STUDIES ON FERTILIZER PLACEMENT USING RADIO ISOTOPES

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A. INTRODUCTION

Investigations carried out by the Coconut Research Institute of Ceylon have shown that the coconut soils of Ceylon which cover an acreage of 1.1 millions and consist of about 30% of the total cultivated land are generally deficient in the major plant nutrients. Fertilizer application has resulted in increases of coconut yields ranging from 30 to 200 per cent. The fact that the application of fertilizers leads to increased profits and reduced costs of production is well recognised. Today about 35% of the coconut lands receive inorganic fertilizers. The annual usage of fertilizers amounts to about 45,000 tons. But there has been little information on the efficiency of different methods of fertilizer placement—information which may help to reduce further the costs of production.

Only a fraction of the fertilizers applied to soil is taken up by the crop—the rest being lost through the process of leaching, soil fixation, release to the atmosphere, or even physical wash-off. Fertilizer placement plays a major role in the efficiency of fertilizer utilisation by field crops. Placement in close proximity to the zone of highest root activity would help to maximise fertilizer uptake by the plant (subject of course to the condition that the salt concentration is not so high as to cause root damage). A knowledge of the distribution of active plant roots in the soil and the location of the region where the density of absorbing root surface is highest are therefor essential pre-requisites to the rational use of fertilizers.

Prior to the application of radio isotopic techniques such studies were based on either direct visual observations of root systems, or field experiments where the relative efficiency of different methods of fertilizer placement is assessed by means of growth of yield data. The method

of direct observations, apart from being laborious, may not provide a precise definition of the zones of highest root activity in the soil. Field experimentation depending on yield data is undoubtedly the ideal method for such studies, since it can also provide quantitative information on the economic aspects of different methods of placement in relation to actual crop production. But in the case of a perennial like the coconut palm, field experiments depending on yield data necessarily involve long term period (6 to 8 years at least) and large extents of land (25 to 30 acres). The application of radio isotopic methods offers a much quicker and simpler means of obtaining the basic information on root activity required for correct fertilizer placement—the time and land requirements for single experiment using radio-active phosphorous was found to be only about 3 months and 0.5 acres respectively.

Presently in Ceylon fertilizers are applied to coconut palms in a 3 foot wide circular or semi-circular trench (6 inches deep) or strip round the palm at a distance of 3 feet from the bole—a method based solely on traditional practice. Coghlan and Hichley (1917) recommended that manures be placed in ploughed furrows between rows of palms, or equidistanced 15 feet from the stem, on the basis that the roots of the coconut tree are more vigorous towards the extremities of the primaries. Sampson (1923) suggested that fertilizers be broadcast over the whole area of the plantation and ploughed in on the premise that this practice promotes extensive development of feeding rootlets over the whole area. In Kerala (India), fertilizers are placed in circular basins at a radius of 4 to 6 feet round the palm. This practice finds support in the observations of Menon and Pandalai (1958) who have recorded that large numbers of rootlets which absorb plant food are concentrated round the stem of the palm up to a distance of about 5 to 6 feet. However, Salgado (1957) found no difference between the traditional circular trench system and broadcast applications of fertilizers in the entire area on a light sandy soil.

Past work has not provided any conclusive evidence in favour of either broadcast application of fertilizers in the whole area or localised placement close to the palm. The investigations described in this article were directed towards obtaining more precise information on this problem using radio isotopic techniques.

B. EXPERIMENTAL METHODS

Isotopes of chemical elements are atoms of the element which have identical chemical properties but different atomic weights. Radioactive isotopes differ from ordinary isotopes in that they emanate characteristic radiations which enable their presence to be readily de-

tected and measured even when they are present in extremely small quantities well below the levels at which the presence of non radio-active isotopes can be determined. It is this property which makes the radio-active isotope such a useful tool in research. For instance, if a phosphatic fertilizer is applied to a plant it will take some months before we can determine whether the plant has made use of the fertilizer by normal chemical methods. Even then, we would not know whether the phosphate in the plant has come from the fertilizer or the soil. But if the phosphatic fertilizer is mixed (or "labelled") with radio-active phosphorous the extent of fertilizer phosphate absorbed by the plant can be determined very quickly by measuring the radiations emanating from the plant material.

Radio-active phosphorous (P^{32}) was selected as the most suitable radio isotope to work with in this study. Placement efficiency was assessed by measuring the radio-activity taken up by palms when equal amounts of labelled phosphate solution were applied according to the different methods under comparison.

Preliminary studies showed that radio-active phosphorous is transported to the crown of an adult coconut palm within two hours of its appplication to the soil. Examination of the relative merits of toddy, nut water, spathe and leaf analysis as a means of studying the uptake of radio-active phosphorous showed that the moderately mature leaves are best suited for such work. Within three days of the application round the palm of a solution containing radio-active phosphorous, there was sufficient radio-activity in the leaflets of an adult coconut palm for accurate estimation. The leaflets showed higher content of radio-activity than the toddy, nut water, or spathes. Leaflets from either side of the middle portion of the 6th frond were selected as the most suitable plant materials for analysis in this work.

C. EXPERIMENTAL RESULTS

The first placement trial was carried out on 12 year old bearing palms on a well drained sandy soil at Bandirippuwa Estate. The palms had been subject to annual manuring in circular trenches. The planting distance between palms was 26 × 26.

The following methods of placement were compared:—(*a*) traditional 3 foot wide circular trench, 3 ft. away from the base of the palm, (*b*) 9 .2 ft. square at centres of squares between rows of palms, and (*c*) basin round the palm extending to a distance of 5.2 feet from the bole of the palm. The areas (84.5 sq. ft.) of application of the radio-active phosphorous were similar for all three placements.

An equal qunatity of radio-active phosphorous solution was applied at the same depth (about 4 inches) for all three placements. In the case of placement (*b*) at the centres of squares, the full dosage of radio-active solution was applied to each of the four squares surrounding the experimental palms since the fertilizer applied to each square can be equally accessible to four palms.

Leaflets were sampled from each of the experimental palms at intervals of one week, one month and three months after the labelled phosphate solution was applied.

The results showed that placement in a basin extending to 5.2 ft. from the bole of the palm is at least about 100% more efficient than placement in either of the other two methods.

A second placement trial was carried out on 40-50 year old adult coconut palms grown on a sandy well drained soil at Marandawila Estate, Bingiriya. The palms had been subject to annual broadcast application of NPK fertilizer mixture in the entire areas of the land for the last 8 years. The methods of placement compared, were similar to those in the first experiment.

The results showed no noticeable difference between placements in the first week. After four weeks, there was a clear trend in favour of placement in the entire areas from the bole out-wards up to a distance of 5 2/3 feet, while after 13 weeks the superiority of this placement had increased to about 100% over the other two placements.

The third experiment compared full circle and half circle application of radio-active phosphate solution in the area round the palm up to a distance of 6 ft. from the stem.

Analysis of leaflets sampled 10, 39 and 70 days after application of the radio-active phosphate showed that a greater quantity of radio-active phosphate (about 40% more) was absorbed by the palm when application was done in full circles.

DISCUSSION

The experimental results showed that, within a depth of about $2\frac{1}{2}$ feet in the case of both the young palms used in this investigation, (the radio-active phosphate was observed to have moved down to a depth of 24-30 inches in the soil ten days after application), the density of active absorbing root surface is considerably higher in the area immediately surrounding the palms up to a distance of about $5\frac{1}{2}$ feet from the bole than either in the traditional manure circle 3 feet wide 3 feet away from the palms, or in the centres of squares between rows of palms. These

applied. In the third experiment where the same quantity of phosphate was applied in full and half circles, the concentration of phosphate per unit area of soil in the half circles was double that in the full circles, whereas the active root surface in the latter was twice as great as in the former. The greater efficiency of full circle application indicates that under the conditions of this experiment, doubling the extent of root surface contributed more to the efficiency of phosphate uptake than doubling the phosphate concentration in the soil. Generally, the application of fertilizers in semicircle is done to economise on labour costs. But it seems that the more efficient fertilizer utilisation achieved by application in full circles would amply compensate the extra cost of labour.

On the basis of these investigations, it is concluded that for maximum efficiency of fertilizer utilisation by bearing coconut palms, fertilizers should be applied round the palm in the entire area up to a distance of about 5½ feet from the bole.

Our present rates of fertilizer application have been based on field experiments where fertilizer applications were made on the traditional circular trench system. The extent to which the more efficient method of placement recommended above would help to reduce costs of production either by way of increase yields, lesser fertilizer requirements, or by both, is a matter for further investigation through the normal field experimental methods based on yield data.

References

BROESHART, H. (1959). "The application of radio-isotopic techniques to fertilizer placement studies in oil palm cultivation". Netherland J. of Agric, Res. 7, pp. 95-109.

COGHLAN, H. L. and HINCHLEY, J. W. (1917). "Coconut Cultivation and Plantation Machinery"—p. 31. (Published Crosby Lockwood & Son, Lond.).

MENON, K. P. V. and PANDALAI, K. M. (1958). "The Coconut Palm—A Monograph" pp. 20-25. (Published by the Indian Central Coconut Committee, Ernakulam).

SALGADO, M. L. M. (1957). Annual Report of the Coconut Research Institute of Ceylon for 1957, pp. 16-17.

SAMPSON, H. C. (1923). "The Coconut Palm"—206 (Published by John Bale Sons and Daniels Son Ltd., London).