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FACTORS AFFECTING BARK YIELD COMPONENTS OF CINNAMON

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INTRODUCTION

Cinnamon (*Cinnamomum verum* J. Pres.) is a tree that grows to a height of about 10m in its natural habitat. But in plantations these trees are coppiced after about 2.5 years of growth and annually thereafter for harvesting its bark. This system of harvesting has converted the cinnamon tree into a bush consisting of many shoots of different ages and has increased the number of shoots that can be harvested at a time. The rough thick bark in large trees that do not yield good quality cinnamon has instead become thin and smooth, containing more bark oil containing tissues in these shoots. This has facilitated the increase of the number of cinnamon plants that can be planted in a given land area and has also made the harvesting of shoots more convenient and systematic. To increase the number of shoots that can be harvested at a time, five or more seedlings are planted at each planting point expecting to have about four plants at the harvesting stage.

Unlike other crops where fruits, seeds or whole plant are harvested cinnamon is unique in that its yield is the bark and the bark yield per bush is determined by several parameters. These parameters and factors that affect them have not been discussed before and are the number of sticks harvested/bush, the length of a stick with harvestable bark (length of the sticks with brown bark) and the weight of bark per cm length of shoot, which is the weight of bark per cm^2 × the circumference of the shoot. This is a measure similar to bark thickness but more meaningful and an accurate measure. Change in these yield parameters also change the percentage of dry matter in bark and is the harvest index for cinnamon.

These parameters and factors that affect the bark yield components in cultivated cinnamon are same as those in cinnamon trees but will have to be considered here in the context of the cinnamon 'bush' in cultivations which are planted in high densities and consisting of many shoots that are regularly (annually) coppiced. Their capacity to grow and regenerate under cultivated conditions either in monocropping or intercropping influences the bark yield components.

Factors affecting bark yield components

One of the main factors affecting the bark yield in cinnamon is light. The quantity of light mainly influences dry matter production and the quality of light plays the major role in the distribution of dry matter in plants (Smith, 1982; Ballare, *et al.*, 1995). Both these are important considerations that affect the bark yield components as well as the proportion of total plant dry weight in bark in cinnamon.

Cinnamon when grown as a monocrop is mainly affected by mutual shading between shoots in a bush and adjoining bushes and the former depends on the number of shoots present in a bush and the latter on the spacing and number of bushes planted in a given area. Both over storey shade and mutual shade are effective when cinnamon is grown under larger trees such as rubber. In such situations dry matter production and regeneration after coppicing are greatly reduced under severe shade and competition from other larger trees. However, the combined response to shade, competition and coppicing affect the bark yield parameters in cultivated cinnamon.

Number of sticks/bush

The number of sticks that can be harvested/bush is the most important parameter that determines yield in cinnamon and is basically decided by the number of seedlings planted per planting point. This is why at least four seedlings are expected to remain in a bush at the time of the first harvest. The number of sticks that can be harvested from a bush also increases with the age of the bush and in old bushes this is very high. In an old plantation (about 70 yrs) it was observed that the number of sticks harvested at a time was between four and seven per bush. In a eight year old monocropping area where the light availability above the cinnamon canopy was almost 100% the average number of sticks/ bush did not seem to vary much in the first five harvests taken and were 2.8, 2.6, 2.3, 2.5 and 2.6. In the presence of sufficient light there was no reduction in the number of shoots and it is the competition and weakening of plants that reduces the number of sticks. In wider inter row spacing of rubber (16.8m) where there was more available light to cinnamon there was no such reduction in the number of sticks compared to the narrow 8.4m inter row space (Table 2). Above data for both on monocropping and intercropping, was from the same experiment (Pathiratna *et al.*, 2004) and shows the combined effect of shade, competition and coppicing at harvests. But under intercropping when shade was greatly reduced in the middle of the 8.1m inter row in the 9th year the average number of sticks harvested were found to be reduced. This reduction can be attributed to weakening of bushes due to reduction of light, competition and coppicing (Table 1).

Length of sticks

In most instances cinnamon is harvested annually and growth in length of sticks is limited and the length of harvested sticks suitable for peeling bark is not more than 2.5m in length. Over grown sticks are not used for peeling as they do not yield good quality bark. The length of the stick is a component that is mostly determined by shade. The effect of etiolation due to mutual shading is the main factor that increases the length of sticks under monocropping and in such an area the average length of harvested sticks in the first five harvests were 228.0, 227.0, 261.9, 235.7 and 237.3cm respectively showing that this parameter usually remains without much change in regularly harvested monocrop cinnamon under uniform plant densities. The term plant density here is actually the 'bush density' consisting of many shoots of different ages.

Table 1. *Bark yield parameters, total plant dry matter above ground and light availability under cinnamon grown under rubber spaced 8.1m× 2.4m and cinnamon spaced 1.2m × 0.91m and harvested first in the 3rd year*

Parameter	Harvest					
	1	2	3	4	5	6
Length /stick (cm)	176.9[a]	165.5[b]	170.6[ab]	149.4[c]	158.5[bc]	141.6[c]
Weight of bark/cm^2 (mg)	12.8[b]	14.0[a]	13.6[a]	10.2[c]	9.6[c]	7.5[d]
Number of sticks/bush	2.9	2.5	2.4	1.8	1.3	1.0
Total plant dry matter (g/bush)	2690.8[a]	1282.6[b]	940.2[c]	991.5[c]	840.1[c]	818.4[c]
Light availability % PAR	82	72	50	27	21	18

Values in a row with the same letter are not significantly different

Under intercropping both over storey and mutual shading affect the growth and regeneration of cinnamon and in an experiment with rubber spaced at 8.1m × 2.4m and cinnamon spaced 1.2m × 0.91m, the average length of shoot seemed to remain without much reduction until the light levels were reduced below 50 % when shade seem to have affected dry matter production in cinnamon (Table 1) (Pathiratna & Perera, 2004). In another trial where cinnamon was inter planted under different spacings of rubber, the length of shoots did not seem to have changed largely, even after six harvests unless the light levels dropped to very low levels compared to those in narrow inter row spacings. But under very low light levels available close to rubber trees, the dry matter production was greatly affected, reducing the length of shoots too (Table 2) (Pathiratna *et al.,* 2004 and Pathiratna *et al.,* 2006). In two other experiments similar significant reductions in stick length was seen when the light levels were 21% and 27% mainly due to the poor growth of cinnamon (Pathiratna & Perera, 1998; Pathiratna & Perera, 2004).

Table 2. *Yield components of cinnamon planted at different spacings (8.4 and 16.8 m shown here) at 6 harvests. Light levels in the inter row space of the 8.4m treatment have dropped from 90% at the time of the first harvest to 12% at the 6th harvest and in the 16.8 m treatment this was 88.7% even at the 6th harvest*

Harvest	Avg.length of stick (cm)		Avg.no.of sticks		Percent DM in bark	
	Space 8.4 m	Space 16.8 m	Space 8.4 m	Space 16.8 m	Space 8.4 m	Space 16.8 m
1	215.4	192.5	1.68	1.53	3.8	4.5
3	179.8	240.0	1.43	1.48	4.3	4.7
6	200.5	230.3	1.02	1.50	2.6	4.3

When over storey shade was uniform under mature rubber, it was observed that the stick length was mostly determined by cinnamon plant density and not by over storey shade. In an experiment under rubber where the over storey shade was 53%-57% and with cinnamon densities of 17,500, 8260, 7980 and 3980 bushes/ha the longest sticks were produced under the highest density of cinnamon. Length of cinnamon shoots has remained lowest in the lowest density treatment. (Pathiratna & Perera, 2006). It is the mutual shading that has affected the length of sticks due to the reduction in the Red: Far Red ratio (R:FR) of light within cinnamon canopies (Pathiratna & Perera 2006) Under dense populations the reduced R:FR ratio within canopies brings about an extension of shoots (Ballare *et al.*, 1995).

Weight of bark per cm^2

Bark thickness is difficult to measure and is not an accurate measure either. Instead the weight of bark/cm length of stick or weight of bark cm^2 is a better measurement and is a parameter that is largely affected by shade and elongation of shoots. In a rubber/cinnamon intercropping experiment where cinnamon was intercropped in the 8.1m inter row space of rubber the weight of bark/cm^2 reduced from 12.8 mg at the first harvest to 7.5mg in the 6th harvest. During this period light availability reduced from 82% to 18% (Table 1). Yet it has remained unaffected until the light levels were about 50% in the same experiment. The same set of data showed a concurrent reduction in dry matter yield of cinnamon indicating the reduction of weight of bark cm^2 in this experiment was due to poor growth of cinnamon under shade. This is also a parameter that is affected by plant density where mutual shading leads to the elongation of sticks. Under high plant densities of cinnamon (between 17,500 – 7980 bushes/ha) where the level of available light has remained uniform throughout under mature rubber, the weight of bark/cm^2 in the highest density treatment remained significantly greater than in the lowest density treatment (Pathiratna and Perera, 2006). This shows that bark thickness under very low available light is affected due to the reduction in growth and under higher plant densities and with moderate shade levels. The reduction in the weight of bark /cm^2 is due to etiolation and shoot elongation resulting from mutual shading. Limitations to dry matter accumulation in the former case and dry matter allocation in the latter case are the possible reasons.

Diameter of sticks

The diameter of harvestable sticks also was reduced with the weakening of cinnamon bushes under severe shade. Cinnamon sticks produced in narrow inter row spacings where available light was low after the 6th year was smaller in diameter than those in the 16.8m inter row space and also under monocropping control (Table 3). Plants under high densities also produced sticks with smaller diameters while those under low densities produced sticks with greater diameter (Pathiratna and 2006). This is due to the differences in the allocation of dry matter for shoot elongation under low and high densities in response to mutual shading.

Table 3. *The combined effect of light (% PAR), competition and coppicing on the diameter of cinnamon shoots at the 4th,5th, 6th harvests. The light levels in the middle of the 8.4m and 16.8m inter row spacing treatments were 10.0 % and 78.3% respectively at the 6th harvest*

Inter row spacing (m)	Harvest 4	Harvest 5	Harvest 6
	Diameter (cm)	Diameter (cm)	Diameter (cm)
8.4	1.79	1.86	1.91
16.8	2.26	2.21	2.27
Control	2.49	2.56	2.58

Percentage dry matter in bark

Percentage of total dry matter in the parts above ground, allocated in bark is same as harvest index in cinnamon. Under monocrop conditions with standard spacings of 1.2 ×.6.0m percentage dry matter in bark was 4.39, 4.43, 4.08, 4.25 and 4.30 respectively for the 1st five harvests but was always low when plants grew under intense shade. In many intercropping experiments it was very low and in cinnamon planted at standard densities with 18% available light the plants were severely affected by shade. In these plants the percentage dry matter in bark was about 3.0% (Pathiratna and Perera 2004). Percentage dry matter was highest under moderate shade when more dry matter was allocated for the extension of shoots (Pathiratna and Perera 1998). Under high plant densities too, the percentage dry matter in bark was higher (Pathiratna and Perera, 2006) and the reason for this is the longer sticks produced due to mutual shading. But when there was more sunlight and more space for growth, the percentage dry matter in bark reduced possibly due to the allocation less dry matter to shoot extension. Such plants have more branches, a larger canopy and more leaves, therefore a lower percentage of dry matter in bark (Pathiratna and Perera, 1998).

Percentage dry matter in bark in cinnamon was also affected by the time of harvesting. In an experiment with uniform shade levels (53%-57%) harvesting intervals of 11 or 12 months have given a greater percentage of dry matter in bark than when the harvesting intervals were 13 or 15 months. The harvesting interval of 15 months has given the lowest percentage dry matter in bark. It is suggested that this is connected with maturing and flowering in cinnamon where flowering is annual and takes place in January. Plants harvested early without allowing them to reach maturity seems to have yielded a greater percentage dry matter in bark than when harvested at the time or time approaching maturity and flowering (Pathiratna and Perera, 2006).

SUMMARY

Bark yield of cinnamon grown as monocrop under full sunlight is only affected by intra species competition particularly mutual shading and is dependant on the plant density. In intercropping both over storey and mutual shading bringing about changes in both quantity and quality of light that affect the dry matter production and distribution in plants has the main influence on the yield components.

Dry matter production is greatly reduced due to competition for light and other resources. This can be seen in intercropping under intense shade and is aggravated by the effect of coppicing at harvests. Under such severe conditions all yield components are affected and are reduced resulting in shorter and thinner sticks with thinner bark and a lower number of sticks. Conditions that favour shoot elongation reduce bark thickness or weight/cm^2. In intercropping these parameters are not greatly affected until light is reduced below 50% and in such light conditions it is the plant density ie mutual shading that affect these parameters. The number of shoots that can be harvested from a bush mainly depends on the number of plants originally planted to form the bush and the age of bush but it is also reduced under severe shade. Time of harvesting is also seen as an important factor that decides the percentage dry matter in bark.

Therefore the information currently available shows that under intercropping conditions, moderate shade levels are more suitable to maintain bark yield components at favourable levels. Higher plant densities are also more suitable both under intercropping and monocropping to increase the length of sticks and percentage dry matter in bark. Harvesting before shoots reach maturity also yields a greater percentage of dry matter in bark.

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