Technology refinement of rubber/banana intercropping using a farmer participatory approach

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ABSTRACT

On-farm adoption of the technologies developed under on-station conditions has been below expectations, demanding technology refinement in accordance with the requirements of end- user farmers. However, assessment of farmers' needs and subsequent adjustment of the technology are time consuming compared with that of direct recommendations which have often been practiced. The study reported here was on the technology refinement of rubber/banana intercropping and identification of issues related to rubber cultivation at the smallholder level in Sri Lanka. Planting of a single row of banana between two rubber rows had initially been recommended in rubber/banana intercropping, however, an on-station experiment showed that planting density of banana with rubber could be increased threefold without any deleterious effect on either crop. Based on some preliminary observations on farmers' needs, a series of on-farm experiments were set up in four villages in both the wet and intermediate zones of Sri Lanka. Both bio-physical factors on plant growth and socio-cultural effects in the rural context were also taken into consideration. Finally, the observations made by scientists were verified through a farmer participated central workshop.

Selection of rubber by the smallholders was driven by two main benefits, firstly as a long-term income source and secondly to secure land ownership. Intercropping was a practical measure to generate income during the early stage of rubber cultivation, particularly in the intermediate zone where farmers depend more on on-farm than off-farm activities. The extension services on rubber were not up to expectations of the farmers. In addition to the market factors, crop selection for intercropping was based on the income level of farmers and availability of family labour. Among the systems tested, two-row planting system for banana with rubber was found to be the most suitable system for smallholders.

Key words: intercropping, participatory approach, on-farm, rubber

INTRODUCTION

Productivity gaps exist between experimental figures and what farmers produce. This is very often attributed to farmers' inability to take up the technology which has been developed under high input systems. Also, scientists are often blamed for not understanding what the farmers' need. Such productivity gaps are evident even in the rubber crop; for instance average annual yield per hectare in Sri Lanka is below 1000 kg (Plantation Sector Statistical Pocket Book, 2001) whilst experimental figures for the recommended clones are above 2000 kg (Attanayaka, 2001). Achieving the productivity targets given by on-station experiments are limited by two constraints. It is obvious that environmental, i.e. soil and climatic factors vary among sites and this would partly explain the productivity differences between experimental and farm sites. Secondly, availability of resources is scarce with smallholder farmers and even in the plantation sector, required inputs are not so abundant. More importantly, priorities placed on crop management are greatly influenced by socio-cultural activities. Collectively, such socio-economic factors contribute largely to the productivity gaps.

With careful management, high productivity levels have recently been achieved by some plantation companies. Being in a resource poor category, smallholders are bound to practise low input cultivation systems and also, their activities are influenced largely by other social obligations. Therefore, farmers inevitably change any technology in accordance with their requirements with that technologies should be refined with farmer participation in order to make them suited to farmers' needs (Chambers *et al.* 1989). Moreover, due to the complexity in the smallholder sector, blanket recommendations are not feasible; hence target groups should be identified before the onset of the dissemination process. Adaptive research with on-farm trails under different environmental and socio-economic conditions would be the answer, but the gap between rhetoric and the reality of farmer participation in research activities seems to be even greater than the productivity gap that exists between

on-station experiments and on-farm conditions (Okali *et al.*, 1994). Nevertheless, the present study reports a success story on the refinement of the technology on rubber/banana intercropping in order to suit it for smallholder conditions identifying the issues affecting rubber based intercropping at the smallholder level in Sri Lanka.

MATERIAL AND METHODS

Preliminary work and scientific background

Planting density of banana in rubber/banana intercropping had initially been recommended by the Rubber Research Institute of Sri Lanka (RRISL) without any systematic study and with the view of minimizing any competitive effects on either crop. Therefore, an on-station experiment on rubber/banana intercropping was initially set up to assess the effect of planting density of banana on growth and yield of both crops. Five treatments were imposed as follow; sole crop rubber, sole crop banana and three intercrops comprising an additive series of one, two and three rows of banana to one row of rubber. No adverse effect on either crop was reported; instead results were promising that density of banana could be increased up to three rows without having any detrimental effect on either crop (Rodrigo *et al.* 1997), but increasing overall profitability by ca. 400% (Rodrigo *et al.* 2001a). More importantly, girth of rubber plants in inter- than in sole- cropped treatments, resulting in early tapping and increased latex yields (Rodrigo *et al.* 2000). Such improved growth performance during early stages of the development was largely due to increased efficiency in resource capture (Rodrigo *et al.* 2001b).

On-farm experiments

The importance of rubber/banana intercropping in the context of the livelihood of poor in Sri Lanka has been clearly shown (Stirling *et al.* 1998), and the next stage was to assess the practicality of high density rubber/banana systems at the smallholder level. Four villages in total, two from each wet and intermediate zones, were selected for on-farm experiments in 1999. Similar to the intercrop treatments used in the on-station experiment, three banana densities comprising one to three rows of banana in between two rubber rows were planted in these on-farm trials. Monoculture banana was not an option to smallholders opt to grow rubber, hence the same was not established. However, a part of the rubber land was not intercropped with banana in order to impose the sole rubber treatment. Each smallholding comprised only a single replication. Where the extent of land was insufficient to establish all intercrop treatments, two intercrops were established, however the number of replications of any intercrop treatment was kept more or less the same within a village. A survey conducted in parallel to the on-station experiment revealed that smallholder farmers hardly apply any inorganic fertilizer to banana (Rodrigo *et al.* 2001a), hence intercropped treatments were split into two sections; with and without the application of inorganic fertilizers to banana. As it was always the case in Sri Lanka, farmers had access to the rubber subsidy programme of the government and received planting materials and approximately half the dose of fertilizer for rubber. In addition, in order to establish the treatments as researchers wished, selected farmers were provided with planting materials of banana and then its fertilizer requirement, i.e. only for the plots designed for it. Initial establishment of rubber in the Intermediate zone was poor, hence farmers were supplied with additional number of rubber plants in order to meet casualties. In general, all on-farm activities were undertaken in a rather extensive manner according to smallholders' discretions.

Growth of rubber and banana was periodically monitored for two years. Girth of rubber and banana plants was measured at 90 cm and 10cm height, respectively. Farmers were provided with log books to record their observations and activities, however, such recordings were successful only with a few, but provided valuable information to monitor the trials. In addition to the direct involvement in on-farm trials, activities of other farmers in selected villages were also monitored. On behalf of the scientists, two agronomists and two social scientists gathered the information in close association with farmers.

Girth increment rates of rubber and banana were calculated. In order to assess the relative performance of rubber under intercropping, the rate of girth expansion of rubber was transformed into the crop performance ratio (CPR), which refers to the girth expansion under intercropping weighted by that in the sole crop (Azam-Ali *et al.*, 1990). Statistical package 'Genstat' (Genstat, 2001) was used in data analysis with One-sample and Two-sample 'T' tests for the comparisons of treatment plots and agroclimatic zones, respectively. In addition, associations were tested with Spearman rank correlation. Nevertheless, assessments in the social context were basically conducted in qualitative manner.

Farmer workshop

The next step was to build up a dialogue among farmers and bring the observations made by scientists for an open discussion in the farming community in order to ascertain any refinements required in the technology adoption. In 2001, a two-day workshop was held at the RRISL, with farmers provided with free transport, food and accommodation. Farmers from selected villages where on-farm experiments were conducted, arrived at the RRISL on the day before the workshop. Facilities were made available to built up a cordial relationship among farmers by sharing their different interests such as folk stories, customs, farming experience.

The workshop began on the following day with a warm welcome by the Director of the RRISL in order to show the recognition given to them in the rubber industry and then the objectives of the workshop were described by scientists. Condition of each on-farm trail was reported in a simple format describing the situation with respect to weeding, personal interest on other intercultivation practices, damage done by wild animals, log book maintenance and growth of rubber and banana (Table 1). The presentation was also supported by pictures of individual on-farm sites and multimedia. It was followed by the presentation on the conclusions made by the scientists (Table 2).

Discussions commenced thereafter; farmers were organized into two working groups with a mixture of people of different ages and different villages. Scientists acted purely as facilitators in the process. Although scientists were interested in discussing their listed observations one at a time, farmers tended to discuss issues collectively. At the end of the discussion, each group appointed someone to present their conclusions. On issues where two groups were had different opinions, there was an extended discussion and final conclusions were drawn with conditions (Table 3).

RESULTS AND DISCUSSION

Crop growth in on-farm sites

In general, intercropped rubber performed better

Table 1. An overview of on-farm experiments established in both wet and intermediate zones.

	Level of Weeding	Damage by animals	Record maintenance	Personal interest	Growth of Rubber	Growth of Banana
Wet zone						
Village 1						
Farmer 1	Good	Severe	Good	Good	Good	Good
Farmer 2	Intermediate	Severe	Good	Intermediate	Intermediate	Intermediate
Farmer 3	Poor	Intermediate	Intermediate	Poor	Intermediate	Poor
Farmer 4	Poor	Intermediate	Good	Poor	Intermediate	Nil
Village 2						
Farmer 1	Intermediate	Nil	Intermediate	Intermediate	Good	Intermediate
Farmer 2	Poor	Nil	Good	Poor	Intermediate	Poor
Farmer 3	Intermediate	Nil	Poor	Intermediate	Good	Intermediate
Intermediate zone						
Village 1						
Farmer 1	Intermediate	Nil	Poor	Intermediate	Intermediate	Good
Farmer 2	Poor	Nil	Poor	Poor	Intermediate	Nil
Farmer 3	Intermediate	Nil	Good	Intermediate	Intermediate	Good
Village 2						
Farmer 1	Poor	Nil	Poor	Poor	Intermediate	Poor
Farmer 2	Intermediate	Nil	Good	Intermediate	Good	Intermediate
Farmer 3	Intermediate	Nil	Good	Poor	Good	Poor
Farmer 4	Good	Nil	Good	Good	Good	Good
Farmer 5	Intermediate	Nil	Good	Intermediate	Good	Intermediate
Farmer 6	Poor	Nil	Good	Poor	Good	Poor
Farmer 7	Good	Nil	Good	Intermediate	Good	Intermediate
Farmer 8	Good	Nil	Good	Good	Good	Good

Table 2: Summary of the observations made on-farm studies by researchers.

(a) Agronomic

Intercropping in general

- ♦ is an useful practical means of providing an additional income during the immature phase of rubber.
- ♦ has no adverse effect on growth of rubber, instead facilitates an increased growth rate of rubber.
- ♦ protects rubber plants from heavy sunlight.

Rubber/banana intercropping

- ♦ increasing banana density up to three rows has no effect on the growth of either rubber or banana.
- ♦ growth of banana is much more sensitive than rubber to competition from weeds.
- ♦ application of inorganic fertilizer is essential for good growth of banana.
- ♦ Application of inorganic fertilizer to banana has no effect on rubber and does not explain the benefits of intercropping on rubber growth.

(b) Sociological context of smallholder rubber cultivation

Rubber in general

- ♦ Farmers grow rubber as a means of acquiring crown lands where possible and to secure land ownership where it is loosely held.
- ♦ Knowledge of rubber plays a significant role in the success of rubber cultivation.

Intercropping

- ♦ The greater the distance between the homestead and land, the less intensive the cultivation inputs and so the poorer the growth.
- ♦ Farmers in the low-income category preferred to grow low capital and less labour demanding crops.
- ♦ Access to the market and its stability encourage farmers to grow a wider range of crops.

Homegardens

- ♦ Crop diversity depends on the period of residency such that the longer the period the more diverse the range of crops grown.
- ♦ Increase in the size of homestead increases the total number of crops, but decreases the number of crops per unit area.

than sole rubber with that mean CPR for rate of girth expansion was above the unity (Table 4 & 5). As shown by the rate of girth expansion, growth of rubber in the wet zone was significantly superior to that in the intermediate zone ($P<0.05$) (Table 4). However, this was not reflected in the number of plants survived due to the fact that initial causalities of the rubber plants in on-farm sites of the intermediate zone were very high and farmers were provided with additional number of plants for infilling. Both climatic and social conditions such as farmers' livelihood, knowledge etc. differed in these two major agroclimatic regions, hence the combined effect of those would have contributed to the differences in growth rates. In banana, regional growth differences with respect to either rate of girth expansion or percentage success were not evident. Being a succulent plant, low rainfall conditions in the intermediate zone would be adverse to the growth of banana; however it is a crop of ubiquitous presence with that farmers have wide knowledge and experience on this crop. This would suggest that within the limits of the study, social factors would have a greater impact than climatic factors on plant growth.

Growth rates of both rubber and banana were associated with the weeding condition of the site ($P<0.05$) (Table 4) with that growth of plants was superior in well-managed sites. Further, similar association was found with percentage of plants survived. In particular, this was significant for banana ($P<0.05$). Undoubtedly, weeds are competitive with crops and results suggested that rubber could withstand the competition imposed by weeds better than banana.

In both wet and intermediate zones, application of inorganic fertilizer promoted the growth of banana ($P<0.01$) (Table 5). Nevertheless, application of fertilizer to banana had no significant effect on the growth of rubber in the intercropped treatments. Hence, had recommended level of fertilizer been given, rubber appeared not to be a great competitor to the banana crop for nutrients.

Discussion on the outcome of the workshop

In general, farmers agreed with the observations

Table 3: Summary of the conclusions drawn up by farmers and researchers at the end of project workshop.

(a) Agronomic

Intercropping in general

- As a practical means of providing an income during the immature phase of rubber, intercropping is very important in the Intermediate Zone *vis a' vis* the Wet Zone as farmers depend more on on- than off-farm activities.
- It protects rubber plants from heavy sunlight and facilitates an improved growth of rubber.

Rubber/banana intercropping

- Increasing banana density up to three rows has no affect on the growth of either rubber or banana. However, farmers prefer the two row planting system of banana due to the fact that should the three row system be practiced, banana clumps must be maintained/pruned properly which is not the case for many smallholders. This was particularly important for banana varieties with large canopies such as Ambun and Anamalu. If banana is over crowded, it would affect the yield of banana, but not on growth of rubber.
- Effect of weeds on the growth of banana is more severe than its effect on the growth of rubber. Despite the importance of weeding, farmers tend to prioritise off-farm activities which provide a quick return, resulting in less time for on-farm activities.
- Application of fertilizer is essential for good growth of banana. The option of using organic manure is limited by its unavailability in sufficient quantities even in rural Sri Lanka.
- Application of inorganic fertilizer to banana has no effect on rubber and does not explain the benefits of intercropping on rubber growth.

(b) Sociological context of smallholder rubber cultivation

Rubber in general

- In new clearings, farmers grow rubber as a means of acquiring crown lands where possible and to secure land ownership where it is loosely held. Also, they prefer rubber as a long-term income source.
- Knowledge of rubber plays a significant role in the success of rubber cultivation, particularly in the Intermediate Zone (IZ) where farmers have less experience of rubber. Since farmers from IZ have no mature rubber, they demand more knowledge on immature upkeep of rubber. In general, farmers are dissatisfied with the extension service, quality of planting materials issued and the timing of their distribution.

Intercropping

- The greater the distance between the homestead and land, the less intensive the cultivation inputs and poorer the growth.
- Farmers in the low-income category preferred to grow low capital and less labour demanding crops. However, if family labour was freely available, then farmers may select high income crops which demand higher labour inputs
- Access to the market and its stability encourage farmers to grow a wider range of crops.

Homegardens

- Crop diversity depends on the period of residency such that the longer the period the more diverse the range of crops grown.
- Increase in the size of homestead increases the total number of crops, but decreases the number of crops per unit area.

made by the scientists (Table 2). They considered intercropping as a practical means to solve the problem of lack of income during the immature phase of rubber. However, this was not an option of great importance to the farmers in most of areas in the wet zone *vis a' vis* the intermediate zone since farmers in the wet zone depended more on off-farm than on-farm activities. In the intermediate zone, the majority of villages were remote and farmers have few options forcing themselves to work and depend on farming activities. Also, they cannot withstand no income phase of rubber, i.e. the immature phase, with that the majority of rubber farmers carry out intercropping on rubber lands with their traditional crops at least for first few years. This view was clearly supported by the interest paid by farmers in intercropping activities in the villages of the intermediate zone and with the good growth of rubber and banana (Table 1). The amount of damage done by animals to intercrops in the intermediate zone were less than in the wet zone, reflecting the greater interest and hence protection given by farmers to their crops in the intermediate zone rather than to any differences in population of wild animals (Table 1). Also, farmers were very confident in their opinion that intercropping, particularly with banana, provided a cooling effect on rubber, resulting in an improved growth and this was in agreement with

Table 4. Growth and establishment of rubber and banana in on-farm conditions with respect to agroclimatic zone and level of weeding. Crop performance ratio is based on the rate of growth expansion, whilst % plants survived represents the plants survived by end of the experimental period. Values are presented as means with standard errors for the treatment plots in on-farm sites falling into particular category.

Agro-climatic zone	Level of weeding	Rubber			Banana	
		Rate of girth expansion (cm/month)	Crop Performance Ratio	% Plants survived	Rate of girth expansion (cm/month)	% Plant survival
Wet zone	Poor	0.42 ± 0.06	1.75 ± 0.25	86.2 ± 5.15	0.72 ± 0.27	60.1 ± 9.2
	Intermediate	0.48 ± 0.03	1.00 ± 0.12	78.8 ± 2.39	1.64 ± 0.25	73.7 ± 7.91
	Good	0.67 ± 0.00	0.97 ± 0.00	100.0 ± 0.00	2.58 ± 0.26	75.0 ± 3.33
Intermediate zone	Poor	0.23 ± 0.06	1.03 ± 0.09	91.4 ± 5.28	0.84 ± 0.17	60.8 ± 7.06
	Intermediate	0.23 ± 0.03	0.94 ± 0.07	92.1 ± 2.39	1.09 ± 0.0.26	72.2 ± 2.76
	Good	0.43 ± 0.04	1.17 ± 0.03	96.4 ± 1.7	2.61 ± 0.0.36	88.6 ± 2.29

Table 5: Growth and establishment of rubber and banana in on-farm conditions with respect to agroclimatic zone and fertilizer level for banana. Crop performance ratio is based on the rate of growth expansion, whilst % plants survived represents the plants survived by end of the experimental period. Values are presented as means with standard errors for the treatment plots in on-farm sites falling into particular category.

Agro-climatic zone	Fertilizer levels	Rubber			Banana	
		Rate of girth expansion (cm/month)	Crop Performance Ratio	% Plants survived	Rate of girth expansion (cm/month)	% Plant survival
Wet zone	Not fertilized	0.48 ± 0.05	1.19 ± 0.17	81.8 ± 5.35	1.09 ± 0.35	63.2 ± 7.47
	Fertilized	0.51 ± 0.05	1.31 ± 0.24	87.7 ± 5.50	1.89 ± 0.27	75.6 ± 6.59
Intermediate Zone	Not fertilized	0.30 ± 0.04	1.06 ± 0.08	90.4 ± 2.42	1.32 ± 0.33	74.1 ± 4.00
	Fertilized	0.28 ± 0.04	0.99 ± 0.05	96.1 ± 1.92	1.68 ± 0.35	75.5 ± 4.69

what scientists found earlier (Rodrigo et al. 2001b).

Farmers preferred two row planting system of banana over either one row or three row system and were of the opinion that if the three row system is to be practiced, banana clumps have to be maintained/pruned properly, which is not a common practice among smallholders. This was particularly important for banana varieties with large canopies such as Ambun and Anamalu. If banana was over crowded, it would affect the yield of banana, but not the growth of rubber.

Timely weeding was required for the success of banana, which in turn was greatly influenced by the availability of family labour. Off-farm activities which provided quick returns, change farmers' priorities resulting in less time for farming. Weeding with hired labour and chemical weeding were considered to be expensive and shared labour was not being generally used for day-to-day upkeep of crops. Even under the cases where expenses for hired labour can be borne, supervision of efficient utilization of such labour appeared to be problematic, if family members are not free to do so. Hence in the absence of sufficient family labour, crops suffered from weed infestation.

If weeds are controlled to a satisfactory level, the need of inorganic/chemical fertilizer for the growth of banana could be minimized. Banana appeared to be a crop which requires frequent application of fertilizer, however, competition by banana with rubber for nutrients was minimal in the intercrops and growth of rubber was independent of the application of fertilizer to banana. Recycling of banana trash would be an option to reduce the fertilizer requirement and if properly done could reduce the level of infestation by banana weevil; however, farmers' were inexperienced in this aspect and so had little confidence in investing time of such activities.

Most of new plantings of rubber are done on lands acquired or obtained from the government and farmers are given a license for farming after the certification of the village headman 'Gramasevaka' and regional government agent. Cultivation of perennial crops provides proof of a farmers' long-term involvement in the land and hence the

eligibility for outright ownership. Being a perennial crop which is grown with subsidy certificate, rubber appeared to be an ideal crop for this purpose, however in addition, farmers were of the view that rubber provides a long-term continuous income. For this reason, farmers have selected rubber among other perennial crops. Moreover, land security is not an issue for most lands that are replanted with rubber. Nevertheless, farmers cultivate other important crops for their livelihood in conjunction with rubber maintaining the diversity of income sources, as recorded earlier by Rodrigo *et al.* (2001c) and Stirling *et al.* (2001).

Distance from home to farm is a primary factor affecting farmers' on-farm involvements and crop safety. However if lands are not nearby, as a solution, farmers go for less intensive systems and select crops which require neither frequent attention nor threatened by animals and thefts. Being a robust crop, rubber has an advantage in this regard, however in such instances possibilities of intercropping are confined to a few crops of similar nature (eg. Citronella in Hambantota region).

Marketability of farm produce together with price stability would be a prime factor involved in crop selection for medium and large scale cultivation. However, subsistence needs of farmers have also been taken into consideration, particularly in small scale production. Also, farmers selected crops depending on their financial status. For instance, farmers in the low income category selected crops which demand low investment and vice versa. Similar observation has also been made earlier (Rodrigo et al. 2001c). However, exceptions do exist and there were many cases within the community where low income farmers were not confined to less labour-demanding crops, but were looking for high income crops as family labour was available.

In general, farmers were not satisfied with the rubber-based extension activities, however farmers in the wet zone were knowledgeable and had many years of experience in rubber cultivation and they were less dependent on extension personnel, other than for the subsidy receipts. Farmers in the intermediate zone were less experienced in rubber cultivation and were dissatisfied with poor involvement of the extension service. Virtually no farmers from the intermediate zone had mature rubber crops, hence they demanded more advice on immature upkeep, in particular on the management of nurseries and disease. During the workshop and visits to the experimental sites, farmers in the intermediate zone expected to learn more on rubber cultivation, even though the programme was not designed to cover this aspect.

Although farmers were not satisfied with the extension activities, they were heavily dependent on the extension service for the monitory and material inputs given through the subsidy programme of the government. However, farmers particularly in the intermediate zone, showed their dissatisfaction on the quality of the planting materials received and the timing of their distribution, which were crucial for the success of the rubber crop. Also, timing of the fertilizer distribution was criticized.

Farmers agreed in principle with the scientists' views on crop diversity in homestead that it depends on the period of stay and the size of the homestead as mentioned in Table 2. However, they added that crop diversity is a matter of interest of individual farmers. Therefore, there were many new homesteads where crop diversity is high and *vice versa.*

Recommendations derived from the on-station experiment were refined in accordance with farmers' views and from ground observations and the advisory circular of the RRISL on rubber-based intercrops and the handbook was amended accordingly (Advisory Circular No: 2001/1 of the RRISL; Rodrigo, 2001). Also, information gathered in the workshop was noted for future research programmes.

In addition to the workshop discussions, farmers visited experimental sites at the RRISL and so experienced how scientists carry out experiments. It appeared to be one of the factors which helped farmers to build up confidence in researchers. According to farmers, visiting the RRISL and participating in the workshop was a wonderful experience to them. Farmers felt that their views are fully recognized by the scientist and expressed their desire to participate in similar activities in the future. With the experience of this workshop, we scientists strongly believed that direct dialogues with end-user farmers are extremely useful and essential to the success of technology transfer.

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