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The Effect of Density of Planting on the Distribution of Arecanut Roots

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THE arecanut palm (*Areca catechu*), being a monocotyledon, has a fibrous type of root system without a tap root, and numerous roots radiate in all directions from the bole. DAVIS (1961) described the roots of the palm in relation to their origin, size, shape, function, structure, etc., and classified them into (i) the main adventitious roots emanating from the bole, (ii) the rootlets that branch from the main roots or their branches, (iii) the pneumatophores or breathing organs and (iv) the aerial roots which arise from the lower parts of the stem. BAVAPPA and MATHEW (1960) made a study of the root system of arecanut seedlings in the nursery stage and recorded that the spacing of seedlings in the nursery markedly influenced root production. Root growth was very poor in closely spaced seedlings. BAVAPPA and MURTHY (1961) while describing the morphology of the root of arecanut palm, reported from a study of root spread of adult palms that the maximum root concentration is found within the first two or three feet from the palm. Barring these observations, there appears to be no report of any detailed study of the underground portions of the adult palm. Work on the relative habits of the root system under varied soil and cultural conditions is being undertaken at the Central Arecanut Research Station, Vittal, and the present report gives the results of a study of root distribution as influenced by the density of planting.

MATERIALS AND METHODS

The study was undertaken in the experimental garden of the Central Arecanut Research Station at the termination of the heavy rains of the southwest monsoon in August and September 1966. The garden has a deep, fairly uniform, well drained and well cultivated soil, and is irrigated during dry weather.

Blocks of palms of uniform age had been planted in 1958 at spacings of 3.6m x 3.6m, 2.7m x 2.7m and 1.8m x 1.8m, from each of which two adjacent palms were selected for examination. The young palms had originally been planted in pits (90 cm cube), the lower 30 cm of which had been re-filled with top soil.

The procedure adopted for studying the root system was the soil-block or the quantitative method, with slight modifications, used or described by FRANCO and INFORZATO (1951), LEON and UMANA (1961), and GEHRKE VELEZ (1962) who undertook similar studies in coffee and rubber. The method consisted of digging a trench, 50 cm wide between the two adjacent trees commencing at a distance of 25 cm from the centre of each tree. The soil from the trench was removed in rectangular blocks 50 cm wide,

25 cm long and 10 cm deep. Excavation was continued until no traces of roots were seen. The roots from each block of soil were washed, dried and weighed.

RESULTS

Distribution of roots at different distances from the palm

The data on distribution of total and fine roots (expressed as dry weight in grammes) at different distances from the centre of the palm in relation to density of planting are given in *Table 1*. It can be seen that from 60.9 to 66.9 per cent of all roots and from 51.3 to 55.6 per cent of the fine roots (less than 2 mm in diameter) are concentrated within 50 cm radius from the centre of the palm irrespective of the density of planting. In the next zone lying between 51 and 100 cm from the stem there was much variation in the concentration of roots depending upon the density of planting. Trees spaced at 3.6 m x 3.6 m had 22.7 per cent of all their roots and 27.5 per cent of fine roots within this second zone, whereas those spaced at 2.7 m x 2.7 m had 27.6 per cent and 33.1 per cent respectively. Trees spaced at 1.8 m x 1.8 m had still greater percentages of roots within this zone, the proportions being 39.1 and 45.7 per cent respectively.

Roots did not extend beyond 100 cm until the spacing was 2.7 m x 2.7 m, nor beyond 150 cm until the spacing of 3.6 m x 3.6 m was reached, when 4.4 per cent of all roots lay within the 150 to 175 cm zone.

Distribution of roots at different depths

The data on distribution of total and fine roots are given in *Table 2* from which it can be seen that the roots may extend to a depth of 2.0 m to 2.6 m below ground level. The maximum concentrations of all roots (66.3 to 79.0 per cent) and of the fine roots (72.2 to 76.3 per cent), are within the first 50 cm layer of the feeding zone. The second layer, 51 to 100 cm below ground level contains from 18.3 to 23.3 per cent of all roots and from 13.6 to 20.0 per cent of fine roots. The strata below 100 cm contain only 2.7 and 4.0 per cent of all roots and fine roots of palms spaced at 3.6 m x 3.6 m, whereas the corresponding quantities for palms spaced at 2.7 m x 2.7 m and 1.8 m x 1.8 m are 12.6 and 14.2 and 7.2 and 8.4 per cent respectively. The variation in the nature of soil exploitation seems to be more pronounced in the top five layers of 10 cm thickness each. Palms spaced closely seem to exploit the deeper layers lying between 21 and 50 cm more than palms planted wider apart.

Overall quantity and spread of roots

In *Figure 1* the concentration of roots (by weight) is shown for palms under different densities of planting. Each curve represents the root system of a set of two palms planted opposite to one another at the required spacing. The pattern of root distribution of the three sets of palms is nearly uniform. Initially there is a marked decrease in the concentration with distance, then it remains almost constant for a distance depending upon the width of interspace between the two palms, and finally increases rapidly again in the proximity of the tree on the other side. The concentration of roots at the mid point between the two trees increases pronouncedly as the spacing

decreases, the weight of roots being in the ratio 1:3:8 for trees planted 3.6 m × 3.6 m, 2.7 m × 2.7 m, and 1.8 m × 1.8 m respectively (ordinates A, B and C in Figure 1).

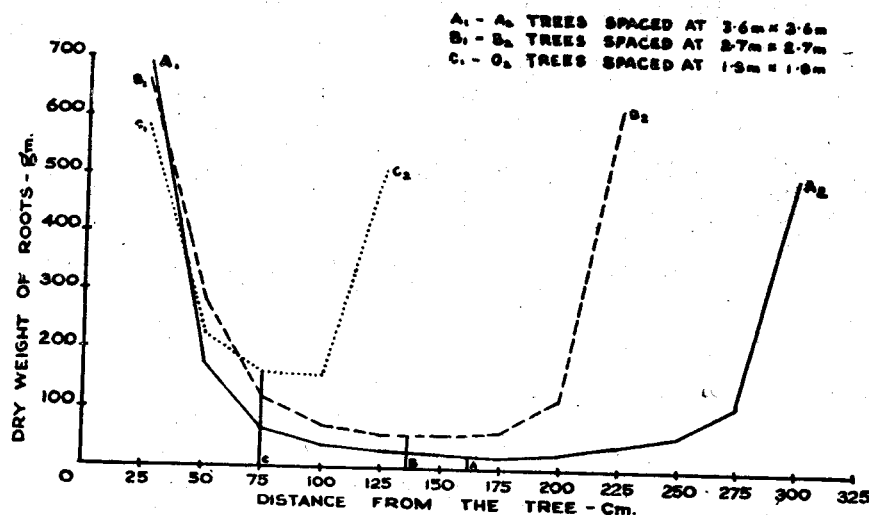


Figure 1. Distribution of roots at different distances from the trunk for arecanut palms at three spacings

The concentration and pattern of spread of root at different depths and distances from the palm in respect of trees at the three spacings are illustrated in Figure 2. It will be seen that the weight of roots progressively decreases in an outward and downward direction, so that the root system has the appearance of an inverted cone.

Table 3. Weight of roots per unit volume of soil and calculated gross weight of roots

Spacing excavated		Weight of roots in sample		Weight of roots per unit volume of soil		Calculated gross weight of roots in feeding zone per tree		
m ²	m ³	Total, g	Fine, g	Total, g	Fine, g	Total, kg	Fine, kg	Fine roots as % of all roots
3.6 × 3.6	1.5	898.5	350.3	599.0	233.5	16.1	6.3	39.0
2.7 × 2.7	1.625	1049.6	495.2	645.9	304.7	12.6	5.5	47.2
1.8 × 1.8	0.9	905.0	540.0	1005.6	600.0	8.1	4.8	59.7

Data presented in Table 3 show the relationship between the weight of roots and the volume of soil they occupy at different densities of planting. The weights of both all and fine roots per unit volume of soil increase with density of planting, whereas the calculated gross quantity of roots produced per tree decreases with increasing density of planting. The proportion of fine roots to all roots increases with density of planting. The percentage of fine roots to all roots is 39, 47.2 and 59.7 when the trees are spaced at 3.6 m × 3.6 m, 2.7 m × 2.7 m and 1.8 m × 1.8 m respectively.

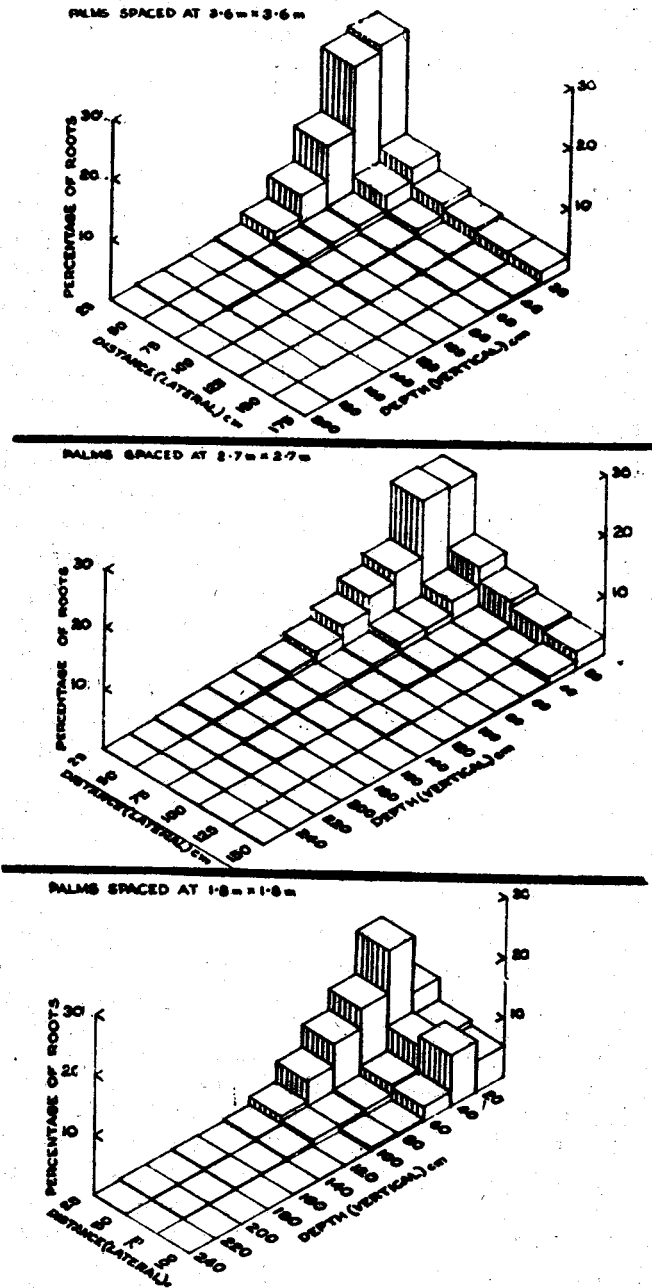


Figure 2. Lateral and downward spread of roots of arecanut palms at three spacings

DISCUSSION

The results show the general pattern of the root system in the arecanut palm with special emphasis on the effect of density of planting. More than 80 per cent of the total root system is found within a cylindrical mass of soil 100 to 125 cm in radius from the stem and extending about 100 cm in depth below ground level, though a small percentage extends more than two metres distance both laterally and downwards from the bole. The maximum concentration and ramification of thick as well as of fine roots is within the top 50 cm layer of the soil. Thus in its probable habit of surface matting of its roots, the arecanut palm resembles many other perennial trees. LEON and UMANA (1961) and NUTMAN (1933a, 1933b and 1934) reported that coffee has shallow feeding roots with 60 to 80 per cent of the total root system located in the first 20 cm layer of the soil. GARDNER *et al.* (1939) stated that 'tree-roots often range deep, but much investigations as have been reported show a surprisingly shallow root system in most orchard plantations at least in humid regions'. When compared to the coconut palm, the root system of the arecanut appears to be within a much more restricted zone since, according to MENON and PANDALAI (1958), the former has extensively distributed absorbing roots.

The present studies further indicate that when the palms are planted at a wider spacing (3.6 m \times 3.6 m) they have a tendency to develop more superficial roots, probably because of the reduced competition, whereas those planted at 1.8 m \times 1.8 m have a greater concentration of roots in the deeper layers, thereby showing increased exploitation of depth more when palms are planted closely. The influence of density of planting in bringing about the marked variation in the production of total roots per unit volume of soil, as well as in the proportion of fine roots and thick roots, also suggests the greater utilization of the available space in the closely planted gardens. Though the utilization of available space is greatest in closely spaced orchards, one should endeavour to ensure that competition and exploitation is not to the detriment of the economy of the garden. The ideal root system of orchard trees according to GARDNER *et al.* (1939) 'is not the one with branches that reach out or down the farthest, but the one that more or less fully explores and occupies the soil to a reasonable depth and within a reasonable radius'. It is also believed that several factors influence development of the normal root system of any tree. NUTMAN (1934) mentioned hard-pans, lava and mud-stone strata, gravel strata, aeration, high water-table, soil reaction, manurial treatments and cultural methods as soil conditions which have a modifying effect on the normal root system of coffee. Thus it is clear that full knowledge of the root system can only be gained by study of soil and plant under varied environmental conditions. LEON and UMANA (1959) who made a similar study of the root system of coffee reported that root density varied according to spacing and that these differences were highly significant, though they did not find any difference in yield attributable to spacing. Nevertheless, a knowledge of the root system is necessary before recommending the best planting distances and cultural, manurial and irrigation practices. Thus the results of the present study indicate that because of the concentration of the roots of arecanut palm in the surface layers frequent deep digging

or opening deep trenches or basins for manuring is likely to injure the roots. Similarly, a high water-table or allowing water to stagnate for long periods within 1 m of ground level may impede normal root development.

SUMMARY

The root systems of eight-year-old arecanut palms were studied in relation to the effect of planting density on distribution of roots. From 60.9 to 66.9 per cent of all roots and from 51.3 to 55.6 per cent of fine roots were concentrated within 50 cm radius of the palm and more than 80 per cent of all roots were within 1 to 1.25 m from the trunk, though some roots extended laterally beyond 1.75 m. The maximum concentration of from 66.3 to 79.0 per cent of all roots and from 72.2 to 76.3 per cent of fine roots was within the first 50 cm layer of the soil surface. The second layer, 51 to 100 cm deep, contained 18.3 to 23.3 per cent of all roots and 13.6 to 20.0 per cent of fine roots. The greatest depth of penetration of the roots was 2.6 m.

Close planted palms appeared to have a greater tendency to explore the lower strata than those planted wider apart. The quantity of roots (dry weight) per unit volume of soil within the feeding zone increased with increasing plant density, whereas the calculated gross quantity of roots produced per tree decreased with increased density of planting.

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