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Growth performance of rubber (*Hevea brasiliensis*) in mixed stand with wild jack (*Artocarpus hirsutus*)

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Abstract

An experiment was started during 2000 in farmer's field at Ponthenpuzha (9° 27' N, and 76° 47' E) near Manimala, in Kerala state to study the performance of rubber (*Hevea brasiliensis*) trees in mixed stand with wild jack (*Artocarpus hirsutus*) trees. Girth and girth increment of rubber was significantly affected when wild jack density increased beyond 20 per cent. However, growth of wild jack was not affected by density of wild jack. Rubber without wild jack in the near vicinity showed comparatively better canopy parameters like height, canopy width, LAI, light interception and root length compared to rubber with wild jack in the near vicinity. Girth and basal area of rubber showed significant negative relation with wild jack density. Wild jack competed with rubber for moisture during post-monsoon (December 2001- July 2002). Simple regression model Y= 3487.3 – 34.8 X was developed explaining the effect of wild jack density (X) on rubber basal area (Y) and it explained 83 per cent variation (R^2 = 0.83).

Keywords: Density, basal area, regression model and wild jack

Introduction

In traditional region, small scale rubber growers allow other trees to grow in the plantations, mainly the timber yielding trees, aiming at the assured long-term economic return from timber. Wild jack (*Artocarpus hirsutus*), a member of Moraceae family, is widely allowed to grow along with rubber. Birds are the natural agents for dispersal of seeds of this tree and hence these trees are naturally established and not planted by farmer. So the density of wild jack varies from plantation to plantation and an important factor, which determines the growth performance of rubber. No study has been conducted so far to assess the performance of mixed stand of rubber with wild jack and hence the present study aimed at.

Materials and Methods

Survey was conducted during 2000 in central Kerala and selected a small holding located at Ponthenpuzha (9° 27'N, 76° 47'E). Rubber was planted in 1997-98 using polybag plants of RRII 105 clone on an area of about 1 ha at a spacing of 5x4 m. Wild jack plants were one-year-old at the time of planting rubber. At the beginning of our study around 90 wild jack plants were found randomly distributed in the plantation. *Mucuna* and *Purearia* mixture was grown as cover crop. Recommended cultural practices were followed for rubber. Recommended fertilizer dose was applied in two splits to rubber and no fertilizer was applied to wild jack plants. During initial years farmer has thinned down the weak wild jack plants and also those standing too close to rubber. Soil is lateritic with pH 4.8, organic carbon 1.9 per cent and phosphorus 0.61 and potassium 5.2 mg/ 100 g. Leaf samples were collected from rubber plants with wild jack standing within five-meter distance from rubber. Similarly leaf samples were also collected from rubber plants without wild jack within 5-10 m distance

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from rubber. Leaf samples were analyzed for the major nutrient content following standard procedure (Morgan, 1941; Bray and Kurtz, 1945; Jackson, 1973). Girth of all the rubber and wild jack plants were recorded at 150 cm height at six-month interval. Mean annual girth increment (GI) during 2001-2003 and GI during monsoon (May-Dec. 2001) and post-monsoon (Dec. 2001-July 2002) were calculated. Canopy parameters like plant height; canopy width and height were recorded during January 2001 from the rubber plants with and without wild jack in the near vicinity. Light transmission and leaf area index were recorded during April 2001 using Linear PAR Ceptometer (Decagon Devices Inc. USA). Basal area (BSA) of rubber and wild jack was calculated using the formula

Basal area $= G^2/4\pi$, where G = girth (cm)

Experimental area was divided into plots to get the information on effect of wild jack density on rubber growth. Leaving borderline on all the sides of experimental area, twelve plots of 25 plants per plot (5x5) were marked. Plots with same number of wild jack were pooled and considered as one plot for analysis and comparison. Hence, the net total plot came to nine only. Plot wise number of wild jack plants, vacancy and weaklings of rubber was recorded and is given in Table 1. Plot wise wild jack density was expressed as per cent to rubber population. Basal area per plot was worked out by adding basal area of all the plants in a plot. For root study four representative rubber plants with wild jack standing within 5 m distance and four rubber plants without wild jack standing within 10 m distance were selected. Two spots were selected each in 1 and 2 m circular area around each rubber plant. At each spot 30 cm pit was dug. One side of the pit was smoothened vertically and collected 10-cm^3 soil with the help of chisel at 0-10, 10-20 and 20-30 cm depth from top. Soil samples were first sieved with 2 mm sieve and hand picked big live roots. Then soil was immersed in a bucket of water and stirred well. Water was filtered through 2 mm sieve. Live root bits were selected and dead and very small root pieces (< 5 mm) discarded. Roots were washed thoroughly with water and separated into rubber and wild jack roots. Separated roots were stored in 50 per cent ethyl alcohol. Root length was measured from root image using Rootedge 2.2c software (Kaspar and Ewing, 1997). For creating root images, roots were removed from alcohol and dried by gently pressing between filter paper and randomly placed without overlap on scanner (HP Scan jet 6300C). Roots were scanned and created Tiff image. Using XLstat software simple linear regression model was developed with total rubber basal area as dependent variable and wild jack tree density as independent factor. Girth, girth increment and basal area data were subjected to one-way ANOVA using SPSS-10 software to test the significance of difference between the different densities (Gomez and Gomez, 1984).

Results and Discussion

In the experimental plots, the total plant density ranged from 520 to 740 plants per hectare (Table 1). Number of weak rubber plants was comparatively more with higher wild jack density. However, the vacancy of rubber did not show any such trend.

Table 1. Details of experimental plots

Plot No.	No. of wild jack	Vacancy of rubber	No. of poor growth rubber plants	Density of trees per ha
1	7	1	1	640
2	11	1	3	720
3	5	0	1	600
4	7	0	3	640
5	9	2	3	680
6	12	1	5	740
7	4	0	1	580
8	7	0	1	640
9	1	1	0	520
10	2	0	0	540
11	5	1	0	600
12	3	0	1	560

Rubber girth decreased significantly when wild jack density increased beyond 20 per cent (Table 2). However, the wild jack girth did not show any significant variation with density. Similar trend was observed with respect to mean annual GI of rubber during 2001-2003 (Table 3). In the mixed tree plantation, when density increased beyond certain threshold, the balance in access to resources is impaired and competition sets in. Hence the girth and girth increment of rubber did not differ significantly with increase in wild jack density up to per cent. Girth and girth increment of rubber decreased significantly when wild jack density increased beyond 20 per cent.

Table 2. Girth of rubber and wild jack as influenced by wild jack density

Wild jack density * (%)	Mean rubber girth (cm) 2001	2002	2003	Mean wild jack Girth (cm) 2001	2002	2003
4	20.3^{a}	33.9^{a}	41.5^{a}	26.0	37.7	43.0
8	21.8^{a}	32.3^{a}	38.8^{a}	25.5	35.2	41.3
12	20.8^{ab}	33.0^{a}	40.4^{a}	29.3	38.4	44.8
16	20.6^{ab}	31.0^{a}	38.1^{abc}	28.9	36.2	42.9
20	19.7^{bc}	31.1^{a}	38.5^{a}	28.4	36.7	42.5
28	18.0ce	28.1^{b}	34.7^{bce}	27.6	36.5	43.6
36	16.4^{cde}	26.0^{bc}	31.7^{cde}	24.5	33.2	41.1
44	15.9^{de}	24.7^{c}	30.3^{de}	32.7	41.0	47.9
48	17.8^{e}	27.5^{bc}	34.0^{e}	23.3	31.1	35.9
Mean	19	29.7	36.4	27.4	36.2	42.6

* Note: Wild jack density as per cent to rubber population

Table 3. Mean annual girth increment

Wild jack density (%)	Mean annual girth increment (cm) during 2001-03	
	Rubber	Wild jack
4	10.6^{a}	8.5
8	8.5^{bcde}	7.9
12	9.8^{ac}	7.8
16	8.7^{cd}	7.0
20	9.4^{abc}	7.0
28	8.3^{d}	8.0
36	7.7^{de}	8.5
44	7.2^{e}	7.6
48	7.9^{de}	6.3
Mean	8.7	7.5

When two trees are grown in close proximity, competition for limited resources is most obvious. Competition for resources can be broadly classified into above ground and below ground competition. Above ground competition is mainly for space and light. Competition for space was slightly indicated by low canopy height and width of rubber in mixed stand with wild jack (Table 4). Canopy height and width was slightly higher in rubber without wild jack. Rubber plant height and branching height did not differ with presence of wild jack. Similarly Westgirth and Buttery (1965) and Devakumar *et al.* (1995) reported short trees with much larger expanse of un-branched trunk at higher plant density. The extent and degree of competition for space and light increase progressively with age. Rodrigo *et al.* (1995) and Westgirth and Buttery (1965) reported that effect of density was very evident only after 4th year due to crown development. The extent of competition for space observed was not that much, as the rubber is still in immaturity stage and enough space is available for canopy to grow. However, it has indicated the setting in of competition for space.

Table 4. Canopy parameters of rubber

Treatment	Plant height (m)	Branch height (m)	Canopy height (m)	Canopy width (m)	Light transmission (%)	LAI
Rubber with Wild jack	6.3	3.1	2.8	2.7	29.5	1.2
Rubber without Wild jack	6.5	3.1	3.5	3.3	33.2	2.2
Wild jack	5.7	2.2	3	2.9	15.9	3.7

Capture of light depends on canopy area and architecture. Per cent light interception and LAI was comparatively better with rubber without wild jack than rubber with wild jack (Table 4). The point to note here is that wild jack has higher light interception and LAI compared to rubber. This may be due to species characteristic, but this put the wild jack in advantage and dominant position in capturing and utilization of the limited resources. This is the reason why with increase in wild jack density, the growth of rubber was affected much and not the wild jack. However, the competition for light was not that severe, as the rubber is still in immaturity stage and space is available for canopy to spread. A species which establishes an early advantage in light capture through more rapid initial shoot growth may also exhibit greater root growth due to increased availability of photosynthates. This may in turn further improve the shoot growth and light capture with more detrimental effect on the less competitive species in mixture.

Below ground competition is mainly for water and nutrients. The soil volume to be exploited is constant. So the introduction of wild jack definitely leads to competition for water and nutrients. Competition for water was clearly evident from difference in seasonal girth increment (GI) of rubber (Table 5). During post-monsoon rubber girth increment was significantly low at > 20 per cent wild jack density but at below 20 per cent density girth increment was not significantly varied. Wild jack density did not significantly influence rubber GI during monsoon. Girth increment of wild jack during monsoon and non-monsoon was not influenced by Wild jack density (Table 5). In general the mean girth increment of rubber during monsoon (6.9 cm) was higher than girth increment during post-monsoon (3.8 cm), but with wild jack there was little difference. Similarly Wibawa (2000) also reported that during dry period, water was the main limiting factor for slow rubber growth when inter-planted with *Paraserianthes falcataria*. Wild jack did not show competition with rubber for nutrients (Table 6). Per cent leaf nutrient content of rubber with

Table 5. Seasonal girth increment of rubber and wild jack

	Rubber		Wild jack	
Wild jack Density (%)	Monsoon (May Dec. 2001)	Non-monsoon (Dec. 2001 July 02)	Monsoon (May Dec. 2001)	Non-monsoon (Dec. 2001 July 02)
4	8.1	5.4^{a}	6.5	5.2
8	6.7	3.8^{bd}	5.8	3.9
12	7.3	5.0^{ac}	4.8	4.2
16	6.7	3.7^{bde}	3.9	3.4
20	7.1	4.2^{bc}	4.3	4.1
28	6.6	3.5^{de}	4.4	4.5
36	6.7	2.9^{ef}	4.3	4.3
44	5.9	2.4^{f}	4.0	4.4
48	7.2	3.4^{de}	4.0	3.9
Mean	6.9	3.8	4.2	3.8

Table 6. Effect of wild jack on leaf nutrient content (%)

Treatment	N	P	K	Ca	Mg
Rubber with Wild jack	3.0	0.18	0.6	2.1	0.34
Rubber without Wild jack	2.9	0.17	0.56	1.9	0.35
Wild jack	2.4	0.11	0.76	1.46	0.36

and without wild jack near the vicinity did not differ. But if total biomass produced is taken into account, then there will be great competition for nutrients at higher plant density. Rooting pattern also matters much in the ability of species to cope with the below ground competition. Root length of rubber was slightly lower with presence of wild jack compared to rubber without wild jack (Table 7). Active roots of rubber are mainly concentrated in top 0-30 cm soil, where the maximum fluctuation in soil moisture occurs. Even though rooting pattern of rubber was not affected much by presence of wild jack, but during post-monsoon (Dec. 2001-July 2002) girth increment of rubber was significantly affected at higher density of wild jack. Girth increment (GI) of rubber during post-monsoon was comparatively low than to GI during monsoon, but such difference was not observed with wild jack girth increment. This clearly indicates deep root system of wild jack. By virtue of deep root system, wild jack can extract nutrients and moisture from deep soil, thus evading the competition from rubber. This is the reason why, with increase in wild jack density, rubber growth is affected and not wild jack growth.

Table 7. Effect of wild jack on rubber root length (cm)

Treatments	Root length(cm)
Rubber with wild jack	496.6
Rubber without wild jack	535.7
Wild jack	116.2

Stand basal area is the best indicator of density and competition. Total rubber basal area decreased with increase in wild jack density (Table 8 and Fig. 1). On the other hand total wild jack basal area increased with increase in wild jack density. However, sum of total basal area of rubber and wild jack did not change much with change in wild jack density. From Fig.1 it is clear that up to 20 per cent wild jack density, the extent of decrease in rubber basal area was slow and afterwards the rubber basal area decreased sharply. Similar trend was observed with mean rubber basal area (Table 8). Total basal area and girth of rubber showed significant negative relation with wild jack density (Table 9). A model was developed using a simple regression, explaining the change in total rubber basal area with change in wild jack density (Fig. 2). Regression model Y= 3487.3 – 34.8 X explains

Table 8. Effect of wild jack density on Basal Area

Wild jack density (%)	Total Basal area (cm^2) Rubber	Wild jack	Total	Mean BSA (cm^2) Rubber	Wild jack
4	3241.7 (95.7)*	147.1 (4.3)	3388.6	140.9 ^{a}	147.1
8	3051.2 (91.7)	274.4 (8.3)	3325.6	122.0 ^{ad}	137.2
12	3403.4 (87.6)	480.4 (12.4)	3883.7	136.1 ^{a}	160.1
16	3004.4 (83.7)	586.7 (16.3)	3591.1	120.2 ^{ad}	146.7
20	2978.4 (80.2)	735.8 (19.8)	3714.2	121.6 ^{a}	147.2
28	2339.2 (69.3)	1036 (30.7)	3375.2	100.3 ^{bd}	148
36	1851.7 (59.7)	1250.9 (40.3)	3102.6	84.2b ^{cd}	139
44	1835.7 (47.5)	2028.2 (52.5)	3863.9	76.5 ^{cd}	184.4
48	2168.2 (62.8)	1286.6 (37.2)	3454.8	98.6 ^{d}	107.2
Mean	2108.7	691.3	3169.97	100.04	131

Note: Figures in the parenthesis are per cent to the total

Table 9. Correlation between wild jack density and rubber growth

	Rubber Girth	Wild jack girth	Rubber BSA	Wild jack BSA
Wild jack density	-0.89*	-0.2	-0.91*	0.93*

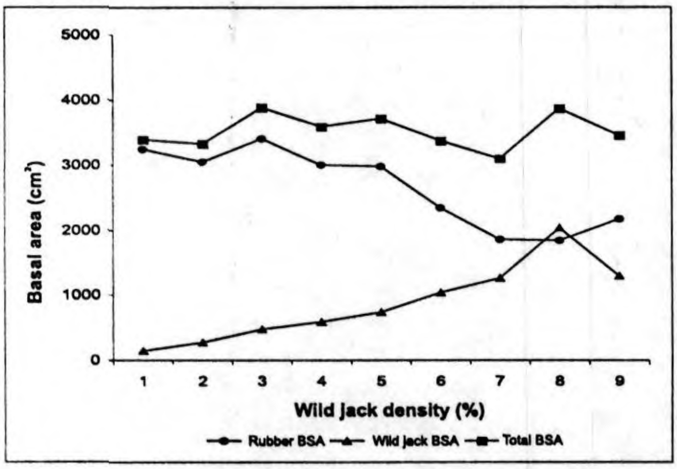

Fig. 1. Effect of wild jack density on basal area

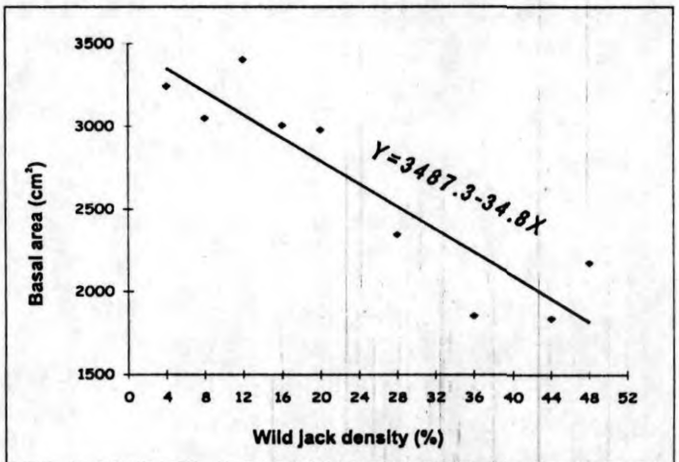

Fig. 2. Regression of rubber basal area on wild jack density

83 per cent variation. Regression model and its coefficient parameters were found significant. Rubber basal area decreased proportionately with increase in wild jack density indicating competition effect of wild jack on rubber.

Since rubber has not attained maturity, there is a need to assess the yield performance of rubber after maturity and to throw more light on the effect of wild jack competition on rubber yield.

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