Journal of Tropical Forest Science 10(1): 86 - 93 (1997)

ROTAN MANAU INTERCROPPED WITH RUBBER: RATE OF ROOT GROWTH BETWEEN THREE AND FOUR YEARS AFTER PLANTING

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Received November 1995

WAN RASIDAH, K., AMINUDDIN, M., AHMAD SAHALI, M. & ZAHARAH, A.R. 1997. Rotan manau intercropped with rubber: rate of root growth between three and four years after planting. Efficient fertiliser management depends partly on understanding the active root distribution. In the present study, the active root distribution of 3- and 4-y-old plantation grown rotan manau (*Calamus manan*) was assessed using isotope tracer technique. For the 3-y-old rotan manau, three distances from the plant base (0.5, 1.0 and 1.5 m) at 5 and 30 cm depths were examined. For the 4-y-old plants, two distances, *viz-á-viz* at a centre between two rattan plants and another in the middle between two rattan plants and two rubber trees were studied. The isotope used was ^{32}P, applied as a solution with KH_2PO_4. The rotan manau plants had been established under mature rubber plantation. High proportions of feeder roots were found at 0.5 and 1.0 m distances at the surface (5 cm depth) for the 3-y-old plants. Uptake of ^{32}P was also observed for the application at 1.5 m distance for both depths but the counts were small. Statistical analysis gave a highly significant difference within the distances and within the different depths. For a better synchronisation between fertiliser application and plant uptake, it seems that application at approximately between 0.5 and 1.0 m distance around the plant is most appropriate at this age. At four years after planting, important uptake was obtained only for the two plants located near the application area. Anyhow, to some extent it reflected that roots had already extended for another 1 m compared to the 3-y-old plants.

Key words: Root activity - *Calamus manan* - radioactive ^{32}P - fertiliser management

WAN RASIDAH, K., AMINUDDIN, M., AHMAD SAHALI, M. & ZAHARAH, A.R. 1997. Penanaman selingan rotan manau dan getah: kadar pertumbuhan akar rotan manau di antara tiga dan empat tahun selepas penanaman di ladang. Pengurusan baja yang cekap sebahagiannya bergantung kepada pemahaman terhadap taburan akar aktif. Dalam kajian ini, taburan akar aktif rotan manau (*Calamus manan*) berumur di antara 3 dan 4 tahun yang ditanam di bawah dirian getah matang dinilai

menggunakan teknik isotop surihan. Untuk pokok berumur tiga tahun, tiga jarak mendatar (0.5, 1.0 dan 1.5 m dari pangkal pokok) pada kedalaman 5 dan 30 cm dikaji. Bagi pokok yang berumur empat tahun, dua jarak aplikasi radioaktif dikaji iaitu pertengahan di antara dua pokok rotan dan dua pokok getah. Isotop yang digunakan ialah ^{32}P, disediakan dalam bentuk larutan dengan KH_2PO_4. Taburan akar aktif tertinggi bagi pokok rotan yang berumur tiga tahun didapati berada pada jarak 0.5 dan 1.0 m dari pangkal pokok dan pada permukaan tanah (kedalaman 0 - 5 cm). Pengambilan ^{32}P juga dikesan pada pokok rotan yang berada pada jarak 1.5 m dan pada kedua-dua kedalaman iaitu 5 dan 30 cm, bagaimanapun bilangan aktiviti adalah rendah. Analisis statistik memberikan perbezaan paras keertian yang tinggi bagi jarak aplikasi berbeza dan juga bagi kedalaman berlainan. Bagi memperolehi penyelarasan yang lebih baik di antara masa pembajaan dan pengambilan nutrien oleh pokok, aplikasi pada kedudukan di antara 0.5 dan 1.0 m di sekeliling pokok mungkin pilihan terbaik. Pada peringkat umur empat tahun selepas penanaman, pengambilan ^{32}P hanya dapat dikesan pada dua pokok rotan yang terdekat dengan kawasan aplikasi. Bagaimanapun, data ini memberi gambaran bahawa akar rotan mengalami pertumbuhan sebanyak 1 m lagi berbanding dengan pokok berumur tiga tahun.

Introduction

Fertiliser input in a commercial forest plantation in Malaysia is not widely practised and application is not recommended unless necessary. However, certain species such as rattan, which are often cultivated under mature rubber plantation, need high input of fertiliser especially during the early growth stage (Aminuddin & Hall 1990). Nutrient deficiency can result in reduced height growth and leaf production (Raja Barizan & Aminah 1992).

Roots are the organs of water and nutrient uptake and the turnover and location of roots in the soil profile can indicate when and where uptake is being made (Anderson & Ingram 1989). The root system of rattans, however, has not been widely studied (Dransfield 1979). Due to this reason, we carried out this study to establish the distribution of feeder roots of rotan manau (*Calamus manan*) at three and four years after transplanting in a mature rubber plantation. For each age group, root activity was measured concurrently at two different stands, located not far from each other. The rainfall, temperature and slope were somewhat similar between the two stands. Isotope tracer technique, the method which has been successfully used in studying the active root distribution of many crops (Zapata 1990), was used for this purpose.

Materials and methods

Study area

The study was conducted on a commercial rattan plantation under mature rubber in Lanchang, Pahang (approximately 3°N and 103°E). The site has a mean annual temperature of 26 °C and mean annual rainfall of 1700 mm . Planting distance was 4.6 by 6.1 m (15 by 20 feet), along the interrows of rubber trees. The

soil is of sedimentary origin. For both ages, the experiment was laid out in a completely randomised design with single plant per plot.

3-y-old rotan manau plantation

A total of 30 palms were used in this experiment. They were chosen randomly based on their uniformity in size and growth, with at least one palm reserved as guard plant (Figure 1). The aim of this experiment was to measure the availability of feeder roots at three distances from the palm and two below- ground depths. The distances chosen were 0.5, 1.0 and 1.5 m and each was examined at both 5 cm (surface) and 30 cm depths. Application point was partitioned into 16 holes (±1 cm diameter) at uniform spacing around the palm base. Each treatment consisted of five replicates.

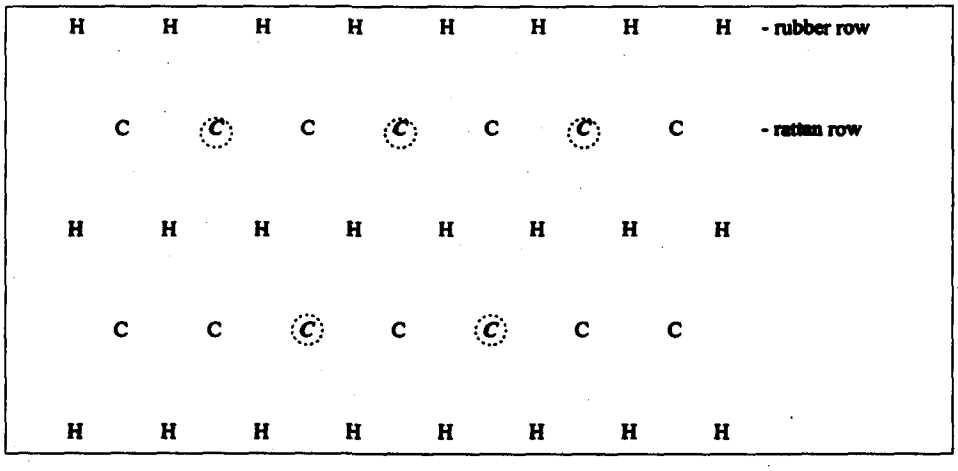

Figure 1. Partial plot layout for the 3-y-old rotan manau

(C) : treated trees
Treatments consisted of : ^{32}P application at 50 cm distance and 5 cm depth
^{32}P application at 100 cm distance and 5 cm depth
^{32}P application at 150 cm distance and 5 cm depth
^{32}P application at 50 cm distance and 30 cm depth
^{32}P application at 150 cm distance and 30 cm depth

Radioactive ^{32}P with the activity of 3.7 x 107 Bq (1 mCi) was mixed with 8 mg P as KH_2PO_4 solution in 200 ml water (carrier) and equally divided into 16 holes prepared earlier by augering. These holes were covered back with soil.

Sampling was carried out 24 days after ^{32}P application (radioactive approaching two half-lives). Every fourth leaflets (counted from the frond tip) at each frond were sampled to represent 25 % of the total leaflets biomass. Samples were taken to the laboratory for testing. The ashed material was digested with 20 ml 2 M hydrochloric acid and the resulting supernatant solution was used to count the activity of ^{32}P using a liquid scintillation counter.

4-y-old rotan manau plantation

Two treatments with four replicates each were established to study the active roots distribution of 4-y-old rotan manau. In the first treatment, ^{32}P was applied in the centre of two plants (plants 2 and 3) within the rattan row (Figure 2). For the second treatment, ^{32}P was applied in the middle of rattan-rubber interrow as described in Figure 3. Surface application was adopted in both treatments. Radioactive ^{32}P with the activity of 11.1 x 107 Bq (3 mCi) was mixed with 10 mg P as KH_2PO_4 solution and 200 ml water. This solution was evenly distributed in a 0.5 m by 1.0 m area.

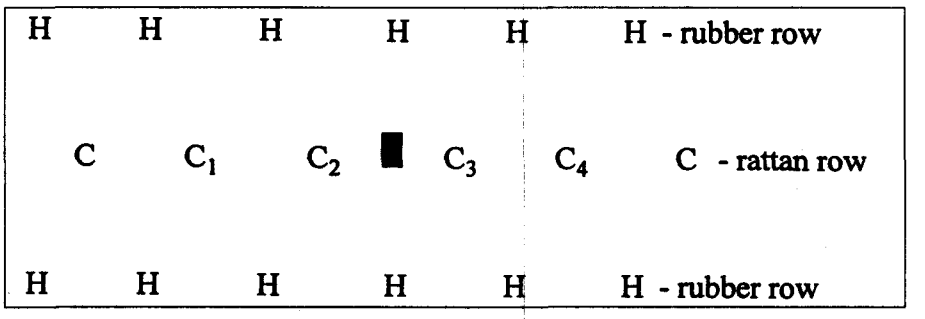

Figure 2. Schematic diagram for the first treatment for the 4-y-old rotan manau. 1, 2, 3, 4 : sampling plants; ■ : ^{32}P application area

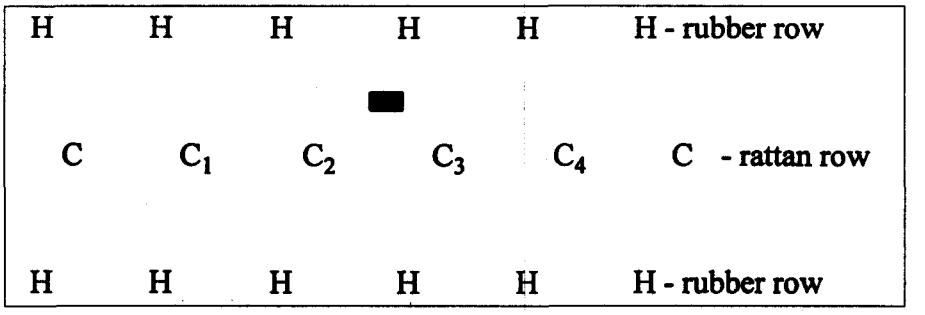

Figure 3. Schematic diagram for the second treatment for the 4-y-old rotan manau

Notations as in Figure 2.

At twenty-four days after application, leaflets from the second frond (counted from the shoot tip) were collected from plants 1, 2, 3 and 4 and analysed similarly as for the 3-y-old plants for ^{32}P radioactivity counting. Rubber leaves from various distances were also sampled and analysed as for rotan manau.

Results

3-y-old rotan manau plantation

Table 1 presents the results of statistical analysis carried out based on the analysis of variance with respect to ^{32}P uptake. Within the three distances and within the two depths studied, F-values show a highly significant difference. An important interaction was also seen between those two variables. Therefore, further analysis for mean separation was executed using planned F-test.

Table 1. Analysis of variance for ^{32}P counting in the 3-y-old rotan manau

Variable	DF	ANOVA SS	Mean squares	F-value	Pr>F
Total	29	4587647.9			
Distance	2	993497.9	496748.93	13.76	0.0001
Depth	1	2139738.1	2139738.13	59.26	0.0001
Distance x Depth	2	587777.9	293888.93	8.14	0.0020
Error	24	866634.0	36109.75		

Since there are two degrees of freedom for distance x depth, the sums of squares were enumerated for both linear and nonlinear root development for both depths studied. Mean squares (MS) were calculated based on the sums of squares value and F-value was obtained by dividing each MS with MS error. The calculated values are presented in Table 2.

Table 2. The calculated mean squares and F-values for comparing the significant root development of rotan manau

Source of variation	DF	Mean squares	F-value	Required F	
				5%	1%
Depth	1	2139738.1	59.26	4.26	7.82
Distance linear (DL)	1	975052.8	27.00		
Distance non-linear (DNL)	1	18445.1	0.51		
Depth x DL	1	486096.2	13.46		
Depth x DNL	1	101681.7	2.82		
Error	24	36109.8			

Table 2 clearly indicates a linear trend in root development as the distance increased for the two depths examined. A highly significant interaction was obtained for the linear root growth with respect to distance from the plant. This phenomenon is further described by regression lines shown in Figure 4. At 5 cm depth, the relation between ^{32}P uptake and distance of application was strong with

correlation coefficient of - 0.97. The second degree curve seemed to be the most fit for application at 30 cm depth. The non-significant F-values for depth x distance non-linear show no interaction to a non-linear root development.

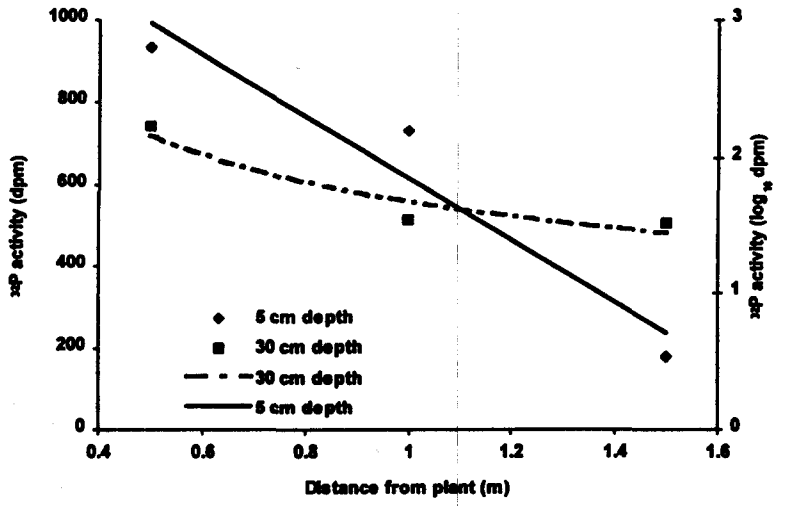

Figure 4. The relationship between ^{32}P uptake by the 3-y-old rotan manau and the distance of ^{32}P application at different depths. $Y = 1367 - 7.53X$ for 5 cm depth with values on the primary Y axis; $Log_{10} Y = 2.6065 - 1.6285X + 0.4831X^2$ for 30 cm depth with value on the secondary Y axis; dpm - disintegration per minute

4-y-old rotan manau plantation

Table 3 summarises results of the root activity experiment on the 4-y-old rotan manau. It appears that ^{32}P recovered from the plants located at different application areas varied considerably. The uptake of ^{32}P by plants 2 and 3 were significantly higher than those observed for plants 1 and 4 regardless of the treatment method. However, plants 2 and 3 from the first treatment gave higher activity.

Table 3. ^{32}P counting activity in the 4-y-old rotan manau leaves

Plant position	^{32}P activity (log_{10} dpm $5g^{-1}$ sample)	
	First treatment	Second treatment
1	0.000 b	0.345 b
2	3.408 a	1.704 a
3	3.306 a	1.997 a
4	0.175 b	0.000 b

Means with the same letter across the column are not significantly different; dpm - disintegration per minute.

Beside rotan manau, some rubber leaves from trees located at various distances were also sampled to count any ^{32}P uptake by the rubber trees. It appears that radioactive ^{32}P can be detected in the rubber trees located at 4.8 and 5.5 m away but not those at 11.5 m (Table 4).

Table 4. ^{32}P activity in rubber tree leaves at various distances from the application area

Distance (m)	4.8	5.5	11.5
^{32}P activity (dpm 5 g^{-1} sample)	150	237	0

Discussion

The scarcity of information on root growth and distribution is undoubtedly a major factor leading to the inefficiency of fertiliser use. Harrison and Dighton (1988) have shown that the use of roots is more accurate compared to foliar analysis in assessing nutrient requirement of plants since roots are the natural nutrient-absorbing organs and they are in direct contact with the source of nutrients in the soil. Dransfield (1979) suggested that a survey on the rattan root systems may uncover much of their ecology.

Results from this study indicate that root distribution of field grown rotan manau at young age may be best described by two variables, distance from the plant and below-ground depth. The highly significant interaction between distance and depth of ^{32}P application showed that plant response to the given nutrients at various distances also depends on the depth of application.

At three years after planting, roots had grown horizontally about 1.5 m away from the palm. The greatest proportion of the roots were in the surface layers, concentrated at a distance of 0.5 to 1.0 m from the plants. The regression equation showed a linear decline in ^{32}P uptake between applications at 0.5 m, 1.0 m and 1.5 m distances. Such response may indicate that uptake of fertiliser will be more efficient if it is applied nearer to the plants. It seems that at this age, application at less than 1.0 m distance around the plant might result in better fertiliser utilisation.

The four-year-old rotan manau had a wider root distribution. The distance between the nearest plant and the application area was 1.8 - 2.3 m and even then, high activity of ^{32}P could be recorded in the rotan manau leaves. Uptake of ^{32}P by the nearest rotan manau was also obvious when the radioactive material was applied at the centre between the two rattan plants and two rubber trees. This shows that the rattan roots had grown more than 2.3 m distance from the base and crossed with roots from the adjacent plants. Based on this result, it appears that broadcasting either around the plant or along the interrow between rattan and rubber trees may lead to similar fertiliser utilisation efficiency.

Another important fact which can be drawn from this study is the rate of root growth. Within the one-year period, i.e. from three to four years old, roots had grown horizontally about 1 m at the surface. Growth rate of the above-ground

parts of rotan manau usually accelerates once the stilt roots emerge, and this occurs normally after one year in the plantation. Aminuddin (1992) has shown that the growth rate of rotan manau increases with age. At one year old, the rate of growth was 0.2 - 0.8 m y^{-1} compared with 1.2 - 2.5 m y^{-1} at three years old and 1.5 - 3.8 m y^{-1} at four years old.

The above finding, however, may also be influenced by a number of factors such as provenance and soil chemical and physical properties. Previous fertiliser application might have also influenced the development of the roots. According to Bowen (1984), increased soil nutrient level as a result of fertiliser application often stimulates root growth, particularly in the enriched area. Therefore, similar assessment on the root growth and distribution on other sites is necessary as the present study only compared root activities between corresponding plants from the same plantation.

Acknowledgements

The assistance and cooperation from the Plantation Manager and staff of Syarikat Kurnia Setia are gratefully appreciated.

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