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# SINK SOURCE RELATIONSHIP IN RUBBER (*HEVEA BRASILIENSIS*) IN DIFFERENT MONTHS IN THE NORTH EAST INDIAN CLIMATIC CONDITIONS

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## SUMMARY

**The factors contributing for low and high rubber yield during May and November respectively, w studied by analyzing the sink strength of high yielding *Hevea brasiliensis* clones. Yield is generally low duri summer months and high during winter months in this region. The major yield components like initial fl rate, dry rubber content and plugging index showed a wide difference in both the months/seasons. Hi temperature prevalent during May causes early plugging and stoppage of latex flow, consequently, reduci the total yield. However, low temperature during November prolongs the flow of latex due to delay in pluggi favouring high yield. The stored carbohydrate pools of bark (tree trunk) and sugar in latex were high duri May indicating under utilization of the available resources. Reduction of storage and low sugar in latex ar subsequent increase in photosynthetic rate during November indicates higher utilization of photosynthat s dt to high sink demand. In general, the yield of rubber is limited more by sink capacity during May and urc capacity during November in the north east Indian climatic scenario.**

***Key words:* *Hevea brasiliensis*, saccharides, sink, source, temperature**

## INTRODUCTION

Under favourable conditions, the yield of rubber may be limited by such basic physiological processes as photosynthesis or carbohydrate partitioning. A central issue in rubber research in north east India is whether the yield is limited more by source capacity or by sink capacity (pool). The source and sink is best described in annual crops. However, in all crops the source are organs that export photosynthates and sinks are in general which import photosynthates. Wilson (1972) expressed source strength capacity as product of state variable source size (leaf area) and the rate variable source activity (rate of photosynthesis). In literature source-sink relationship is well documented in different crops where sink is mostly the seed/fruit. Further the sink-source studies are quite extensive and often contradictory in literature (Yoshida 1973). It is generally accepted that allocation of photosynthates is in response to sink demand (Cook and Evans 1967), but it has been shown in several systems that the rate of photosynthesis at source changes with changes in sink requirements (Neales and Incoll 1968). The argument is circular, higher source can create higher sink. Limitation to crop yields are frequently sought in either photosynthesis - the source of assimilates or in the sink - the site of assimilate and the sink size of assimilate utilization. This division recognizes the two major processes involved in the production of assimilate in the leaves and utilization of this assimilates. Focussing on sources and sinks provides what appears to be a simple two-component system; unfortunately, analysis of this system does not always clearly identify the yield limiting processes (Evans 1993). The concept of feed back inhibition of photosynthesis is a well documented hypothesis in physiology (Neales and Incoll 1968). However, the sink-source relationship in rubber grown in north east India (non-traditional regions) is not clearly known (Jacob *et al.* 1999, Devakumar *et al.* 2002, Alam *et al.* 2002). The sink capacity in rubber depends on the

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extent of exploitation by tapping and the sink size (latex volume or dry rubber yield) can be changed by manipulating the tapping system and length of tapping cut also. The objective of this study is to find out the limiting factor for rubber yield in climatic conditions of north east India.

## MATERIALS AND METHODS

An experiment was conducted at the research farm, Agartala (91°15' E, 23°53' N, 30 m msl) of Regional Research Station of Rubber Research Institute of India. A popular clone RRII 105 and a fast growing clone RRII 118 were selected for this study. The trees were tapped following the ½ S d/2 6d/7 system of tapping. Yield was recorded from 36 trees by cup coagulation method for two years in both the clones. The other parameters like initial flow rate, plugging index and dry rubber content were recorded from 8 trees of each clone for four times during May and November. To study the latex flow pattern, one set of trees were taken as control and another set used as treatment (temperature control) plants. The ambient temperature in the tapping panel area of treatment plants was lowered to 18±1°C during May and increased to 28±1°C during November by circulating water at the respective temperature through a polythene bag in the tree trunk during latex flow period (Fig. 1). The temperature was brought down to 18±1°C by adding ice to water before circulation. Similarly, the water temperature was increased up to 28±1°C by adding hot water before circulation. Dry rubber content (DRC) was determined by gravimetric method and plugging index was determined following Milford *et al.* (1969). Photosynthetic rates of sunlit leaves of immediately cut branches were measured in morning hours between 0900 and 1000 hours at steady state conditions using portable photosynthesis system (Model LI-6200, Licor, USA) during May and November 2001.

Soluble sugar and starch were analysed in pooled samples of bark collected from (below the taping panel) all trees during May and November. The samples were dried at 80°C for 72 hours and ground to powder. A known amount of ground dried tissue was added to 80% aqueous ethanol and incubated for 30 min to extract soluble sugar. The extract was centrifuged for five minutes to settle the tissue, the ethanol decanted and the

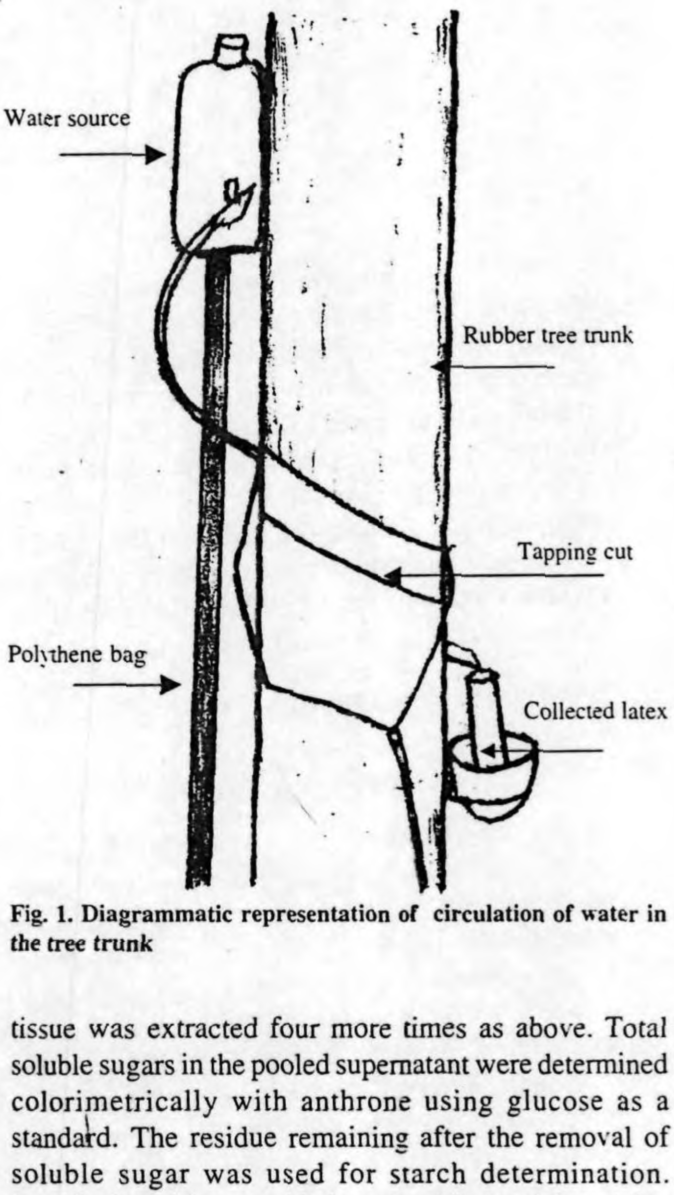


**Fig. 1. Diagrammatic representation of circulation of water in the tree trunk**

tissue was extracted four more times as above. Total soluble sugars in the pooled supernatant were determined colorimetrically with anthrone using glucose as a standard. The residue remaining after the removal of soluble sugar was used for starch determination. Perchloric acid was added to the dried residue. After centrifugation for five minutes, the supernatant was collected. The extraction was repeated four times. From the pooled supernatant, the starch was determined with anthrone. A known amount of latex was extracted with 2.5% trichoroacetic acid and aliquots were used for estimation of sucrose (Scott and Melvin 1953).

## RESULTS AND DISCUSSION

The monthly rainfall varied from 12 to 363 mm in different months. Monthly mean minimum temperature varied from 10.5 to 25.5°C and maximum temperature

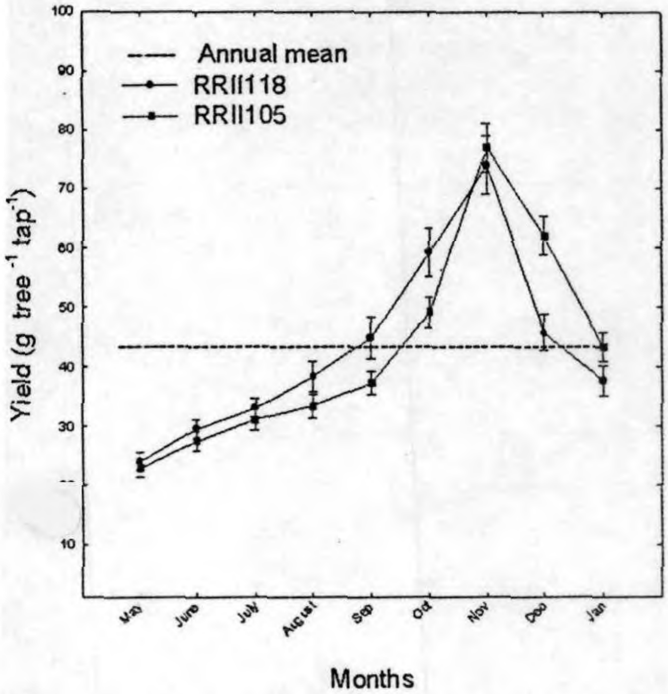


Fig. 3. Monthly mean yield (two years) of two clones at Agartala, North East India

components viz. initial flow rate, length of tapping cut, rubber content of latex and plugging index (Sethuraj *et al.* 1984). The latex, contained in the latex vessels of the bark springs out when a tapping cut is made on the trunk of the rubber tree (Gomez 1983). The latex being predominantly watery, its flow from the tree forms one of the classical phenomena influenced by several plant factors (Buttery and Boatman 1976). Despite the clonal variation, latex yields are generally affected by other factors also. The pattern of latex flow is remarkably altered by climatic factors. The duration of flow as well as the amount of latex is reduced when the tree is under adverse condition (Sethuraj *et al.* 1984). However, the extent of such reduction was also influenced by change of air temperature (Fig. 4). High flow rate, high DRC and high plugging index (PI) were observed during May and low flow rate was observed for a longer period with low DRC and PI during November (Table 1). The average monthly minimum temperature of November is 18°C (Fig. 2). Due to this reason, the air temperature of the tapping panel area was lowered to 18°C in treatment plants during the month of May. It was observed that the latex flow duration increased to 20 minutes more compared to control with a minor reduction of PI (Table 2). The duration of flow was comparatively low and the rate of initial flow was high in both the clones (Fig. 4) in the month of May. Due to early plugging, rubber content, which accumulated in the latex, resulted in the increase of DRC percentage. Similarly, latex flow stopped early in the treatment plants (Fig. 4) with reduction of yield (46%) and with increase of PI (Table 1), when the air temperature was increased to 28°C (average temperature of May) during November. Clonal variation in latex flow was reported mainly due to plugging pattern (Milford *et al.* 1969). The temperature between 18°C to 24°C was reported to be favourable for optimum latex flow (Shangphu 1986, Shuochang and Yagang 1990).

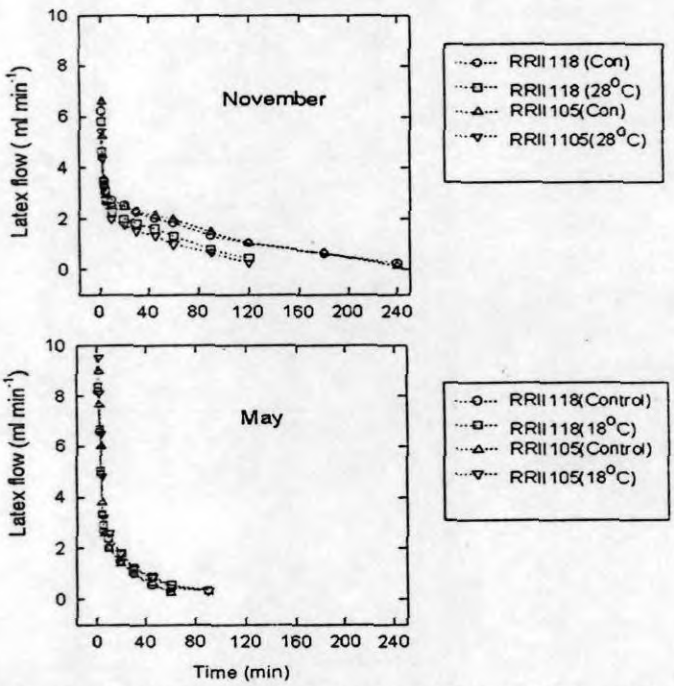


Fig. 4. Latex flow pattern of two clones in different air temperature during May and November

Sinks can be defined as regions of the plant which are heterotrophic for photosynthetically fixed carbon. Even though there are large number of sinks present in the rubber plant, the latex is considered as a major sink, which is economically important. The latex is being extracted by controlled wounding of bark of the main trunk. Wounding can be manipulated to get more latex or yield, which forces the source to supply more sucrose to laticiferous cells. Sucrose is the main translocatable form, and the main substrate for metabolism in the sink. Sucrose ranged from 24.9 to 32.6°C. Mean daily sunshine hours varied from 4.1 to 8.0 hours and average relative humidity ranged from 60 to 86% during the year (Fig. 2).

The mean dry rubber yield varied from 24 to 76 g per tree per tap (average of clones) during the year (Fig. 3). Yield was low in summer months and high in the months of October to December. There was little difference in annual yield between the clones, however, RRII 118 showed high yield during summer and RRII 105 during winter. Yield in rubber is influenced by four major yield

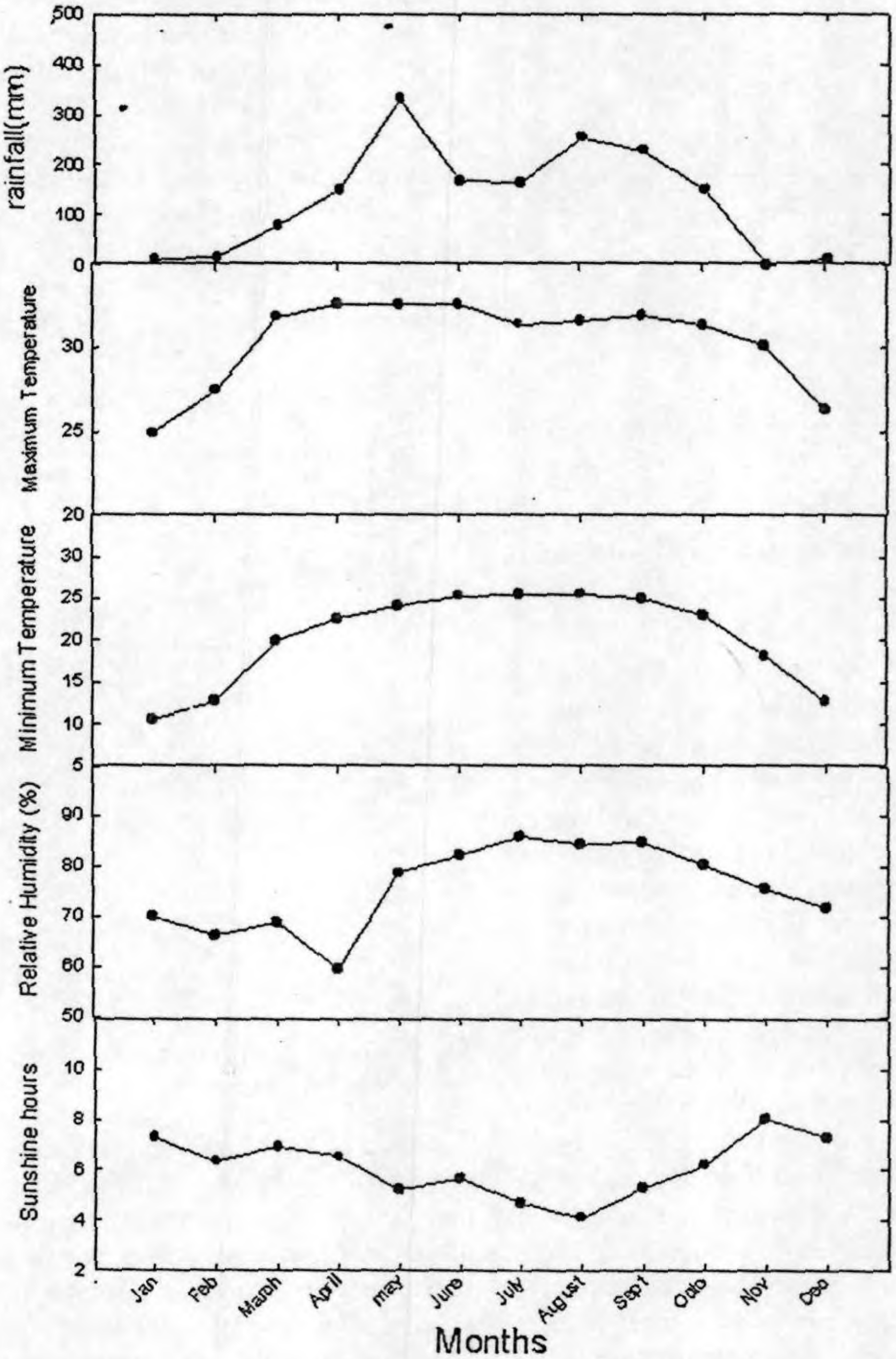


**Fig. 2. Monthly mean (five years) rain fall, maximum and minimum temperature, sunshine hours and relative humidity at Agartala**

Table 1. Initial flow rate, dry rubber content and plugging index of two clones in different air temperature during month of May and November

| Clone/Treatment | Initial flow ($ml\ cm^{-1}min^{-1}$) | Dry rubber content* (%) | Plugging index* |
|---|---|---|---|
| **May** | | | |
| Control | | | |
| RRII 105 | 0.180 ± 0.018 | 36.8 ± 0.91 | 6.22 ± 0.97 |
| RRII 118 | 0.117 ± 0.027 | 37.0 ± 0.43 | 8.28 ± 1.38 |
| Treatment (18°C) | | | |
| RRII 105 | 0.177 ± 0.02 | 36.6 ± 0.52 | 5.93 ± 0.79 |
| RRII 118 | 0.113 ± 0.02 | 37.7 ± 0.12 | 7.14 ± 0.87 |
| **November** | | | |
| Control | | | |
| RRII 105 | 0.086 ± 0.02 | 26.3 ± 0.85 | 1.33 ± 0.22 |
| RRII 118 | 0.070 ± 0.019 | 26.9 ± 0.65 | 1.74 ± 0.40 |
| Treatment (28°C) | | | |
| RRII 105 | 0.107 ± 0.025 | 26.6 ± 0.55 | 2.40 ± 0.10 |
| RRII 118 | 0.085 ± 0.022 | 26.9 ± 0.50 | 2.54 ± 0.39 |

(n = 8 ± SE), *Significant (t – test at P = 0.05)

Table 2. Sugar content of latex and bark and starch content of bark during May and November

| Month/Clone | Latex sugar (mg/g latex) | Bark | |
|---|---|---|---|
| | | Sugar (mg/g dry wt.) | Starch* (mg/g dry wt.) |
| **May** | | | |
| RRII 105 | 1.5 ± 0.2 | 14.0 ± 2.0 | 50.0 ± 4.5 |
| RRII 118 | 1.8 ± 0.2 | 15.0 ± 2.3 | 55.0 ± 4.3 |
| **November** | | | |
| RRII 105 | 1.2 ± 0.1 | 15.0 ± 2.1 | 37.0 ± 3.5 |
| RRII 118 | 1.4 ± 0.1 | 14.0 ± 2.0 | 38.0 ± 3.3 |

(n = 8 ± SE). *Significant (t – test at P = 0.05)

is the basic substrate for rubber (polyisoprene) production. In our observation, the latex sugar content was low during November compared to that of May, indicating higher utilization of sucrose (Table 2). High concentration of sucrose in latex may indicate either an increased supply (Tupy and Primot 1976) or low metabolic utilization (Prevot *et al.* 1984) for rubber synthesis. In general, high yielding clones maintained low latex sugar (Dey *et al.* 1995), which is evident in RRII 105 compared to RRII 118. Significant accumulation of starch in the bark tissue during May indicates the inability of utilization of storage (Table 2). However, reduction of starch content during November showed storage mobilization. The sugar content in the bark tissue has not shown any differences in both the seasons and clones. In rice, it was reported that the nonstructural carbohydrates remains in the leaves or culms, when the sink size was inadequate (Murata and Matsushima 1975). High sink to source ratio lines of rice varieties exhibited high carbon exchange rate (CER) per

Table 3. Photosynthetic rate of two clones during month of May and November

| Month/Clone | Photosynthetic rate* ($\mu mole\ m^{-2}\ sec^{-1}$) |
|---|---|
| **May** | |
| RRII 105 | 10.60 ± 0.90 |
| RRII 118 | 9.76 ± 0.80 |
| **November** | |
| RRII 105 | 13.75 ± 1.10 |
| RRII 118 | 12.71 ± 1.00 |

(n = 16 ± SE). *Significant (t – test at P = 0.05) unit leaf area and accumulated lower amounts of nonstructural carbohydrates in vegetative tissues than other lines (Lafitle and Travis 1984). It is generally accepted that allocation of photosynthates is in response to sink demand (Cook and Evans 1967).

High CER per unit area was observed during November than May in both the clones (Table 3). Low CER with high percentage of starch in the bark may be due to low sink demand, which is evident in low yield during May. High CER with low percentage of starch showed high yield in November which appears to be due to a high sink demand. Increase of yield may be due to increase in partitioning and that too in the expense of reduced growth at low air temperature in November.

The rainfall pattern showed that soil moisture is not a factor for this region and sunshine hours appears to be adequate (Fig. 2). Around 38 hours of sunshine per week are required for optimum yield in rubber (Raj *et al.* 2004). High temperature may be one of the main factors, which causes early plugging and restricts latex flow reducing the sink demand. Drainage of latex is less due to shorter period of flow and low yield ultimately results in sink limitation during May. However, the latex flow increased for a longer period due to delay in plugging during the low temperature period in November, ultimately increasing the sink size resulting in high yield which causes source limitation. *Hevea* yield is generally source limited if latex flow continues for a longer period. It is also sink limited when flow stops early due to plugging. Further, yield could be increased by increasing the period of flow during summer by delaying plugging through application of stimulants. Also, a high amount of latex could be drained over a period of time by increasing the frequency of tapping as long as the yield regulating factors remains unchanged.

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