

Effect of competition from rubber (*Hevea*) on the yield of intercropped medicinal plants, *Solanum virginianum* Schrad., *Aerva lanata* (L.) Juss. Ex. Schult and *Indigofera tinctoria* L.

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Abstract

Three species of medicinal plants *S. virginianum*, *A. lanata* and *I. tinctoria* were intercropped in the 8.4m inter row space of four year old rubber planted in east-west directed rows. Three plantings of *A. lanata*, two plantings of *S. virginianum* and three harvests of leaves of *I. tinctoria* were taken during a one year period. The available light (PAR) at 1.2 m away from rubber trees was 32.6% and 28.9% of the incident light at 1 and 8 months after the establishment. In the middle of the inter row (4.2m from rubber row) the respective values were 56.3% and 43.8%. The root length density of rubber (RLD) was highest at 1.0m from rubber trees and lowest in the middle (4.0m) of the inter row and showed a large increase (2-3 fold) in the 8th month after planting. The plant dry matter yield of *A. lanata* in rows in the middle of the inter row was not reduced at the three plantings. In *S. virginianum* there was a large reduction in yield at the 2nd planting in all three rows (1.2m, 2.4m and 4.2m from rubber), but in *I. tinctoria* leaf yields have increased over the four harvests in rows at 2.4m 4.2m. Differences in the response of the three species to competition from rubber were evident. The effect on the two determinate spp. *A. lanata* and *S. virginianum*. was greater compared to the perennial *I. tinctoria* where leaves were harvested. Use of organic fertilizer on intercrops greatly increased the rubber RLD with the possible increase in competitiveness from rubber.

Key words: dry matter yield, light availability, root length density

Introduction

Solanum virginianum (Katuwelbatu), *Aerva lanata* (Polpala) and *Indigofera tinctoria* (Nilavariya) are three species of medicinal plants of economic importance and the total annual requirement of these three species in Sri Lanka is about 135,094

kg, 47,281 kg and 54,206 kg respectively (Abayawardhena and Hettiarachchi, 2001). The total requirement of *S. virginianum* is presently imported and the other two species are collected locally from natural stocks despite the threat for extinction. Therefore, the cultivation of

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these economically important medicinal plants has become important to supply the local market as well as to conserve them.

As apart of a research program undertaken to investigate the possibility of growing these three species of medicinal plants viz. *S. virginianum*, *A. lanata* and *I. tinctoria* in rubber lands they were tested as intercrops and found to grow successfully under rubber during the first 1-2 years (Pathiratna *et al.*, 2004a & b). This is due to the availability of sufficient sunlight and minimum root competition in the inter row space of young rubber. But when the growth of rubber trees advances the canopy starts to close in about 4 yrs (Pathiratna & Perera 2003b), and light becomes a limiting resource (Squire, 1993). Shade under trees tends to reduce the growth and yield of most inter crops (Hughes & Keatinge 1983) and at the same time the roots of trees also invade the inter row space affecting the growth of intercrops (Cannell 1983, Schroth & Zetch 1995). Intercrops under rubber are also affected similarly (Pathiratna & Perera 2003 a & b).

These medicinal plant species are not commonly cultivated and their light requirements are not clearly known, but when they were grown under moderate shade provided by *Gliricidia*, some retardation in growth and yield was recorded (Pathiratna *et al.* 2004 a & b) indicating the influence of shade. Their performance under rubber can also be affected similarly when canopies and roots start to invade the

inter row space. The extent of such competition effects is not known and these also can limit the time they can be intercropped under immature rubber. There was no possibility in this project to continue planting these species for many years to study the effect of shade and root competition under 4-5 years old rubber on growth and yield. Instead, an area with 4years old rubber where there was moderate shade was selected to study the effect of moderate shade and root competition on the growth and yield of three the spp. of medicinal plants.

Materials and Methods

The experimental area was a 4 year old rubber plantation of the clone RRIC 121 where rubber has been planted with an inter row space of 8.4m. The in-row space was 2.4m. The intercrops were planted leaving a space of 1.2 m to the rubber row in 9.0m long plots. These treatments were replicated thrice in a completely randomised block experiment. This site with east/west directed rubber rows were selected because the middle of the inter row receives more light throughout the day compared to contour planted rubber (Pathiratna & Perera, 2003 a).

Experimental methods

I. tinctoria

There were 7 rows of *I. tinctoria* in the inter row and were planted as 4 week old single seedlings in polythene bags. Planting holes were 30cm³ in size spaced 90 cm², half filled

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with cow dung (approx. 15,000 kg/ha) at the time of planting and fertilized with a 12:9:8 NPK mixture (15g/plant) after every harvest. Thirty cm long ends of all branches were removed at harvests every 60 days. Each plant was harvested separately, leaves separated and dried at 70 °C overnight to record the dry weights. Four such harvests were taken during the year.

A. lanata

A. lanata was planted in 11 furrows spaced 60 cm in the inter row space parallel to the rubber row. Seeds soaked overnight in water were directly sown in 30cm × 20cm furrows filled with cow dung (15000 kg/ha). After one month 12:9:8 NPK fertilizer at the rate of 200kg/ha was added. Plants were harvested by uprooting after 4 months. Three such plantings were done in the same plots during the year. Same furrows were used for the subsequent plantings and the same amount of fertilizer was added. After germination of seeds extra plants were removed leaving 60 plants/m of furrow. Each row was divided into 30cm portions for the purpose of harvesting and each section was treated separately. The number of plants in each portion was counted and the yield/plant was calculated.

S. virginianum

There were 11 rows of *S. virginianum* planted at a spacing of 60 cm × 40cm with 4 week old single seedlings in polythene bags. The size of the planting holes was 30 cm³. The

fertilizer was cow dung at the rate of 15,000 kg/ha in the planting hole and 200 kg/ha of a 12:9:8 mixture of NPK, added one month after planting. Plants were harvested by uprooting at the end of 4 months and each plant harvested was dried and weighed separately. Two such plantings were done during the year and at each planting same levels of fertilizer were used.

Measurement of rubber root length density

The root length of rubber in the inter row was determined at 1 and 8 months after the commencement of the experiment and done by digging furrows of 0.5m length, 20 cm wide and 30.cm deep parallel to the rubber rows and in between the inter crop rows. The second root sampling was done in different furrows to avoid the previous furrows. Measurements were taken at three distances from the rubber row viz., 1.0m, 3.0m and 4.0m. All roots present were collected, rubber roots separated and lengths of rubber fine roots with a diameter 2.0mm or less were measured by the 'Grid Line Intersect method' (Marsh 1971) and the length per 1000 cm³ was determined.

Measurement of the size of the rubber canopy and light availability in the inter row

The canopy size of the rubber trees was measured as the radius of the canopy towards the inter row. Five trees from either side of the inter row were randomly selected and the

measurements were taken in the 1st and the 8th month after the commencement of the experiment. Light availability in the inter row space at 1.2m and 4.2m from the rubber row was measured 1 and 8 months after the commencement the experiment and was measured as $\mu\text{ mols m}^{-2} \text{ s}^{-2}$ PAR using a Delta-T canopy Analysis System. The beam fraction sensor available in this arrangement enabled to take a measurement of incident light in an open place with every reading taken inside the inter crop plot. The percentage of transmitted PAR from the rubber canopy and the average of three measurements taken at 9.00, 12.00, 16.00 hrs of the day were determined. Five measurements from each distance were taken and were repeated for two days.

Results

Root distribution in the inter row

The root length density of rubber at a distance 1.0m from rubber trees was similar in all three medicinal plant spp. at the first measurement (Fig. 1). Their reduction with the increase in distance from rubber (1.0m, 3.0m and 4.0m) was also similar in all the three inter crops at this measurement (Fig. 1). The next measurement taken in the 8th month shows a large increase in RLD (2-3 fold approx.) in all places under the three spp. Yet RLD of *A.lanata* at places 3.0m and 4.0m from rubber was significantly lower compared to the other two intercrops. In all three spp. the RLD in the middle of the inter row (4.0m) was also significantly lower than in the two rows closer to rubber at this stage (Fig. 2).

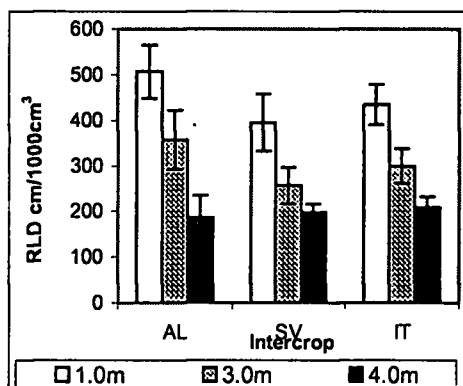


Fig 1. Rubber root length density (RLD) in the inter row under three inter crop species viz., *A.lanata* (AL), *S.virginianum* (SV) and *I.tinctoria* (IT) at 1.0m,3.0m and 4.0m from the rubber row measured in the 1st month after establishment

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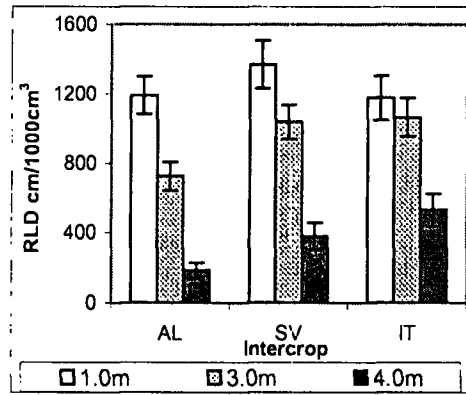


Fig. 2. Rubber root length density (RLD) in the inter row under three inter crop species viz., *A. lanata* (AL), *S. virginianum* (SV) and *I. tinctoria* (IT) at 1.0m, 3.0m and 4.0m from the rubber row measured in the 8th month after establishment

Canopy size and light availability in the inter row

The mean radius of the rubber canopy was 3.0 m and 3.5 m respectively at the 1st and 8th months after the establishment of the experiment. A gap between the canopies of the two rubber rows on either side was about 2.4m and 1.4m at these stages and light passing through this was considerable. Light availability in different intercrop plots did not show significant differences and an average for the whole area is considered here (Table 1).

Yield of intercrops

A. lanata

A. lanata was harvested as whole plants and the dry matter yield in g/plant showed a significant decline with repeated planting in row 2.4m and not in the row 4.2m away from rubber. In the row closest to rubber (1.2m) there was a large decline in the 3rd planting. When the reduction in yield in the row closest to rubber was compared with that of the middle row the yield decline was 70.0%, 70.9% and 83.2 % at the 1st, 2nd and 3rd plantings respectively (Fig 3).

Table 1. Light availability as percentage of incident PAR in medicinal plant plots under 4yrs old rubber

Distance from rubber row (m)	Light availability in the inter row (%PAR)	
	1 st month	8 th month
1.2	32.6 ± 5.6 or (645.5 μ mols m ² s ⁻¹)	28.9 ± 6.9 or (549.1 μ mols m ² s ⁻¹)
4.2	56.3 ± 5.0 or (1114.7 μ mols m ² s ⁻¹)	43.8 ± 4.5 or (832.2 μ mols m ² s ⁻¹)

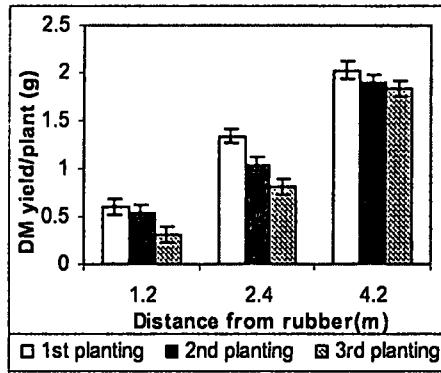


Fig. 3. Effect of competition from 4 yrs. old rubber on the yield of *A. lanata* planted in furrows 1.2m, 2.4m and 4.2m from rubber at the three plantings. (4.2 m distance from rubber was the middle of the inter row).

S. virginianum

This species was planted only twice and the DM yield in the 2nd planting was significantly lower than in the 1st in all three rows, 1.2m, 2.4m and 4.2m from rubber. The progressive decrease in yield with the increase in closeness to rubber was also significant

in both plantings. The yield in the row closest to rubber was very low compared to the in the middle at both plantings and the yield in the first row was 80.2% and 75.7% of the one in the middle at the two harvests respectively (Fig 4).

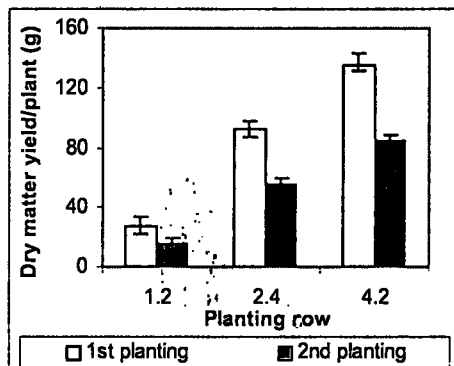


Fig. 4. Effect of competition from 4 yrs. old rubber on the yield of *S. virginianum* planted in furrows 1.2m, 2.4m and 4.2m from rubber at the three plantings. (4.2 m distance from rubber was the middle of the inter row).

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I. tinctoria

This species was planted once and the ends of all branches to a length of 30cm were harvested to collect the leaves. The progressive leaf yield increase in rows 2.4m and 4.2m was significant over the harvests. But in the row 1.2 m from rubber the increase was only between the 2nd and 3rd harvests. The leaf yields at the respective harvests also have increased with the increase of distance from rubber and the lowest yields were in the row closest to rubber. Consequently the leaf yields in the first row (1.2m) were 46.9%, 54.3%, 49.7% and 56.9% of that in the middle row at the 4 harvests respectively (Fig. 5).

Discussion

The rubber trees in this experiment were planted in east-west directed rows with an inter row space of 8.4m. Although the canopy gap was small (2.4m and 1.4m at the two measurements), the east-west row arrangement seems to be advantageous

as seen in the high light availability in the middle of the inter row, the benefit of which is also seen in the yields of intercrops (Pathiratna and Perera, 2002). The distribution of rubber roots in the inter row was measured as the length density of fine roots and is considered as a good measure of root distribution and of root competition (Schroth, 1999). In all experimental plots the rubber RLD was similar in corresponding places in the inter row at the commencement of the experiment with the lowest RLD in the middle of the inter row. The very large increase in RLD particularly in rows close to rubber is not only due to the growth of roots, but due to the greater proliferation of rubber root in response to added cow dung. Roots respond to the presence of organic matter by branching profusely (St. John, 1983) and also this could have indirectly increased competition for intercrops (Wilson, 1988; Schroth, 1999).

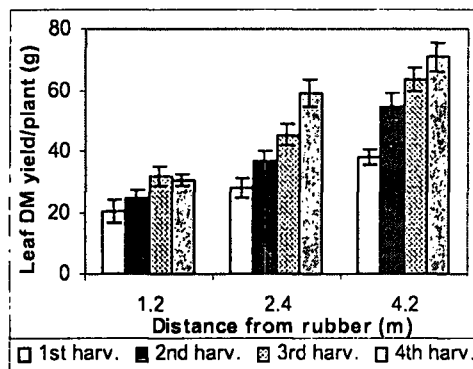


Fig. 5. Effect of competition from 4 yrs. old rubber on the leaf yield of *I. tinctoria* planted in furrows 1.2m, 2.4m and 4.2m from rubber at the four harvests (4.2 m distance from rubber was the middle of the inter row).

The low RLD in the middle of the inter row at both measurements is an indication that the whole inter row was not invaded by rubber roots at this stage. In the *A. lanata* plots RLD in the middle row and in the next was lower possibly due to the cutting of planting furrows along the inter row at the three plantings removing roots in the furrow. But in the case of *S. virginianum* no such furrows were made but cutting planting holes also could have damaged the roots considerably at the two plantings. However, the planting rows closest to rubber always had roots in its vicinity. *I. tinctoria* was planted only once and there was no possibility for the disturbance of the roots and RLD have remained slightly higher in middle of the inter row.

The plant dry matter yield of *A. lanata* in the middle row has remained comparatively high over the three plantings due to some tolerance to low light levels. The low level of RLD in this position also could have contributed to this. The large reduction in DM yield at the 2nd planting of *S. virginianum* may be due to the greater sensitivity of this spp. to low light levels and increased RLD despite the supply of the same amount of fertilizer at every planting. Under these low light conditions the utilization of added fertilizer can be poor (Jackson and Caldwell, 1992). But in the case of *I. tinctoria* planting was done once and only the branches were harvested and during this period plants have grown continually, though the growth was not

similar in all rows. The growth of plants was better in rows in the middle due to the availability of more light and less roots and have yielded more leaves.

When the change in dry matter yields in the three species due to the competition from rubber is considered by comparing the yields of the row in the middle of the inter row with that of the row closest to rubber, the highest percentage of reduction was seen in *S. virginianum* and *A. lanata*. These are determinate plants with a short growth period of about 4 months and they are more sensitive to competition and stress as they have little opportunity to compensate to stress (Fisher, 1975; Conner, 1983). *I. tinctoria*, a perennial where only leaves were harvested, tolerance to competition and harvesting seems to be more. The crops that yield vegetative parts particularly leaves are more tolerant to shade (Cannell, 1983) as more dry matter is allocated to leaves under shade (Boardman, 1977).

These results therefore indicate that higher dry matter yields cannot be obtained under these conditions from *A. lanata* and *S. virginianum*. due to low light availability and competition from rubber. *I. tinctoria*, is less sensitive to shade and competition but high leaf yields cannot be expected when intercropped under rubber planted with these narrow spacings. Greater proliferation of feeder roots of rubber due to the addition of organic fertilizer in the inter row and the possible enhancement of root competition from rubber is also evident in the results.

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