three emitters were placed 60 cm away from the base of the palm on three sides. The following treatments were considered for the study of phosphorus and potassium mobility.

1) No fertilizer application with drip irrigation
2) 50% of recommended dose applied once in 10 days
3) 50% of recommended dose applied once in 20 days
4) 50% of recommended dose applied once in 30 days
5) 100% recommended dose applied once in 10 days
6) 100% recommended dose applied once in 20 days
7) 100% recommended dose applied once in 30 days

The soil samples were collected at 0, 15, 30, 45 and 60 cm distance from the drip point and at 15, 30, 45 and 60 cm depth. The soil samples were collected after completion of application of fertilizers in May 1999 in five year old arecanut plantation. After collection, the samples were air dried and ground to pass through 2 mm sieve. Available P was estimated after extraction with Bray's reagent and ascorbic acid reductant method for colour development. Available K was estimated by flame photometer using ammonium acetate extraction method (Jackson, 1973).

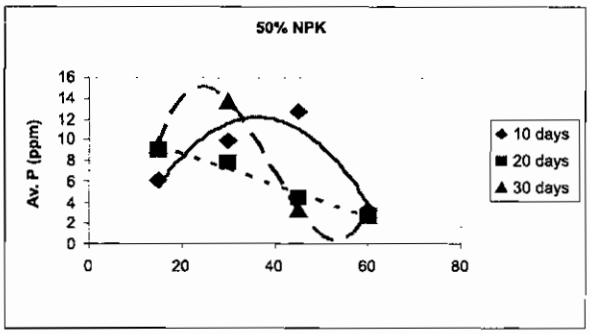
Results and Discussion

The available P and K distribution in soil was significantly affected by both depth and distance from dripping point (Fig.1 and 2). The available P content was the highest at the dripping point and declined progressively with distance from dripping point (Fig. 1). This was true in all the fertigation treatments. The availability was much greater in soil when applied at 10 days interval compared to 20 and 30 days interval. The P content was maximum between 15-30 cm depth and declined thereafter. Similar trend has been reported by Keng *et al.* (1979) in Oxisols. Shinde and Firake (1998) reported that phosphate moved horizontally up to 25-30 cm from point source because of saturation at reaction sites by P near the point of application. The authors also noticed that P moves normally 2-3 cm with surface irrigation. The soil of the experimental site being acidic in nature, P will be immediately fixed when applied to the soil. However, this study shows that fertigation has resulted in movement of P up to 30 cm depth which is the active root zone area. It has been reported that more than 70% of the roots are concentrated within the first 60 cm depth from the ground level and within a radius of 60 cm from the palm (Bhat and Leela, 1969).

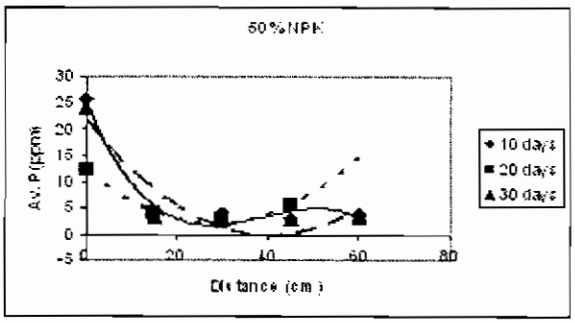
Available K concentration was maximum at 30 cm soil depth and decreased thereafter irrespective of fertilizer dose and frequency of fertigation (Fig. 2), while it was higher near the point of emitter and decreased with distance. Fertigation with 100 % NPK at 10 days interval resulted in higher available K at different depths and distances compared to 20 and 30 days interval. Since most of the potassium will be in water soluble form, it will move with water. This is because the soil is acid laterite with Kaolinite as dominant clay mineral, which means the fixation of potassium will be less. Further more than 80% of the available K was accumulated within 30 cm distance from the dripping point. But the situation was different with respect to the movement of K at different depths. The available K content increased with depth. This might be due to less fixation of K in soil and movement of K with the movement of water to deeper level. In soils having very low CEC and K fixation capacity, the potassium as fertilizer will move along with the water. Similar reasons were attributed by Keng *et al.* (1979) and Uriu *et al.*, (1980), while explaining the behaviour and distribution of potassium.

In absolute control treatment, where no fertilizer was applied, the mean available P and K content were low in general compared to fertigation. Available P and K content were the highest at dripping point and declined progressively with distance from dripping point (Fig. 3).

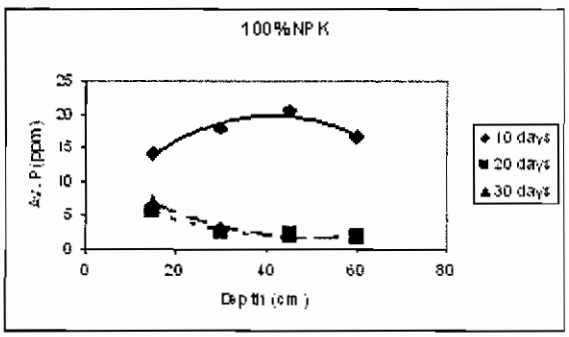
The soil moisture estimation indicated that drip irrigation maintained soil moisture content in arecanut rhizosphere above field capacity level (18-22% as reported by Veerappa Devaru (1990) up to 90 cm distance and 30 cm depth (Table 1). The favourable soil moisture



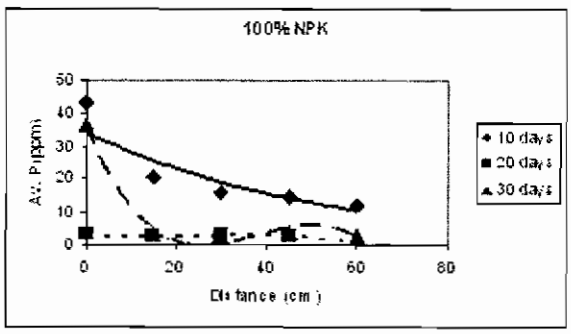
10 days : y = -0.0146x² + 1.0609x - 7.0388 (R² = 0.8682)
20 days: y = -0.0005x² - 0.1119x + 11.108 (R² = 0.9759)
30 days: y = 0.0012x³ - 0.1437x2 + 4.8009x - 34.412 (R² = 1)



10 days : y = -0.0005x³ + 0.058x² - 2.0745x + 25.169 (R² = 0.9737)
20 days: y = 0.0124x² – 0.7013x + 12.05 (R² = 0.9929)
30 days: y = 0.0135x² – 1.0883x + 21.831 (R² = 0.8746)

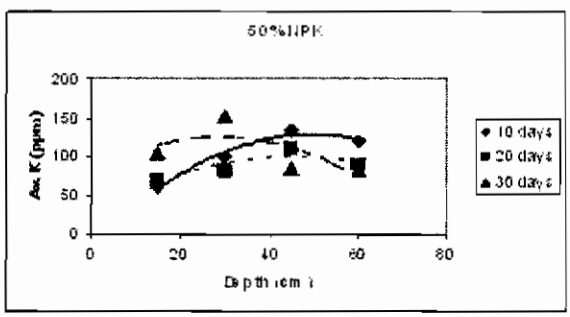


10 days : y = -0.085x² + 0.7052x + 5.302 (R² = 0.9296)
20 days: y = 0.0035x² – 0.3355x + 9.7488 (R² = 0.925)
30 days: y = 0.0037x² – 0.3863x + 11.641 (R² = 0.9866)

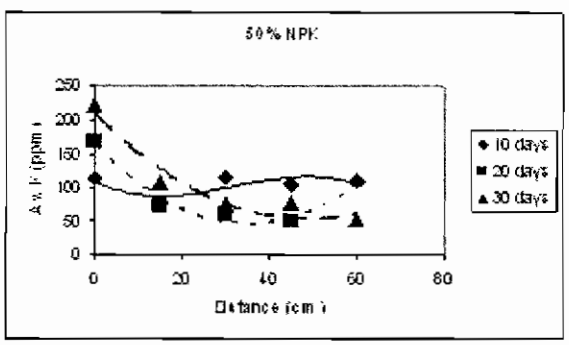


10 days : y = y = 34.127e$^{-0.0193x}$ (R² = 0.8498)
20 days: y = y = -8E-05x³ + 0.0055x² - 0.1001x + 3.27 (R² = 1)
30 days: y = y = -0.0009x³ + 0.0984x² - 3.359x + 36.145 (R² = 0.9872)

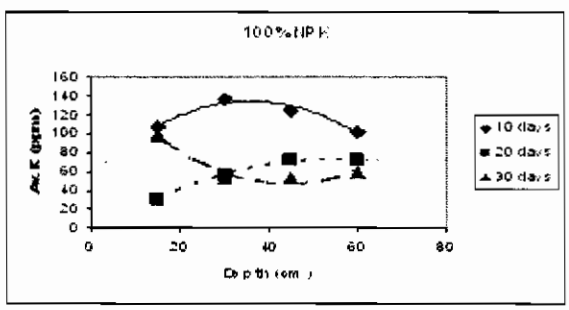
Fig. 1. Phosphorus distribution as influenced by fertigation with different fertilizer levels and frequencies of application



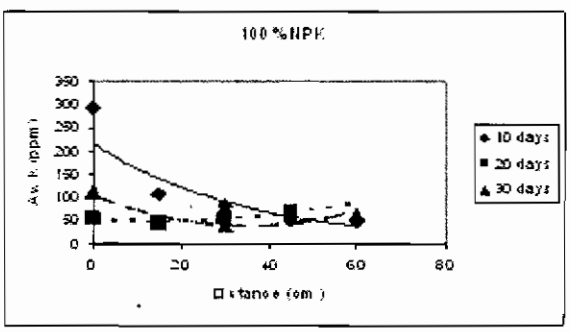
10 days : y = -0.0578x² + 5.7628x - 14.685 (R² = 0.9723)
20 days: y = -0.0341x² + 3.1248x + 28.638 (R² = 0.719)
30 days: y = -0.0538x² + 3.1159x - 80. 12 (R² = 0.4791)



10 days : y = -0.0015x³ + 0.143x² - 3.3143x + 110.3 (R² = 0.4535)
20 days: y = 0.0924x² - 6.554x + 163.02 (R² = 0.9603)
30 days: y = 0.0655x² - 6.3584x + 208.61 (R² = 0.9306)



10 days : y = -0.0599x² + 4.3171x + 56.78 (R² = 0.9449)
20 days: y = -0.0289x² + 3.0754x - 8.7037 (R² = 0.9994)
30 days: y = 0.0584x² - 5.1632x + 161. 12 (R² = 0.9412)



10 days : y = y = 218.65e$^{-0.0285x}$ (R² = 0.8831)
20 days: y = 0.0192x² - 0.5419x + 54.989 (R² = 0.9877)
30 days: y = 0.0528x² - 3.7141x + 106.22 (R² = 0.7839)

Fig. 2. Potassium distribution as influenced by fertigation with different fertilizer levels and frequencies of application

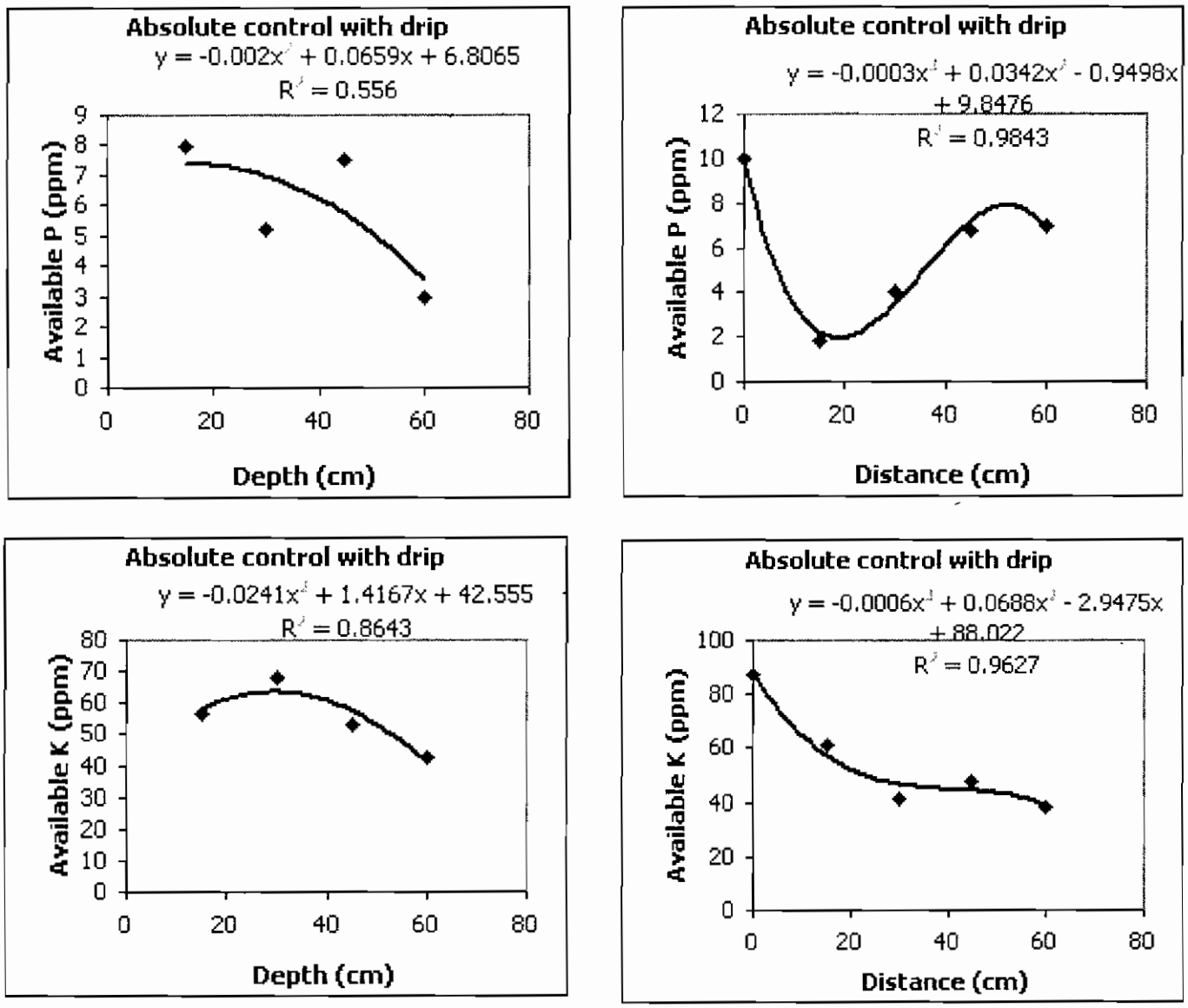


Fig. 3. Effect of absolute control with drip irrigation on distribution of phosphorus and potassium in arecanut basin

levels have strongly influenced the distribution of available P and K in rhizosphere.

Table 1. Soil moisture content (%) in arecanut basin at different distances and depths

Depth (cm)	Distance from base of palm (cm)		
	30	60	90
30	27	27	22
60	27	26	16
90	15	8	3

Nutrient distribution pattern showed that both 50 % and 100 % NPK levels maintained more or less same available phosphorus and potassium concentration in arecanut rhizosphere. This indicates that 50 % of recommended NPK is sufficient for pre-bearing arecanut. Earlier report from the same experiment (Sujatha *et al.*, 2000) indicating better growth performance with fertigation at 50% NPK also supports the above results.

Conclusion

This study showed that adoption of fertigation places nutrients in active root zone besides maintaining favourable soil moisture level resulting in much greater movement of phosphorus and potassium. Further, this study also gives scope for reducing the fertilizer dose if applied through drip irrigation on long term basis as nutrient availability is more in the rhizosphere at 50% NPK.

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