EFFICIENCY OF DIFFERENT METHODS OF FERTILISER APPLICATION IN COCONUT USING RADIO-ISOTOPE TECHNIQUE

P. K. RAY, R. S. DWIVEDI AND SUNNY NINAN,
Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram-690 533, Kerala, India.

ABSTRACT

Different methods of plant injection and soil placement techniques were tried. $KH_2{}^{32}PO_4$ was used in this study which was simultaneously confirmed by tagged single Superphosphate fertiliser application. In plant injection technique, ^{32}P was fed to the palms through growing root tip, cut end of root, stem injection and leaf axil application; whereas in soil placement method, the radio-active P was applied to the palms through basin, circular trenches, strips and holes made around the bole. Plant injection technique was efficient and economical than soil application method. Among plant injection methods, the application of ^{32}P through cut-end of roots was most efficient and the radioactivity in the palm was detected after 4 hours of application. On the other hand, the radio-activity in the palm was detected after 8, 12 and 18 hours of application through stem, leaf axil and growing root tip, respectively. Out of four methods of soil application tried, the placement of radioactive P through holes gave quick recovery. The ^{32}P activity was detected in the palm after 7, 8, 8 and 11 days, respectively, in hole, circular trench, strip and basin application methods. The ^{32}P absorption was equally efficient in the palms, receiving irrigation daily and once in a week.

INTRODUCTION

The coconut palm grows under varying soil and climatic conditions. It removes large quantities of nutrients from the soil, every year, which causes deficiency of major nutrients in soils. Since coconut gardens are normally situated in regions of heavy rainfall, the soils are severely leached and eroded, thus rendering them poorer in plant nutrient status. Most of the soils, under coconut cultivation, have been reported to be generally deficient in the major nutrients. Owing to advancement of science, natural fertility of soil is no more a limiting factor. Application of ferti-

lisers in the proper manner leads to increased profit and reduced cost of production. For a perennial tree crop like coconut having thousands of roots, efficient feeding of nutrients is a problem. Appropriate method of application of fertilisers to coconut is yet to be standardised, to ensure efficient uptake and utilization. The traditional field experiments followed for studying such problems depend mainly on yield data. Nethsinghe (1966), reported that due to inevitable time lag between yield response and fertiliser application and possible interaction with climate particularly rainfall, it requires a long period of experimentation (at least 6 to 8 years) and large area of land (atleast 10 to 15 ha) to draw conclusive results. Even then, the treatment effect may not be reflected on yield, particularly in inherently rich soil. Also due to population heterogeneity the response may get masked.

Radio-isotope technique can be employed with advantage in this contest. It is particularly useful to study the uptake of nutrients from different soil depths, plant associations and the positional effect of fertilisers with great degree of certainty (Subbiah and Wakhalo 1973). The present investigation is aimed at finding out efficient method of feeding nutrients to the coconut using ^{32}P.

Material and Methods

Two methods viz., plant injection and soil placement methods were tried. $KH_2{}^{32}PO_4$ was used in this study which was simultaneously confirmed by tagged single superphosphate fertiliser application.

Plant injection techniques

^{32}P was fed to the palms through growing root tip, cut-end of root, stem injection and leaf axil application. In each method three adults and three seedlings were selected and to each palm 1 mci $KH_2{}^{32}PO_4$ contained in 1 *l.* complete nutrient solution was applied during summer and rainy seasons. After the treatment, the samples from spindle, middle, and outer leaves and untreated roots were taken at 1, 3, 6, 9, 12, 18, 24 hrs. and 3, 15, and 30 days for counting the radioactivity.

The activity was applied to the palm through growing root tips by exposing the roots, representing four sides of palm and

inserting each root tip in a narrow mouthed bottle containing 250 ml tagged solution. The mouth of the bottle was plugged with cotton and the bottles were covered with soil.

Application of ^{32}P to the palms through cut end of root was performed by exposing healthy brown roots from four sides of bole and cutting them in water at 50 cm lateral distance. The cut end was fed with radioactivity by inserting it into narrow mouthed bottle containing 250 ml tagged solution, as mentioned above.

In leaf axil injection method, all the leaves from the central whorls of crown were selected. Their axils were cleaned and in each axil 100 ml radioactive solution was injected.

The stem injection technique was used for applying radioactivity by hanging an injection bottle of 1 litre capacity and inserting its probe into the stem 10 cm inside at an inclination of about 60°. The probe was tightened and the flow of the radioactive solution was regulated so as to check the overflow of liquid.

Soil Placement Method

The radioactivity was applied to the palms through different soil placement methods viz. basin, circular trenches, strips and holes made around the base. Three adults and three seedlings were selected for testing the efficiency of each method. Five mci $KH_2{}^{32}PO_4$, diluted to 3.2 *l* to contain 40 ppm P was applied to each palm. After the application of radioactivity in the soil, it was given 50 to 250 *l* irrigation water, depending upon the soil moisture content. Plant samples from spindle, middle and outer leaves and roots were collected after 1, 3, 5, 7, 9, 11, 15 and 30 days of application. Methods of placement of radioactivity are mentioned below:

Basin, 1.2 m diameter, around the bole was made. Soil from the basin was removed up to root surface depth and the radioactivity was applied alround the basin.

Two trenches 20 cm wide were made around the bole at 0.5 and 1.0 m distances. The radioactivity was added in the former and latter trenches at depths of 20 and 40 cm, respectively.

In the strip method, 1.2 m diameter basin around the bole was divided equally in eight parts and the activity was applied to only two pairs of strips facing each other. The strip had slanting depth which started at 5 cm and ended at 30 cm at its distal end.

The application of radioactivity, to the palm through holes made in the soil around the bole in four circles spaced at an interval of 30 cm was done. In each circle two holes of 10, 30, 50 an d70 cm depths were made. 100 ml radioactivity was poured in each hole.

The efficiency of different methods was judged on the basis of accumulation of ^{32}P (CPM/g dry matter) in the palms per unit time till 30 days when equal amount of radioactivity was applied.

Results and discussion

Soil application method

The results presented in Table 1 revealed that out of the four methods tried in soil application, the placement of radioactivity through hole gave quick recovery but it was not as economical as trench method since CPM/g dry matter was less than that of trench method throughout the experimental period. The ^{32}P was detected in the palm after 7 and 8 days of application in hole and trench methods respectively. In general, broadcasting and basal application are the prevailing practices for applying fertilisers to coconut. Utilisation of fertilisers by coconut applied to soil depends upon a number of factors: extent of rooting depth and rooting pattern, root density in various soil zones, effective contact area between root and soil particles, activity of different parts of root system and nutrient availability. It was observed that though radioactivity was detected in both strips and trench methods after 8 days of application, ^{32}P accumulation in all palm-parts in trench method was more throughout the experimental observation as compared to strip method. Placement of fertilisers in close proximity to the zone of highest root activity would help to maximise fertiliser uptake by the plant. Quick recovery through hole method might be due to effective contact of tagged fertilisers with large number of roots at varying depths and lateral distances of soil from the hole. Root activity and soil feed-

Table 1. *Efficiency of different methods of soil placement for ^{32}P absorption and accumulation in coconut palm (rainy season)*

Part of palm	^{32}P activity (CPM/g dry matter) no. of days after application								
	1	3	5	7	8	9	11	15	30
					Hole method				
Spindle	nil	nil	nil	240	282	315	382	301	201
Middle leaf	,,	,,	,,	200	310	460	530	406	304
Outer leaf	,,	,,	,,	160	200	320	301	250	185
Root	,,	,,	,,	120	160	200	250	300	110
					Strip method				
Spindle	nil	nil	nil	nil	240	320	401	410	215
Middle leaf	,,	,,	,,	,,	425	570	610	592	300
Outer leaf	,,	,,	,,	,,	376	422	510	501	260
Root	,,	,,	,,	,,	120	180	280	310	180
					Trench method				
Spindle	nil	nil	nil	nil	280	350	480	510	295
Middle leaf	,,	,,	,,	,,	600	810	880	940	704
Outer leaf	,,	,,	,,	,,	402	521	610	606	364
Root	,,	,,	,,	,,	240	280	325	360	210
					Basin method				
Spindle	nil	nil	nil	nil	nil	nil	88	108	46
Middle leaf	,,	,,	,,	,,	,,	,,	81	100	50
Outer leaf	,,	,,	,,	,,	,,	,,	56	72	37
Root	,,	,,	,,	,,	,,	,,	34	64	30

ing zones of mango was studied by Bhojappa and Singh (1973) using ^{32}P and their first trial revealed that maximum root activity was present at 240 cm lateral distance in 30 cm soil depth and in the second trial the maximum value was observed at 120 cm lateral distance and 15 cm depth. In the present study circular trench method of fertiliser—application was found to be most effective and economic in ^{32}P absorption pattern throughout the experimental period upto 30 days. Based on maximum recovery of radioactivity in the coconut palm through trench method, it could be assumed that the active root zone of palms are confined to 40 cm soil depth and 1.2 m lateral distances. But this is not adequate and further investigations are being done to determine the active root zone of coconut palm using ^{32}P and Rubidium—86 as tracers.

Application of fertilisers and manures in circular basins with a radius of 1.8 m from the base of the palm and 25 cm depth has been suggested (Anon., 1975). The present study revealed that application in basin was least efficient. The poor response through basin method may be due to exceedingly slow movement of phosphorus through soil (Roy and Thomas, 1951). Under usual soil condition, it is one of least mobile plant nutrients. Phosphorus applied to soil remains in the upper few cm of the profile unless mechanically incorporated to lower depths (Ray, 1975).

Shivarama Shetty, (1977) suggested that P fertilisers should be applied fairly deep in soils, preferably with green manures or bulky organic manures. Radio-isotope studies on coconut palms in Sri Lanka revealed highest ^{32}P uptake from placement distance of 0.5m from the palm and noticeable drop in uptake from depths below 24 cm (Anon., 1970). It was noted that in all the methods tried, the activity in the palm during summer was detected about two days earlier than that during rainy season, provided the palms were irrigated after radioactivity application. This may be due to higher transpiration in dry season compared to wet season. By applying radio-isotope, it was also confirmed that the ^{32}P absorption was equally efficient in palms receiving irrigation daily and once in a week.

Plant injection technique

From the results reported in Table 2 it is evident that radio-

Table 2. *Efficiency of different methods of plant injection for ^{32}P absorption and accumulation in coconut palm (rainy season)*

Part of palm	^{32}P activity (CPM/g dry matter) at different periods of sampling.									
	Hours							Days		
	2	4	6	8	12	18	24	3	15	30
					Growing root tip injection					
Spindle	nil	nil	nil	nil	nil	90	460	760	310	101
Middle leaf	,,	,,	,,	,,	,,	180	592	1022	620	206
Outer leaf	,,	,,	,,	,,	,,	160	521	980	340	112
Root	,,	,,	,,	,,	,,	80	300	601	260	96
					Stem injection					
Spindle	,,	,,	,,	117	240	311	507	620	306	210
Middle leaf	,,	,,	,,	160	320	502	617	928	617	313
Outer leaf	,,	,,	,,	200	612	610	612	860	532	211
Root	,,	,,	,,	160	210	312	416	710	480	121
					Cut-root end injection					
Spindle	,,	122	802	1220	1410	1501	1680	860	716	304
Middle leaf	,,	330	460	580	660	991	1240	937	432	285
Outer leaf	,,	196	227	390	416	711	1040	632	516	325
Root	,,	126	192	216	312	501	674	411	302	205
					Leaf axil injection					
Spindle	nil	nil	nil	nil	320	512	635	872	285	170
Middle leaf	,,		,,	,,	952	502	786	1034	600	301
Outer leaf	,,	,,	,,	,,	160	306	528	398	260	110
Root	,,	,,	,,	,,	140	312	360	230	220	98

activity in the palm was detected after 4, 9, 12 and 18 hours of application through cut end of root, stem, leaf axil and growing root tip, respectively. During summer the absorption of radioactivity was quick and the activity was detected after 3, 6, 9 and 12 hours if application through cut end of roots, stem, leaf axil and growing root tip injections, respectively. Among plant injection methods, application of ^{32}P through cut end of roots was found to be most efficient. Rennie and Halstead, (1965) reported that the stem injection of ^{32}P in wheat plants moved rapidly and was fairly evenly distributed in the root system. A radioactive element is liable to rapid distribution in the plants, if administered to the stem. In the case of hard stemmed plants, the root and and leaf axil injections of radioactivity offer unique advantage.

Plant injection technique was efficient and economical than soil application method for feeding of nutrients to coconut. The fixation of phosphorus might be the main cause for its low availability to coconut palms when applied through soils. Tagged single superphosphate in the form of paste was absorbed through leaf axil as quickly as liquid form but this was not true in case of other methods. No variation in the radioactivity absorption period was recorded in trench method when ^{32}P was applied in the form of single superphosphate (powder) and KH_2PO_4 (Liquid). In other methods similar pattern was not noted.

Acknowledgements

Thanks are due to the Department of Atomic Energy, Government of India for providing financial aid to one of the authors and to Bhabha Atomic Research Centre, Trombay, Bombay for supplying radioactive materials needed for this investigation.

References

ANONYMOUS, 1970. Radioisotope studies on efficiency of fertiliser utilisation by coconut palms (IAEA collaboration). *Ceylon Cocon. Quart.* **21**: 33–36.

ANONYMOUS, 1975. Package of practices and recommendations. Directorate of Extension Education, Kerala Agril. University pp. 10–13.

BHOJAPPA, K. M. AND SINGH, R. N. 1973. Studies on the root activity and soil feeding zones of *mango* (*Mangifera indica*) using 32p. *Newsl. Indian Soc. for Nuclear Techniques in Agric. Biol.* **2**: 112–113.

NETHSINGHE, D. A. 1966. The application of isotopes in fertiliser research on the coconut palm. *Ceylon Cocon. Quart.* **17**: 61–62.

RAY, P. K. 1975. Physico chemical studies of soils in relation to phosphorus availability and its evaluation by soil testing methods. Ph.D. Thesis, Calcutta University.

RENNIE, D. A. AND HALSTEAD, E. H. 1965. A ^{32}P injection method for quantitative estimation of the distribution and extent of cereal grain roots. *Isotopes* and *Radiation* in *Soil–Plant Nutrition Studies* (IAEA) Vienna, pp 489–504.

ROY, B. B. AND THOMAS, B. 1951. The phosphate reserves in some old permanent pasture plots. *Emp. J. Agric.* **19**: 175–184.

SIVARAMASHETTY, K. 1977. Manuring of Coconut palm. *Indian Potash J.* **2**: 20–28.

SUBBIAH, B. V. AND WAKHALLO S. 1973. Nuclear Techniques for root studies. *Newsl. Indian Soc. for Nuclear Techniques* in *Agric. Biol.* **2**: 184–187.