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MANAGEMENT OF INTERCROPS UNDER RUBBER: IMPLICATIONS OF COMPETITION AND POSSIBILITIES FOR IMPROVEMENT

L S S Pathiratna

INTRODUCTION

Growing intercrops in the rubber inter row is an attractive practice for obtaining economic benefits. But the sustenance of good yields is limited by the competition from rubber. Most intercrops recommended are smaller than rubber trees and come under the influence of the latter. The above ground interference from rubber is imposed by its expanding canopy and below ground by its roots. The combined effect of both these factors will be envisaged as competition, affecting the performance of intercrops.

Intercrops grown under immature rubber are virtually unaffected by competition as the inter row space receives sufficient light and the interference from rubber roots is low at this stage. But when rubber trees mature canopies close and rubber roots spread into the inter row space interfering the growth and yield of intercrops. Examining these aspects that determine the level of competition is necessary in order to improve the current practices of inter cropping under rubber.

Canopy growth of rubber

The size of the canopy and its growth into the inter row decide the time and the extent of interference due to shade and the canopy growth is determined by the growth pattern of the branches which is mainly a clonal characteristic. Branching habit is also affected by the method of planting, inter-row space and the stage of growth (age) of the trees and other environmental factors.

Inter-row space, canopy size and branching

The space between trees affects the size of the canopy and branching in rubber. Their extension and the lateral spread is always restricted by the closeness of trees or density stress. The canopies of trees in neighbouring rows usually close in about 5 years under standard spacing systems (*eg*: 8.1m x 2.4m) and shows a high sensitivity to overcrowding that results in natural pruning of branches under very high densities (Table 1 and Plates 1 and 2).

Plate 1. The effect of high plant densities (900 trees/ha) on the reduction of the canopy size, restriction and natural pruning of branches in clone RRIC101 as seen in the 15th year

Table 1. *The canopy size and the average number of branches (main and secondary) of clone RRIC 101 in the 15th year under different tree densities. (Figures in parenthesis are rubber trees /ha)*

	Inter-row spacing (m) and (plant density ,trees/ha		
	2.5 × 10.0 (400)	**2.5 × 6.0 (666)**	**3.54 Δ (920)**
Avg. no. branches	9.6	5.4	2.2
Canopy radius (m)	4.4	3.6	1.3

In closely planted rubber trees particularly in paired row systems, the spread of the canopy between tree pairs do not always represent the length of the branches because of their vertical inclination.

The number of branches produced also increases with the increase of space between trees. In paired row systems where the distance between two trees across a pair was about 2.1m, the growth of all types of branches into this space was largely reduced, but number and the elongation of branches is greater towards the open inter-row space (Table 2).

Plate 2. The increase of the number and the spread of branches under low plant densities (400 trees/ha) thus changing the shape of the canopy of the same clone in the same experiment in Plate 1.

Table 2. *The mean number of branches (main, secondary and small) in clone RRIC 121 aged 6 years under different inter row spacings with single rows and paired rows of rubber (A- across two trees in the paired row; B- into the inter row). Two rows in a pair were triangularly spaced*

Spacing system	Average number of branches					
	Main		Secondary		Small	
	A	B	A	B	A	B
7.2m × 2.4m Single Rows	-	1.2	-	1.4	-	6.8
8.4m × 2.4m Single Rows	-	1.0	-	0.8	-	13.8
13.2m × 2.4m Single Rows	-	1.4	-	2.6	-	18.6
13.2m × 2.4m Paired Rows	0	1.0	0	0.8	3.0	8.2
18.0m × 2.4m Paired Rows	0	1.0	0	0.8	5.0	14.0

Light availability in the inter-row space

Light availability in the inter-row space is almost 100% during the first two years and its reduction due to canopy growth is seen after the 3rd year. This reduction in light availability takes place early at places close to the rubber trees compared to the middle of the inter-row and in about eight years the whole inter-row gets shaded under standard inter row spacings.

At positions close to the rubber rows the light availability is similarly reduced in about 3 years even when the inter-row space is large (12.0m and more). In such systems light levels remain as high as 80% at places beyond 3.5m from rubber trees and in the middle of the inter row even after seven years (Pathiratna *et al.*, 2004).

Light transmission from the rubber canopy also increases when rubber trees grow older. In a 20 year old clearing where rubber was planted with an inter-row space of 9.1m, the amount of light received in middle of the inter row was about 40% and was high compared to trees in younger clearings with similar spacing. This is due to the thinning of the rubber canopy with age and the tallness of trees. Weakening of the canopy may be due to disease, branch damage and even natural pruning of the lower branches (Pathiratna & Perera, 2005).

Although the spatial arrangement, *i.e.* contour or east west oriented row planting of rubber trees did not affect the size of the canopy, the inter row under the latter system had more light during the first six years of planting. This is an effect due to the scattered nature of rubber trees with respect to the path of the sun in the contour system, where as in the east west row system the path of the sun lies in the same direction as of the rubber tree rows (Pathiratna & Perera, 2003 a).

Root distribution in the inter-row

Rubber

The growth of rubber roots into the inter row space takes place gradually and in the first two years most of the roots are concentrated in the 1st 2.0m in the bole of the tree. By about seven years, the roots are able to explore the whole inter row space under standard inter row spacings (8.1m × 2.4m) and there is the possibility that roots from both rows intermingle in the inter-row at this stage. The root density in the inter row is also greater in older trees than in younger trees (Pathiratna & Perera 2003 b).

A major area of the inter row towards the middle remains less infested with rubber roots for a longer period when the inter row space is large. The middle of the inter row of a 18.0m spacing had a very low length density of fine roots even in the 6th year and is an indication that the middle of wider inter rows can remain less competitive from rubber for a longer period than in narrow spacings (Pathiratna *et al.*, 2004).

Effect of intercrops on rubber root length density

Besides other factors, the presence of inter crops also affects the distribution of fine roots of rubber in the inter-row. Addition of plant remains and fertilizer also encourages the proliferation of fine roots that indirectly increases competitiveness to intercrops. Rubber roots in the presence of highly competitive species like grasses reduce root density possibly by displacing them. Such effects are minimal in less competitive crops like cinnamon or coffee (Pathiratna & Perera 2003 b).

Effect of rubber trees on inter crop root length density

Rubber on the other hand being the larger partner of the system can reduce the root growth of intercrops (Pathiratna & Perera 2003b), mostly due shading that can be severe under higher tree densities and closeness to trees.

Competition and crop yields

Effect on rubber

Forage grasses are intercrops that reduce the growth of rubber trees even with fertilizer added at standard levels (Waidyanatha *et al.*, 1982). Regular removal of forage leading to the depletion of nutrients and limiting soil moisture in dry weather are important factors of competition (Plate 3). The closeness of grass to rubber trees also enhances competition on rubber (Dissanayake & Waidyanatha 1987).

However, most other intercrops do not show such adverse effects on the growth and yield of rubber.

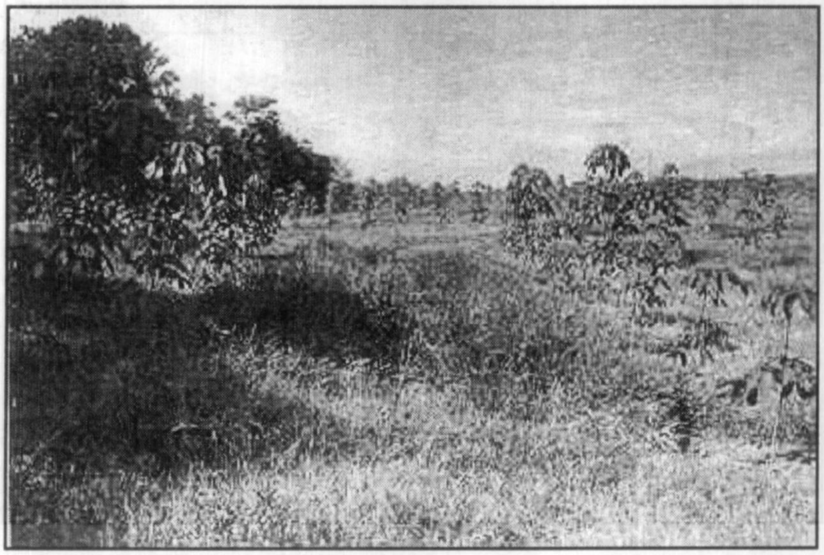

Plate 3. Survival of *Brachiaria brizantha* in a rubber/ grass intercropping trial under very dry conditions when all weeds including other local grasses have perished. Competition for water is imminent in this situation that can possibly affect the growth of rubber (From a rubber/grass intercropping trial established in 1991 in an estate in Kalutara district).

Effect on intercrops

Rubber being the larger partner of the system with its ability to explore a larger above and below ground area, has a better chance of competing with the inter crops reducing their yields. In this type of crop combinations root competition is considered more important than shoot competition in deciding competitive balance, intensity of competition and resource use. Root competition depends on the species, the age of the trees and other limiting environmental factors. Improving canopy growth and root proliferation in the inter row due to the presence of some intercrops also indirectly enhances competition from rubber. Competition also seems to be intense under old mature rubber mainly because of heavy root proliferation in the inter row even if the light availability is moderate.

The extent of the effect of competition also depends on the plant species and the type of plant part harvested. High irradiance requiring forage grasses are more sensitive to shade. In instances where shade is combined with regular removal of photosynthetic biomass, root growth, regeneration and dry matter yields of inter crops are severely affected.

Herbaceous determinate plant species seems to be more vulnerable to competition because their growth time is short and are more sensitive to stress and competition. They have little opportunity to compensate for stress. Crops that suffer least from shade are those that yield vegetative parts, particularly leaf possibly because more dry matter is diverted for increasing leaf area under shade.

Possibilities for improvement

Increasing the sustainability of intercrops by minimizing competition from rubber and reducing any adverse effects of intercrops on rubber are the two important aspects that needs improvement. Existing possibilities to achieve this are the manipulation of the tree spacings, spatial arrangements and crop selections.

Spacing and spatial arrangements

Increasing the space between rubber rows enhances the availability of light in the inter row while it also helps to keep the major part of the inter row with low root densities of rubber (Pathiratna *et al.*, 2004).

Rubber trees planted in east/west directed rows also have shown to provide more light into the inter row space for longer period of the day and have shown its advantages (Pathiratna & Perera, 2002). Therefore, wider inter-row spacings combined with east/ west directed rows where ever possible, can be considered as a suitable arrangement.

Selection of inter crop species

Crops are generally selected for high yield. Even in the case of shade tolerant species like coffee, cocoa or pepper, the tolerance or adaptability to shade is disregarded as a requirement. Such new selections produce high yield and requires higher levels of light (Fahl *et.al.*, 1994, Galyuon *et.al.*,1996). But these selections are not suitable for intercropping where shade tolerance combined with moderate yields are the important criteria. As a means for obtaining better yields under intercropping situations, re-introduction of old shade tolerant selections is now essential. Species such as *Calamus* (rattan) that can make use of light falling through canopy gaps are also adapted to survive under the canopies of large trees.

Selection of crop species with favourable shade adaptation attributes is important. Species where shaded leaves are likely to be adapted to low light levels such as cinnamon (Pathiratna *et al.*, 1998) and coffee (Friend,1984) are preferred to crops where lower shaded leaves rapidly senesce (Ong & Monteith, 1993). Crops with a high capacity to utilize fluctuating light under tree canopies (Intrieri *et al.*, 1995) and those with long-lived leaves having low nutrient uptake rates that conserves nutrients (Chabot & Hicks, 1982) are able to thrive under shade better. Crops with short lived leaves that senesce early in response to shade require more nutrients to replace what was lost in senesced leaves and the demand is more.

In intercrops where vegetative parts are harvested such as cinnamon, tolerance to pruning will also be important selection criteria. Crops that are more sensitive to pruning are not suitable as it reduces fine root development (Van Noordwijk *et al.*, 1996) and affects regeneration. .

Agronomic practices

Applying fertilizer to intercrops at the time leaf senescence sets in and root activity is least in rubber (Snoog, 1976), may be more suitable to avoid loss of intercrop fertilizer to rubber (Zainol *et al.*, 1993).

Harvesting can reduce the density of fine roots under severe pruning regimes. Therefore if the harvested part is vegetative, regeneration of new shoots can be affected due to defoliation (Van Noordjwijk *et al.*, 1996). When a large part of the above ground biomass is removed shortage of stored energy results in the production of weak shoots or die back (Fownes & Anderson, 1991) and has been observed in cinnamon. In such situations methods and timing of harvesting also have to be changed taking the shade conditions prevailing under rubber into consideration.

SUMMARY

The growth of the rubber canopy is greatly influenced by tree spacing, age and growth vigour of trees. Growth of rubber roots into the inter row is mainly dependant on the age and the density of trees and are also influenced by agronomic practices under different intercropping systems. In adjusting rubber tree spacing and spatial arrangements to avoid competition, east-west directed wider inter rows will suit best. As planting rubber in east-west rows is not always possible wider inter rows are adequate. Selection of suitable crops for intercropping is also important.

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