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PHOTOSYNTHESIS AND PRODUCTIVITY OF RUBBER

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Plant growth and yield are controlled by the interaction of the genetic potentialities of plants and the environment in which they grow. The physiological processes of plants are the machinery through which the genetic potential operates for growth or productivity in the environment. Among the physiological processes, photosynthesis is the fundamental one to plant metabolism for the acquisition of radiant energy, which is the driving force behind growth and the rate of crop growth.

Photosynthesis and other related parameters:

Solar energy is transformed into chemical energy by green plants through the process of photosynthesis. The light for photosynthesis has major importance and it not only initiates the entire process, but also regulates the capacity of the photosynthesizing organs for reduction of CO_2 and production of energy. The canopy photosynthesis depends on the characteristics of leaves (total area, leaf age, orientation towards light intensity, individual photosynthetic activity) as well as on different environmental factors, mainly radiation. The leaf area index (LAI) varies with the age of a stand and also has significant effect on growth and photosynthetic rate, which increases with age and reaches maximum up to 14 LAI at 10th year for Clone RRIM 501 and declines further (Shorrock, 1965). Variation in area was also not observed in different planting density (Satheeshan et. al., 1982). Photosynthetic rate is negatively correlated with leaf area studied in *Hevea* seedlings (Dey *et. al.*, 1982). However, the literature about effect of leaf angle of *Hevea* is scanty which is most important factor for light interception in canopy. Canopy photosynthesis was studied by Monteny (1989), where 60% of leaves of canopy were taken as erect and calculated canopy photosynthetic rate which was double when compared to leaf level. Photosynthesis of a canopy is basically the integration of the photosynthetic rate of leaves that form the canopy. There are wide range of variation in photosynthetic rates in *Hevea* reported in the literature (Samsuddin, 1986, Dey *et.al.*, 1995, Nataraja and Jacob, 1999). Leaf age is one of the foliar chara-cteristics and it influences also the net photosynthetic rate which is due to developmental changes experienced by the plant organs along with progressive differentiation. Photosynthesis started for at least a week after leaf emergence and with an increasing trend up to 23-30 days and there after the rate declined slowly (Samsuddin and Impens, 1979). Leaf duration of *Hevea* may be ten months, usually it was observed that the new leaf formation starts in late January and defoliates in early December in traditional areas. However, variation is noticed in non-traditional areas. For each species there is a trade off between its annual investment in leaf production and return in terms of carbohydrate supply by foliage. Givnish (1988) estimated that the uptake of 1g CO_2 yields 0.68 g glucose, whcih in turn yield 0.28 g leaf, in general. Three most important factors in photosynthesis are : 1) the light response curve of the leaves, 2) the radiation intercepted by leaf canopy and 3) the distribution of light within the canopies. Photosynthetic response of a canopy to light is more linear than that of a single leaf. The lower leaves in the canopy that are not light saturated may still get benefit from an increase in light. The profile of photosynthetically active radiation (PAR) reaching the canopy of rubber tree exhibits a declining gradient towards the lower strata of the canopy. Although, the lower leaves are adapted to low light regimes, the maximum photosynthetic rate of shade leaves is low compared to sun leaves (Satheeshan *et.al.,* 1982). When canopy foliage is young and well watered, the carbon dioxide assimilation rate is very high (1.8×10^{-6} kg $CO_2 m^{-2} s^{-1}$) compared to the same foliage of 10 month old. The reduction of the foliage photosynthesis is 35 to 45% for the same average input with an energy efficiency of 4 and 2.5% respectively (Monteny and Barigah, 1985). The photosynthesis light response curve show photosynthetic quantum efficiency of 0.03 and 0.04 μ mol μ mol^{-1} respectively at leaf and canopy levels of a fast growing rubber tree clone GT 1 (Ceulemans and Saugier, 1991). The variation of daily mean photosynthetic rate and monthly total photosynthetic output in a year are double curve type at South China climate. The peak monthly photosynthetic output is higher for the second half than the first half of the year for clone RRIM 600 and GT 1 (Yauhua *et. al.,* 1983a).

Respiration:

The process of respiration provides energy demanded by the living components of plant to perform their biochemical and physiological functions. The dark respiration rate depends mainly on temperature and the maintenance respiration processes that occur at different rates with their own regulation, have CO_2 productions in common. The respiration rate of Hevea leaf or woody organ and temperature was of an exponential function and the relationship between the respiration rate of woody organ and diameter was of a reciprocal function (Yaohua *et. al.,* 1983b). The annual respiration estimated for clone RRIM 600 (17 years old and 5.6 LAI) showed that the stand consumed 3651 kg/ha. of organic matter through respiration (68.6% by foliage, 16.3% by roots and 14.2% by trunk and branches) equivalent to 62.2% of the total photosynthesis out put (5867 kg/ha.) The seasonal variations in respiration were observed and the highest peak was in the month of August and the lowest in January & February.

Growth :

Growth is considered to be an accumulation of organic material which is the biochemical conversion of reserve substances in to structural dry matter consists of organic compounds that remains at the end of the plant life. The biomass production by a tree is partitioned between the tree organelles, which changes in response to a changing environement. The annual biomass production during the first five years of growth (Clone RRIM 510) is about 1000 to 14,000 kg and 24,000 kg per ha during canopy forms a complete ground cover (Shorrocks, 1965). Variation of biomass production was also observed when sink was manipulated by different system of exploitation (Sethuraj, 1985). There is a scope for further increase in biomass production under full irrigation in dry sub-humid climatic regions (Vijaya Kumar, 1988).

Assimilate partitioning :

Assimilate partitioning is a process by which assimilate for growth are allocated to leaves, stem, root and storage organs or yield. Though only a part of the total biomass is harvested, all components are important to allocation of new dry matter even before the economic products are formed. The distribution pattern is a function of physiological age and the growth rate is basically source dependent. The more carbohydrate supplied, the faster growth and more yield. The rubber is harvested by controlled wounding known as tapping. The growth is reduced and a portion of biomass is also lost due to tapping (Templeton 1969). Such reduction is because of not only the loss of vital metabolites though latex, but also the high energy requirement for the resynthesis of rubber (polyisoprene with a calorifc content 2.5 times as that of glucose). The lost biomass, which is identified as K factor and varied with system of exploitation and positively related with harvest index (Sethuraj, 1985). The yield of rubber over years was negatively correlated with girth increment (Samsuddin *et. al.* 1987). In general, if a clone had higher rubber formation, its dry matter accumulation was low. There is a competition between rubber formation and dry matter accumulation. The system of exploitation also determines the partitioning pattern and therefore influences yield and growth rate (Sethuraj, 1985).

Various authors have tried to estimate the physiologically maximum yield that could be expected from a mature stand of rubber, and arrived at an estimate varying from 7000 to 12000 kg dry rubber per ha (Templeton, 1969; Sethuraj, 1981; Corley, 1983). The maximum annual growth rate that would seem to be feasible on the basis of leaf area index and conversion efficiency would be of around 40t/ha of dry matter. If half of the assimilates are used for rubber production and if the rate at which unrealized dry matter increment is converted to rubber equals the theoretical maximum of 44 percent, the rubber production would be around 9000 kg/ha.

Photosynthetic rate recorded in a controlled environment has been correlated with yield of clones of large scale trial (Samsuddin *et.al.* 1987). In this context, the wide variation of photosynthetic rates of *Hevea* can be utilized for breeding and selection programme for further increase of productivity. However, other than breeding and selection, study of photosynthesis and other physiological parameters may be best utilized in prediction of growth and productivity of *Heava* where the crop is not grown.

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Rubber planted in 1996 at Beharuhat (Jalpaiguri Dist., North Bengal) by M/s. Kanchan Tree Plantation, Siliguri attained an average girth of 30 cm by March 2000. The holding was recognised as a Demonstration Plot by the Rubber Board.

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