trials planted in 1995

RAS 1.1 · RAS 2.2 · AVG · RAS 3 klon · RAS 3.1 · RAS 3.2 timber · AVG

IN CM

replications per trial and average

Kalimantan trials planted in 199[5]

RAS 1.1 · RAS 2.2 · AVG · RAS 3 klon · RAS 3.1 · RAS 3.2 timber · AVG

IN CM

replications per trial and average

Preliminary results of RAS on-farm experimentation

In terms of RAS establishment, the 3 main factors being evaluated are rubber planting material (clonal rubber), weeding and fertilization level, in particular phosphate (P) (Penot, Fairhurst and al, 1996).

The most critical period for RAS establishment are the first 2 years where competition with weeds and/or secondary forest (in RAS 1) is the most aggressive.

The set up of the network has been done in 2 years between January 1995 and October 1996. The first results available concern the first set of trials established in West-Kalimantan in January/April 1995 and enable us to modify trials protocols according to field situation and farmers feedback.

Clonal rubber vs secondary forest regrowth : the weeding level.

The first preliminary results show that the required weeding level in RAS 1 for clonal rubber is far higher than that of jungle rubber. The later requires only no weeding or 1 weeding/year while depending on weed pressure, between 3 and 6 weeding/year are necessary for clonal rubber in Jambi, and a minimum of 6 weeding/year in West-Kalimantan due to Imperata. The first RAS 1 trial planted in January/April 1995 in Sanggau, with 0, 1 and 3 weeding/year shows clearly that weeding level was not sufficient to overcome Imperata which systematically invaded all plots (fig 2). Figure 1 shows that growth (in height and diameter 10 cm above grafting point) of RAS 1 plots (all plots together as there were no significant differences occurred between plots) is similar to that of RAS 3.2 plots completely invaded with Imperara (and established on sheet Imperata grassland that can be considered as the worst situation for rubber). Therefore, protocols have been modified with 4, 6 and 8 weeding/year in West-Kalimantan (3-6 and 9 in Jambi). First observations seems to show that 3/4 weeding/year may be sufficient in Jambi. The number of weeding/year is relevant in West Kalimantan because Imperata comes back regularly at least up to canopy closure provide sufficient shadow. In Jambi, another way to assess weeding pressure is necessary and farmers are probably the best placed to assess that pressure and decide to weed or not.

Annual intercropping: the most efficient alternative for rubber growth

By comparison, RAS 2.2 plots (fig 2) have a better growth performances close to that of a control, established with the average growth of 3 clones well maintained. These preliminary results were discussed with farmers and have helped the team to modify the treatments, in particular the weeding levels according to rubber growth requirement. There higher labour requirements have not been well accepted by farmers and difficulties in following weeding protocols have been observed showing that the maximum acceptable limit was reached in term of labour acceptable to farmers in West-Kalimantan. RAS 2.2 labour requirement is better accepted due to rice cropping.

In West-Sumatra, the continuous upland cropping system (rice/groundnut rotation) provides very favourable conditions for rubber growth. In West-Kalimantan fig 3 shows that rubber growth is significantly affected by quality and level of weeding of rice intercropping with the example of 4 farmers having cropped rice but with a different level of weeding and maintenance. However, rice fertilization does not

RUBBER GROWTH MONITORING
WEST KALIMANTAN
RAS 2.2/95   First set of trials

TABLE 2

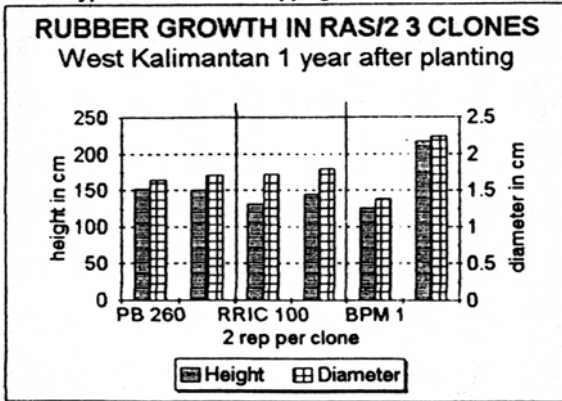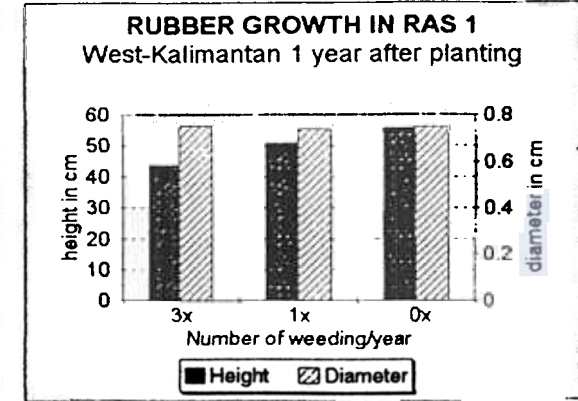**GROWTH COMPARISON OF 3 CLONES**

RAS 2 type with rice intercropping

RUBBER GROWTH IN RAS/2 3 CLONES
West Kalimantan 1 year after planting

TABLE 3

RAS 1 trial : rubber growth according to weeeding level

First protocol with 0, 1 and 3 weeding/year

RUBBER GROWTH IN RAS 1
West-Kalimantan 1 year after planting

RAS 2.2 trial : rubber + associated trees + rice intercropping

TABLE 4

EFFECT OF LEVEL OF WEEDING

RUBBER GROWTH IN RAS 2.2
West kalimantan 1 year after planting

TABLE 5

EFFECT OF RICE FERTILIZATION ON RUBBER GROWTH

RUBBER GROWTH IN RAS 2.2
West Kalimantan 1 year after planting

PLOT A & B/+ BPS fertilization
PLOT C & D / no rice fertilization
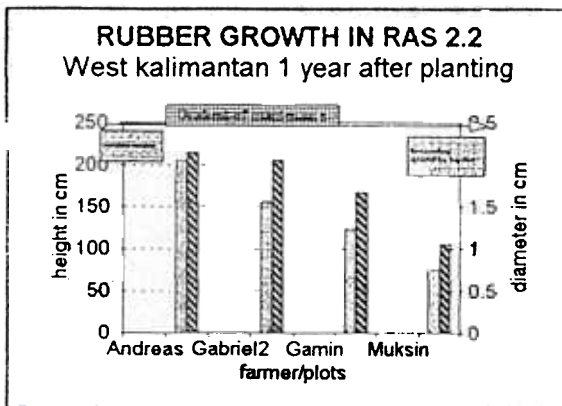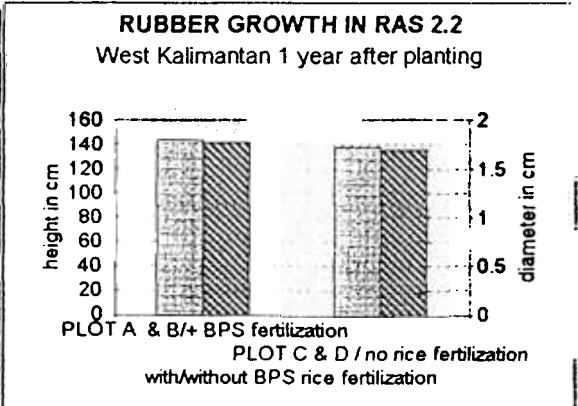with/without BPS rice fertilization

RAS 3 trial : rubber + associated trees + rice intercropping year 1 + covercrops

TABLE 6
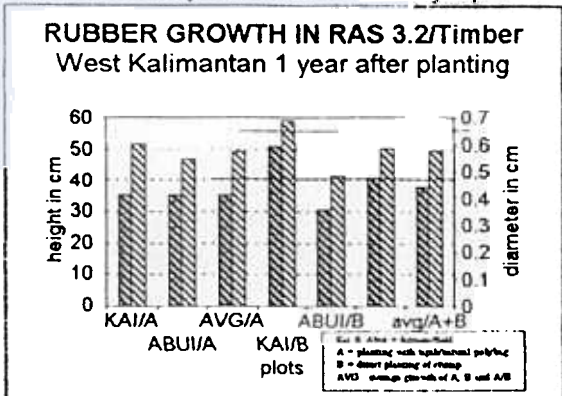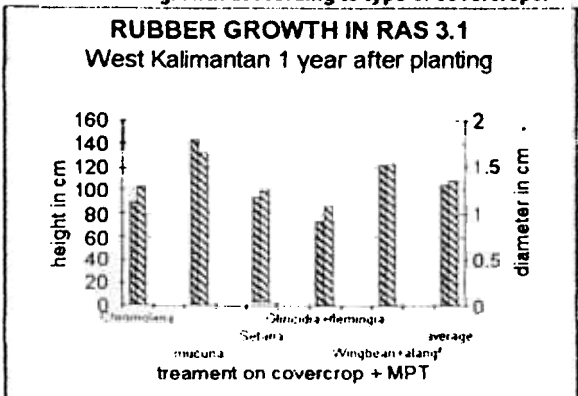
RAS 3.2 : Covercrops have been overcome by Imperata.


RUBBER GROWTH IN RAS 3.2/Timber
West Kalimantan 1 year after planting

TABLE 7

RAS 31. : ruber growth acccording to type of covercrops.

RUBBER GROWTH IN RAS 3.1
West Kalimantan 1 year after planting

treament on covercrop + MPT

RUBBER GROWTH MONITORING
WEST SUMATRA

PKT demonstration plot

TABLE 8   Planting of rubber : 1993
                                Growth data collection: June 1996

RUBBER GIRTH AT 3.5 years old
PKT/PRO-RLK/GTZ dem-plots in W Sumatra
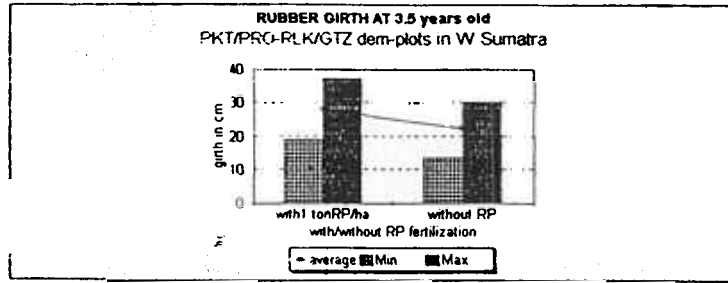
RICE YIELDS IN RAS 2.2
WEST KALIMANTAN

RAS 2.2/95   First set of trials

TABLE 9
Rice yields in RAS 2.2 in Sintang with rubber trees at the age of 3.5 years old.
Treatment on rice varieties and level of fertilization
Transmigration area : imperata grassland.
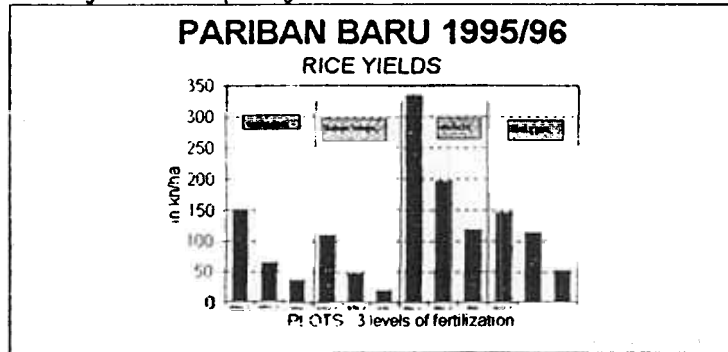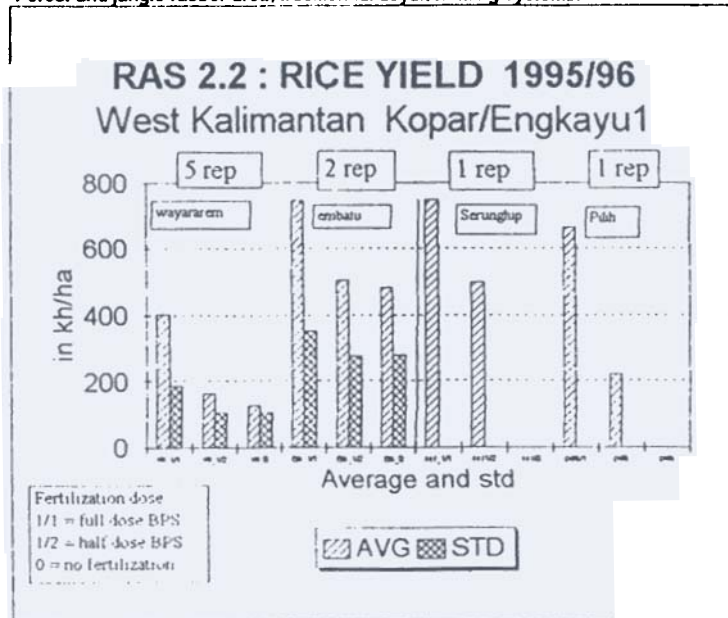

PARIBAN BARU 1995/96
RICE YIELDS

TABLE 10
Rice yields in RAS 2.2 in Kopar/Engkayu with rubber trees at the age of 1 year old.
Treatment on rice varieties and level of fertilization
Forest and jungle rubber area, traditionnal dayak farming systems.

RAS 2.2 : RICE YIELD 1995/96
West Kalimantan Kopar/Engkayu1

Fertilization dose
1/1 = full dose BPS
1/2 = half dose BPS
0 = no fertilization

seem to have an impact on rubber growth during the first year (fig 4). A significant difference may be expected the second year.

RAS 3 : covercrops/MPT/FGT vs Imperata at low labour cost.

The main constraint continues to be Imperata as shown in fig 5 with RAS 3.2 plots entirely invaded by Imperata. The objective is to find out what is the best combination with covercrops/MPT/FGT to overcome Imperata at a very low labour input. An experience has been made to compare direct planting and "tapih technique". In that case, one cannot observe any differences also in the type of planting technique (direct planting in January vs tapih (vegetal polybag) in April as both planting time are obviously too late in the rainy season to enable a sufficient development of young trees and compete with alang^2. Early planting of rubber in polybag is an essential condition for RAS establishment.

The first set of treatments with various covercrops and MPT's has been entirely overcome by Imperata. Therefore, some RAS 3 trials have ben transformed into RAS 1, because natural vegetation regrowth finally overcome Imperata after 1 year showing that a failure in establishing covercrops in RAS 3 may be recovered according to surrounding vegetation.

Following that first experience, a better selection of covercrops has been made on 1 field. Fig 6 shows that best results were obtained with Mucuna and Wingbean invaded by Imperata. In fact, since may 1996, Mucuna has been overcome by Imperata (as well as Wingbean) and the best plot is now the one with Chromolena, the only covercrops were Imperata has entirely disappeared.

The weeding/fertilization combination is a key component in the trade off between rubber growth/competition and input/labour cost.

Rubber fertilization : P is a key component for rapid rubber growth

The first trials in West-Kalimantan have been planted with a very low level of inputs (200 grams of Rock Phosphate per tree at planting time) which has proved far from sufficient for growth of clonal rubber in competition with the forest regrowth in RAS 1, or with Imperata in the dry season with RAS 2. P. A small amount of N (50 grams/tree every 3 months for the first 2 years), added to Rock Phosphate resulted in a very good growth of GT 1 clone in Jambi. In West-Kalimantan, where the soils are very poor, the TCSDP fertilization programme (NPK every 3 months) has been adopted for the first 2 years only. The supply of fertilizers has stimulated rubber growth and competing successfully with forest regeneration in RAS 1 in West-Kalimantan.   In West-Sumatra a previous demonstration-plot (PK/Pro-RLK/GTZ) showed the efficacy of large amount of RP (1 ton/ha) at planting time for rubber growth (fig 7). P is definitely a major limiting factor in all sites, but N-K is also necessary in West Kalimantan and West-Sumatra, at least for the first 2 years (compared to the 5 years of rubber fertilization in TCSDP recommendations.

Comparison between clones

Comparison between clones (fig 8) shows that BPM 1 and PB 260 have the best growth performances, followed by RRIC 100, however BPM 1 seems to be more heterogeneous. The selected clones are all high yielding, fast growing, resistant to leaf diseases (in particular *Colletotrichum*) and adapted to farmers tapping (BPM 1, PB 260, RRIC 100 and RRIM 600, introduced in 1996). In Jambi, GT 1

shows relatively good performance however *Colletotrichum* is present in that province (as well as in West-Sumatra). It is preferable to use in RAS clones that are tolerant or resistant to that leaf disease as a forest environment, the combination with other trees may increase the risk. Pigs and monkeys which are the main constraints in forests margins. -

The above indicated the importance of establishing clonal rubber recommendations based on field trial observations in various ecological zones. In Jambi, the *Colletotrichum* leaf disease seems to be at a very low level, enabling farmers to use other non resistant clones (such as GT 1, RRIM 712 or BPM 24). This led to the planting of a RAS 1 type trial with the 4 selected clones (and seedlings) in order to compare their performances in a forest environment.

Rice intercropping in RAS 2.2

Rice experimentation in RAS 2 has shown a significant effect of N-P-K fertilization (at economic level) in the first year (graph 9/Kopar-Engkayu) and the third year (graph 10/Bariban Baru) after rubber planting. However yields are too low to off-set the cost of fertilization. While fertility is the first constraint, other factors are : rice seed quality and availability, susceptibility of rice to insects pests and blast, and erratic rainfall at critical periods (in particular after flowering), traditional planting patterns, shading after the second year and insufficient weeding. Further constraint analysis is necessary to identify optimal conditions for upland rice intercropping to minimize risk for farmers. CRIFC trial in Jambi shows that HYV upland rice yields may reach 2-3 tons/ha with a complete package using rice varieties such as Wayararem and Jatiluhur, fertilization, 3 weeding and crop protection. In Imperata infested land, zero or minimum tillage may also be used in order to limit the labour requirement and enhance profitability of herbicide use. Another constraint in RAS 2 is the availability of associated trees, the necessity for the farmers to establish their own nursery and the relatively high mortality of the trees in the field due to insufficient weeding. Labour investment is generally low (except by the Minang farmers in West Sumatra), justifying the low labour approach. In West-Kalimantan, a medium level of inputs, in particular fertilization, is necessary for RAS establishment.

RAS 3 on Imperata grassland

Preliminary observations on covercrop establishment in RAS 3 shows the following constraints : seed quality is very poor and lead to low density sprouting, generally rapidly overcome by Imperata, covercrops cannot grow without a minimum supply of P (200 kg in West-Kalimantan, though this was not necessary in Jambi), the non-viny covercrop species (selected for minimizing weeding compared to classical LCC used in plantation such as *Calopogonium, Centrosema pubescens or Pueraria javanica*) such as *Flemingia Congesta, Crotalaria, Chromolena Odorata, Wing bean and Mucuna* have difficulty in competing with *Imperata* in the first dry season. Shading from MPT's, planted in October with rubber and rice, may help to overcome , or limit *Imperata* in the dry season. A combination of covercrops and MPT's (*Gliricidia*) and fast growing pulp trees *(Gmelina arborea, Paraserianthes falcataria and Acacia mangium)* has been selected for experimentation in 1996. First results show that Chromolena odorata was most successful at outcompeting Imperata.

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Conclusion

In all cases, the early planting of rubber stumps with 1 whorl in polybag at the very beginning of the rainy season in October is an absolute necessity. The direct planting of stumps has been a failure in West Sumatra due to very poor soils, steep slopes, bu mainly due to erratic rainfall, and has also lead to high losses in West-Kalimantan due to poor quality of planting material supplied by a local development project (though this may reflect the quality of planting material to which farmers may have access). The stumps in polybags have already developed a root system necessary for rapid growth, in order to be sufficiently developed by the dry season (March-September in all sites) and to be able to compete with secondary forest regrowth in RAS 1 and *Imperata* in RAS 2 and 3. The availability of good quality stumps with sufficient girth is also a significant criterion. In West-Kalimantan, stumps are traditionally produced with a small diameter due to poor growth in nurseries. This highlight s the necessity to produce recommendations for building a clonal rubber planting material supply system with higher quality that could be achieved by farmers. The budwood garden programme objective is to a certain the ability of farmers to produce such high quality planting material. Another result is that if competition with weeds is important, and in particular Imperata, water is probably the main constraint in the dry season (with a possible stop in growth) as shown also in experimentation in South-Sumatra (Wibawa, 1995).

Cost-Benefit analysis of RAS technologies compared to jungle rubber and TCSDP rubber monoculture system : the economic rationale of RAS.

Introduction to the comparison of 7 rubber based cropping systems

A preliminary financial analysis of 7 rubber based systems ranging from the least intensified, but the most used and traditional in Indonesia - jungle rubber - to the most intensified, RAS 2.2 with annual and perennial intercropping has been done (Penot, 1996) through the calculation of NPV (Net Present Value) over the complete lifetime (up to 35 years), the productivity and return to labour of various rubber based cropping patterns.

If technical components of RAS technology are currently being tested in the fields with farmers at real scale, it seems also very important to have an assessment of its economic validity.

Some of the components of these calculations are assumptions as these systems, in particular RAS are still in the stage of on-farm experimentation with farmers. However, yields patterns of rubber and other associated trees or crops have been carefully chosen to reflect reality, according to yields observed in other similar agroforestry systems described by various author (De Foresta, Michon, Gouyon, Salafsky, Dove...). The 7 systems are described in details in table 5).

RAS recommendation domains

In all cases, rubber is the main economic driving force of each system. Income diversification enable farmers to profit from market opportunities for fruits, timber, rattan and other non-timber products. RAS 1 and RAS 2.5 are designed for farmers in remote or pioneer areas with low cash availability and without land shortage. RAS 2.5 is targeted particularly especially for piedmont zones close to

TABLE 5

The 7 systems are the following :

- 1 - **traditional jungle rubber with unselected rubber seedlings** (actual existing system): this system has no cost other than labour in term of inputs and is very extensive.

- 2 - **Jungle rubber with clonal seedlings (GT1)** (existing system, in particular in areas close to estates, but not yet well developed) : this system uses a planting material available in all zones where estates have been established with clones. The cost of establishment is limited to the cost of the seeds or seedlings.

- 3 - **TCSDP like monoclonal rubber plot** (existing as development schemes): this system is based on the traditional project technological package developed by TCSDP[7] including clones and a high investment of weeding and maintenance,. This system requires a high level of input and labour and is ,so far, considered the 'modern and intensified' rubber cropping pattern. Costs are TCSDP estimates (TCSDP reports, DGE)), adapted with 1996 prices. In 1995, TCSDP has introduced upland rice intercropping in its technological package, so we did (for the first 3 years with improved rice and fertilization).

- 4 - **RAS 1**[x] (experimental): this is basically a jungle rubber system using clones and a minimum of inputs (TCSDP like fertilization for the first 2 years) and labour (weeding is limited on the row). The inter-row is not weeded and secondary forest is allowed to grow replacing the traditional LCC covercrops used in TCSDP system. This system is similar to the "jungle weeding" as referred by Djikman (1951) but adapted to modern clones. This is a low input/medium labour system. The challenge here in terms of research is to see if clones can compete and grow well in an agroforestry environment at a given level of inputs (basic fertilization) and labour (minimum number of weeding per year). Emphasis is put on return to labour optimization. Biodiversity is expected to be similar to that of jungle rubber. The target is the farmers in pioneer or remote areas, as well as those with limited labour resources. Biodiversity in RAS 1 is high, similar to that of jungle rubber.

- 5 - **RAS 2.2** (experimental) : rubber + associated trees + rice intercropping the first 3 years. Associated fruits and timber trees are planted at a density of 92 trees/ha. Improved or 4 months local rice (with fertilization) is grown during the immature period. The system is intensive with a medium level of input/labour requirement. Income is diversified with rubber, rice, fruit and timber production.

- 6 - **RAS 2.5** (experimental) : rubber + cinnamon : this system is specifically developed for the Jambi province where cinnamon is a recent opportunity for local farmers. A cinnamon planting density of 3 x 3 meters results in 1100 cinnamon trees/ha intercropped with rubber.

- 7 - **RAS 3.3** (experimental) : rubber + associated trees + FGT (fast growing pulp trees) : this system is designed for degraded lands where Imperata is a major risk. The first year is cropped with rice; immediately after the harvest non climbing covercrops such as Flemingia or Crotalaria are planted in order to limit the level of weeding. Associated trees and FGT are planted in the inter-row. FGT are harvested in the 5th year. This system is specifically developed for West-Kalimantan (Sanggau area) where pulpwood species can be sold to the planned pulp factory.

The main difference between RAS 1 and RAS 2/3 is that RAS 1 requires a specific environment to be set up with surrounding vegetation being forest, jungle rubber or tembawang with no Imperata. The associated trees are those which naturally growing and subsequently selected by the farmer. In RAS 2/3, associated trees are directly planted by the farmers who can choose the species among those which are adapted and are not too competitive with rubber. In RAS 2/3, tree diversity is limited to the cropped species, however farmers may select among the naturally growing species those which have an economic output.

All systems except RAS 2.5 have rice intercropping the first year.

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[7] TCSDP = Tree Crop Smallholder Development Project/World Bank

[x] All Rubber Agroforestry Systems have the following characteristics :
- rubber is planted at 550 trees/ha (6 x 3 meters). The selected clones are PB 260, RRIC 100, RRIM 600 and BPM 1
- associated trees (if any) are fruits (local and improved rambutan) and local timber trees at 92 trees/ha (9 x 12 meters)
- FGT (Fast Growing pulp Trees) are planted at 3 x 3 in between rubber and associated trees (400 trees/ha). They are harvested the 5th year after planting.
- cinnamon is planted at 3 x 3 in the inter-row and harvested the 7th year.
- fertilization follows TCSDP recommendations for the first 2 years.