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RUBBER CUM SUGARCANE INTERCROPPING; A SUITABLE CROPPING SYSTEM FOR FARMERS IN THE INTERMEDIATE ZONE OF SRI LANKA

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ABSTRACT

In the process of expanding rubber cultivation to the non-traditional areas with drier climate, it is extremely important to find remedies for both biophysical and socio-economic limitations for it. In this regard, intercropping sugarcane with rubber was used as a tool in the present study. Sugarcane was planted in two densities together with immature rubber crop under on-farm conditions in the intermediate zone of Sri Lanka and growth and yield parameters were assessed. The planting density of sugarcane did not affect sugarcane yield per unit length of planting, hence the greatest yield per hectare was given by the highest density tested. Either density of sugarcane had no adverse effect on the growth of rubber, instead intercropped rubber showed an improved performance over the sole crop. Alleviation of radiation stress on photosynthesis by the partial shading given by sugarcane was identified as the factor which governed the better growth of intercropped rubber. Social implications of the rubber/sugarcane intercrop are discussed.

Key words: dry climate, intercropping, rubber, sugarcane

INTRODUCTION

Rubber (*Hevea brasiliensis* Mull. Arg.) originated from Amazon forests and now is a principal crop in wet tropics. Being a raw material for many and the important of vital industries, rubber will maintain its importance for years in future, despite of market price fluctuations. In Sri Lanka, it provides a major source of

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foreign exchange earning and also, a means of income generation to resource poor people. It is assumed that over 500 thousand people are employed either directly or indirectly in the rubber industry (Sri Lanka Council for Agricultural Research Policy 1992). The rubber as a crop, is grown in an area of *ca.* 158 thousand hectares and produces *ca.* 96 thousand tons of dry rubber annually (Plantation Sector Statistical Pocket Book 1999).

In Sri Lanka, rubber cultivation has generally been confined to the wet zone in which the scope for further expansion of rubber cultivation is limited due to the very high demand for land. Population density of major rubber growing areas in the wet zone has increased by *ca.* 19% during the period of 1981-1994 (de Silva, 1997) and thereby extent of the rubber cultivation has decreased by 21.7% (Plantation Sector Statistical Pocket Book 1999). Therefore as an alternative, the intermediate zone where the annual rainfall is in the range of 900-2150 mm (Panabokke, 1997) which appears to be sufficient for rubber cultivation, is currently being focused for further expansion.

Although agro-climatic conditions for rubber appear to be conducive in the intermediate zone, socio-economic constraints for such expansion should be considered seriously. As identified in the wet zone, the income gap between planting and harvesting of rubber may pose a significant problem to poor farmers in the area. With compared to the wet zone (WZ), the situation could be worse in the intermediate zone (IZ), since most farmers depend on seasonal or short term crops which have a minimal pay back period and also, rubber may take extended period for its maturity for tapping due to lesser rainfall in the IZ. Introduction of short term crops to rubber cultivation would be a practical answer in such situations, thereby farmers may get continuous income until the rubber crop is mature enough to generate an income. Having said that, one should be extremely careful in selecting intercrops as in addition to the biophysical suitability, such crops should tally with the farmers' interests in the area.

Sugarcane is a crop of high value in the dry and intermediate zones of the country, particularly in the Uva province with available market. Once planted, it has an ability to produce several harvests for years through ratoons. In general, intercropping increases total crop density resulting in an improved resource capture hence land use efficiency, despite the possibilities of reduced performance at individual crop level. Nevertheless, evidence suggests that intercropping on rubber lands provides not only the improved overall land use efficiency but also better growth of rubber compared to the sole cropping (Keli *et al.,* 1997; Kouadio *et al.,* 1997; Rosyid *et al.,* 1997; Rodrigo *et al.,* 1997). Among the factors identified for such better intercropping performance, beneficial effects of shade on photosynthesis and light use (Rodrigo *et al.,* 2001a), would be particularly important for the rubber in the intermediate zone where high radiation loads are always the case due to less cloud effects.

Rubber cum sugarcane intercropping

Having understood the potential benefits of intercropping with respect to rubber cultivation, this study focused on the feasibility of introducing a rubber/sugarcane intercropping system in the intermediate zone of the Sri Lanka. Special attention was paid to identify the suitable density and the varieties of sugarcane in the system.

MATERIAL AND METHODS

This study was commenced in 1992 in Monaragala district coming under the IZ. Smallholder farmers who had requested the subsidy payments from the Rubber Development Department, were interviewed for their interest in order to select sites. Due to limited resources and problems in managing trials, four farmers, two from Batugammana, one from Teruppahuwa and one from Bibile were selected for 1992. Three sites were properly established; and another two of the four sites selected for 1993 were successfully established (Table 1). At the end, five sites in total were used for the study.

Table 1. *Summary of the smallholdings used for on-farm rubber/sugarcane intercropping trials*

Notation given to the farmer	Year of establishment	Extent of the land (hectares)	Whether the farmer had rubber before	Experience in sugarcane cultivation
NMR	1992	0.8	No	For several years
JMR	1992	0.5	No	For several years
WMS	1992	0.8	Yes, 1.6 ha	For several years
TP	1993	0.4	Yes. 1.6 ha	For several years
DMPC	1993	0.8	No	For several years

Experiment comprised three main treatments, namely sole rubber and two intercrops with two sugarcane densities, *i.e.* four and five rows of sugarcane between two rubber rows. Both in sole and intercrops, planting density of rubber remained same at 500 plants per hectare with a spacing of 2.4m x 8.1m. Sugarcane rows were 1.2m apart and therefore, the distance between rubber and sugarcane was 1.6m in the five row (SC5) and 2.25m in the four row (SC4) intercrops. In addition to the main treatments, four sugarcane varieties, namely SL8306, SL7103, CO775 and H38/2915, were incorporated as sub-plots in the main density treatments. Each smallholding contained two sets of replicates. Being on-farm trials, the crop management could not be done as recommendations set by research institutes. Basically, crops were established as per the recommendations of the rubber and sugarcane research institutes. All farmers received fertilizer for rubber under the rubber subsidy scheme and for sugarcane from the Sugarcane Research Institute. Although farmers were advised to follow the recommendations of relevant research institutes for other general upkeep such as weeding, timing and frequency of such practices were greatly influenced by the socio-economic factors.

Data gathering, particularly yield figures, of on-farm trails was extremely difficult as the sites were scattered and far way from research institutes. Biophysical assessments were conducted till 1995, of the sites established in 1992. Being in immature phase, only the growth of rubber was monitored using annual girth assessments of the trunk at 0.9 m height. Also, height of rubber was measured at the end of first year growth, but could not be continued in subsequent years due to difficulties in reaching the top of the canopy. However, for the sites established in 1993, there was only single set of girth measurements at 18 months after planting. Yield of sugarcane was recorded with the harvests of mother crop in all five sites and of two ratoon crops in the site of JMR. Also, gas exchange parameters of rubber in both sole and intercrops were studied using a portable infra red gas analyser (Li Cor LI6200). This was restricted to a single day and to a single site (*i.e.* JMR), however conducted diurnally with two sets made at 0900-1000 and 1130-1230 hours of the day. The highest rate of CO_2 assimilation was shown by the most recently matured leaf whorl of rubber (Nugawela, 1989; Rodrigo, 1997), hence it was used for the study with two leaves from the whorl and then two plants per each treatment for each set of measurements.

RESULTS

Growth of rubber, indicated by the girth at 0.9 m height, in both intercrops (SC4 and SC5) outperformed that of the sole crop rubber through out the study on all smallholdings (Figs. 1 and 2). On average, girth of intercropped rubber on three sites established in 1993, showed a 61% increase over that of sole rubber by the end of 35 months. Assuming a linear growth, the mean rate of girth increase over the period in intercrops was 0.58 cm $month^{-1}$ and 41.5 % greater than that of sole crop. However, growth of rubber in the two intercrops was more or less similar on all smallholdings except on the site NMR where that of SC5 appeared to be greater than that of SC4 in the latter stage. Though the mean plant height of rubber after a year of growth, was not statistically different, intercropped rubber showed *ca.* 29% greater values over the sole crop (Table 2). Growth of rubber was independent of the sugarcane variety; hence it was not presented on such basis.

Table 2. *Effect sugarcane density on plant height of rubber. Values are in meters and the treatment codes R, SC4 and SC5 represent the sole crop rubber and intercropped rubber planted with four and five rows of sugarcane. Values in the parenthesis show the Standard Error of Means.*

Notation given to farmers	R	SC4	SC5
NMR	1.23 (±0.11)	2.23 (±0.16)	3.05 (±0.17)
JMR	2.91 (±0.17)	3.19 (±0.21)	3.44 (±0.14)
WMS	3.26 (±0.21)	3.87 (±0.07)	3.34 (±0.14)

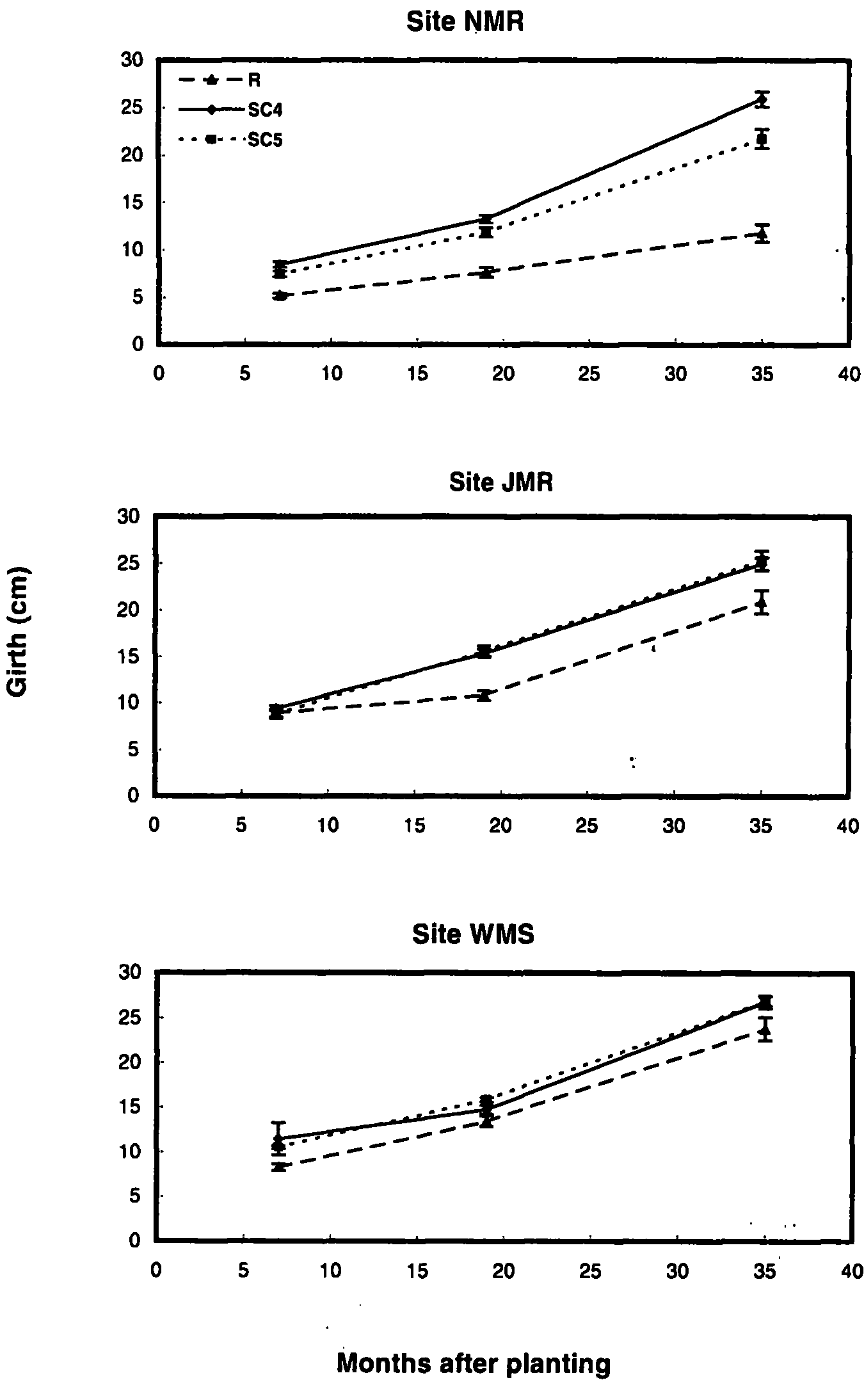
The performance of the economic yield of sugarcane varieties with respect to yield per unit length of planting row, varied without any distinct pattern on different smallholdings resulting in no statistical differences (Figs. 3 and 4). Also situation was same in mother and first ratoon crops, however, by second ratoon crop, the yield has declined to values of 65.4 % of the mother crop. Mean yields of sugarcane varieties for the mother crop and for all smallholdings tested were 18.7, 18.8, 22.5 and 20.4 kg m^{-1} for SL7103, CO775, H38/2915 and SL8306 varieties, respectively. Also, mean yields for mother, first ratoon and second ratoon in JMR were 7.2, 8.6 and 4.7 kg m^{-1}, respectively. Except for few occasions, in general, the yield per hectare was greater in the high density system of SC5 irrespective of the variety grown and three harvests. Therefore, average over the experimental period and different sites, SC5 system produced 222 MT per hectare per year, and was 62.6 MT above the SC4 system.

Despite the increase in incident light levels, the rate of CO_2 assimilation of rubber in all treatments declined in the afternoon with compared to the values recorded in the morning (Fig. 5). However, this decline was minimal in the SC5 intercropping system.

DISCUSSION

Obviously, the intermediate zone of the country is having lesser amount of rainfall than the wet zone, however, the problem is more associated not with the amount of the rainfall received, but its distribution. Therefore, plants undergo prolonged dry spells resulting reduced growth rates. This is a challenge for further expansion of rubber cultivation which is now focused to the intermediate zone, since

Fig. 1. Treatment effect on the plant girth (measured at 0.9 m height) of rubber for three different sites established in 1992. Treatment codes R, SC4 and SC5 represent the sole crop rubber and intercropped rubber planted with four and five rows of sugarcane. Error bars are for the Standard Error of Means where 'n' is over 14 for all sites


Site NMR
R
SC4
SC5
Site JMR
Site WMS
Girth (cm)
Months after planting
0
5
10
15
20
25
30
35
40

the land availability in the wet zone of the country is becoming increasingly limited with rapid urbanisation. Evidence shows that rubber takes extra years in drier region to become harvestable resulting a significant problem particularly to smallholder farmers (Unpublished data of the Genetic and Plant Breeding Department of the RRISL). Most of those studies have been confined to the sole cropping systems of rubber; however, according to the present study, intercropping sugarcane with rubber undoubtedly improves the growth rate of rubber (as indicated by the girth and height of plants) comparable to that in the wet zone (Rodrigo *et al.* 1995; Rodrigo *et al.*, 2000), alleviating the problem. Although this happened to be the first time to record such a growth improvement in the drier region of Sri Lanka, it has been evident before with intercropping in the wet zone of the country (Rodrigo *et al.* 1997) and elsewhere (Keli *et al.*, 1997; Kouadio *et al.*, 1997; Rosyid *et al.*, 1997).

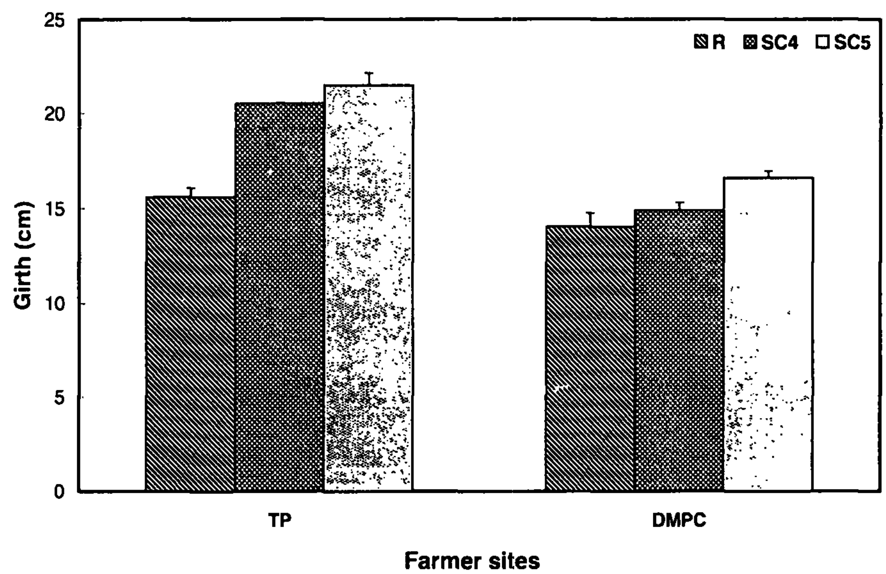


Fig. 2. Treatment effect on the plant girth (measured at 0.9 m height) of rubber for two different sites established in 1993. Treatment codes R, SC4 and SC5 represent the sole crop rubber and intercropped rubber planted with four and five rows of sugarcane. Error bars are for the Standard Error of Means where 'n' is over 11 for both sites

In addition to the beneficial effects on rubber, either planting system of sugarcane has not affected its yield on per unit length basis; hence the high density SC5 system was capable of providing highest yield per hectare. This is extremely important to farmers not only by providing greater yields, but also by improved net

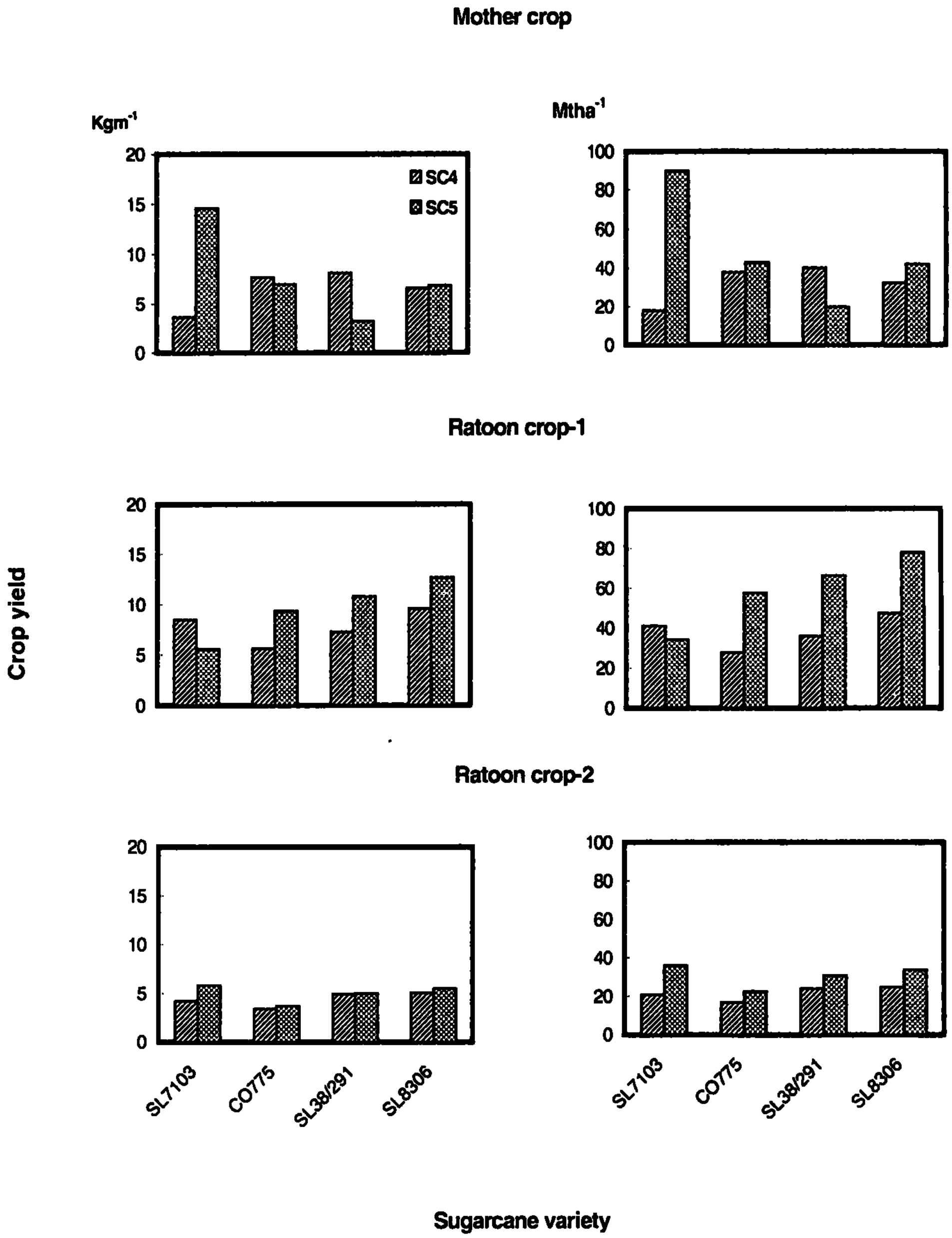


Fig. 3. Treatment effect on sugarcane yield at the on-farm site of JMR (established in 1992) in mother and first and second ratoon crops. Treatment codes SC4 and SC5 represent the intercrops with four and five rows of sugarcane

profits since the establishment cost at the high-density system of sugarcane involves extra expenditure only for planting material and with reduced weed growth. Increased land use efficiency is a must for resource poor farmers (Stirling *et al.*, 2001) as it was observed that some farmers tended to grow seasonal crops even within the small gap left between rubber and sugarcane.

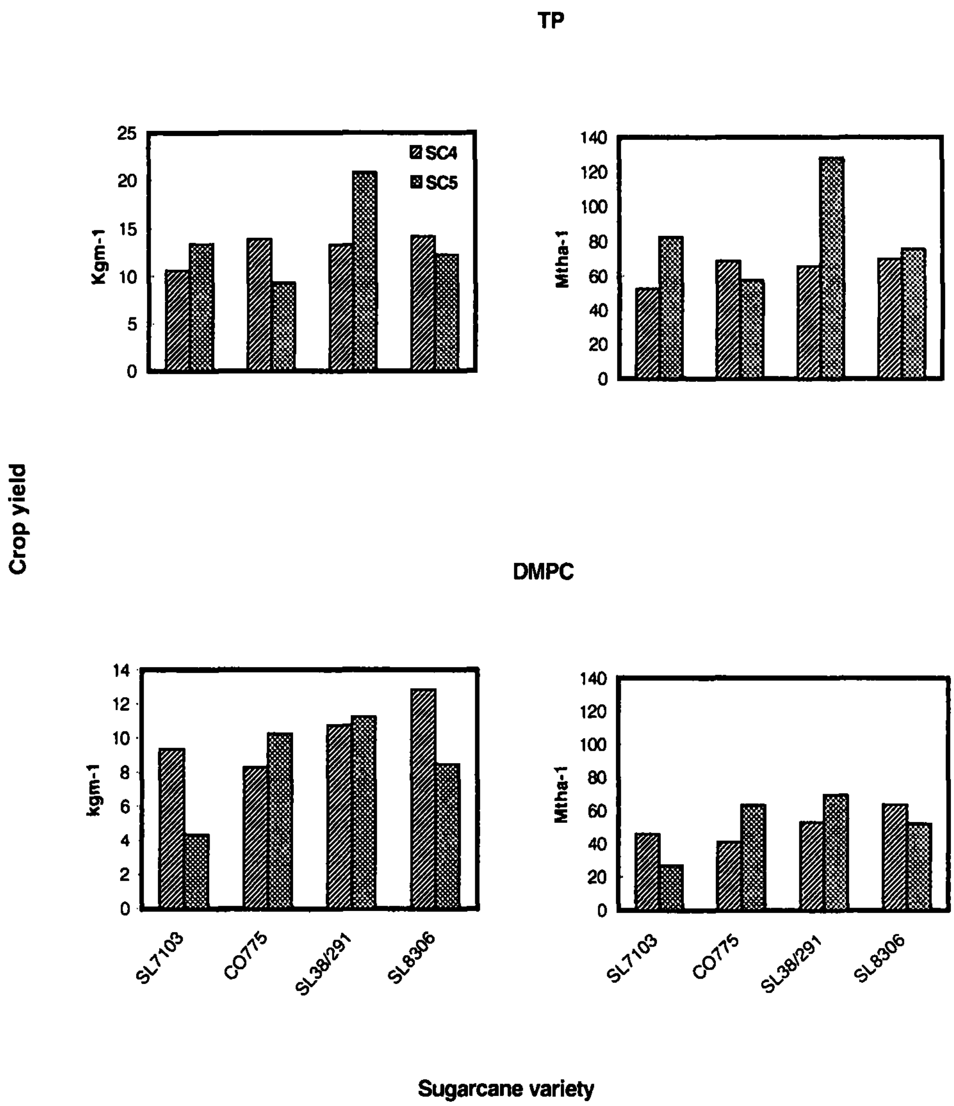


Fig. 4. Treatment effect on sugarcane yield of mother crop at the on-farm sites of TP and DMPC (established in 1993). Treatment codes SC4 and SC5 represent the intercrops with four and five rows of sugarcane.

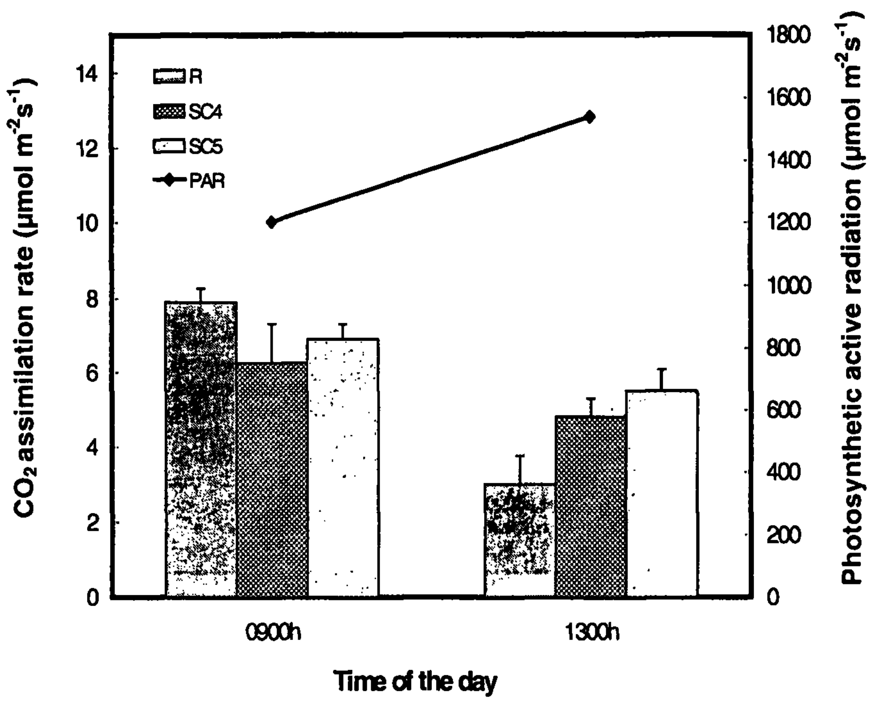


Fig. 5. Diurnal variation in photosynthesis of rubber at leaf level in different cropping systems. Treatment codes R, SC4 and SC5 represent the sole crop rubber and intercropped rubber planted with four and five rows of sugarcane. Error bars are for the Standard Error of Means where n=4. Incident light in the basis of Photosynthetic Active Radiation (PAR) for a given time interval is also given.

The livelihood of the rural people in the intermediate and dry zones of the country depends more on farming with Chena crops (*i.e.* subsistence and quick cash crops), hence farmers cannot afford to have longer no income period of rubber, though they prefer rubber as a crop for long term income generation (Stirling *et al.*, 2001). Intercropping with rubber plays an important role in this context providing early return and with improved growth of rubber as evident here. Sugarcane, being an economic crop which requires little attention once established and provides several ratoon crops for several years, fits well within the requirements of farmers. Marketing of sugarcane can be done directly to the sugar factory in the same district or there is well established cottage industry for juggery within the village premises. For instance, the marketability and the flexibility of labour involvement are some of the major factors referred by wet zone farmers for their preference to banana in rubber based intercrops (Rodrigo *et al.*, 2001b). In addition to socio-economic benefits, being a C4 plant. sugarcane carries biophysical advantages required to perform in areas with less rainfall and high temperature

Total crop yields of the intercropping systems always tend to be greater with respect to those in sole crops with increased resource capture through heterogeneity of the canopy and the root system. However. the improved growth performance of intercropped rubber is not explained by such phenomenon and based on experience in the wet zone, it can be attributed to beneficial effects of partial shading that increase dry matter partitioning to above ground structures such as leaves (Rodrigo *et al.*, 1997) and improved overall light use efficiency hence canopy photosynthesis (Rodrigo *et al.*, 2001a). The photosynthetic rate of intercropped rubber was slightly lower in the morning hours than that of the sole crop, however, by afternoon it was *vice versa* with greater decline in photosynthesis in the sole crop, despite the increase in incident light. Therefore, as supported by previous studies, the overall rate of photosynthesis would be grater in intercropped rubber revealing the fact for improved growth. Mid day depression in photosynthesis is generally associated with transient moisture stress caused by high radiation loads on plant leaves during these hours and/or down regulation of photosynthesis due to accumulation of assimilates in active sites (Henley *et al.*, 1991; Baker *et al.*, 1994; Layne & Flore 1995); in drier climates, the situation could get aggravated by less clouds leading to high radiation loads for a given period. Intercropping with sugarcane, a C4 plant, which prefers such conditions genetically for greater productivity, would alleviate the radiation stress on rubber plants during early stages with shading, resulting in less chance for photoinhibition hence improved productivity. However, levels of photoinhibition in rubber in different cropping systems and its effect on overall productivity in drier climates are yet to be studied.

It is always the case that farmers accept technologies looking at the success of their peer group members. Not only the fact that the improved growth of rubber in the rubber/sugarcane system is a good sign which invites more farmers to practise the same, on-farm conditions provide additional confidence to them. With compared to that of the sole crop, improved growth of rubber in intercrops would obviously reduce the immature phase of rubber and provide improved latex yields plus more timber yields at the end adding further benefits to intercropping.

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