# Agricultural Research and Innovations with Special Relevance to Malaysian Rubber Smallholders

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Of the 4.28 million ha of cultivated land in Malaysia in 1980, about 46.8% or just over 2 million ha was under rubber. Individual independent smallholdings accounted for 54.7% while small farms organised under schemes, e.g. the Federal Land Development Authority (FELDA), and the Federal Land Consolidation and Rehabilitation Authority (FELCRA), accounted for about 20% of the total area under rubber. Thus almost 75% of rubber or 1.5 million ha are cultivated by smallholders, the majority of the small farms being less than 3 to 4 ha. The remaining area (about 0.5 million ha) is managed as organised estates.

The total area of rubber under the estate sector has been declining. In 1960, this sector accounted for 0.89 million ha or 45% of the rubber areas. On the other hand, the total area in the smallholder sector has increased from 1.08 million ha in 1960 to 1.49 million ha in 1980.

At the same time, the productivity in the smallholder sector is low compared to that in the estate sector. In 1960, the average yield per planted hectare was only 436 kg/ha in the smallholders sector, while that in the estate sector was 758 kg. By 1970, the average yield in the two sectors was 752 and 1189 kg/ha, respectively. These large differences were ascribed to many factors, the main one being that by 1970, about 90% of the rubber in the estate sector had been replanted with the then modern clones while such replacement in the smallholders sector was less than 70%. Another factor considered as a contributor to this was that almost all research on rubber was conducted in the estate sector. The realisation of this disadvantageous position of the smallholdings resulted in research also being directed to selected problems in the smallholders sector from the mid-1960s (Pushparajah et al. 1973a). Till the mid-sixties as indicated earlier, all research investigations were conducted in the commercial estates. It cannot be denied that the smallholders benefited from this research though the results of the investigations were directly applied to these holdings often without adjustments for their conditions. From the mid-sixties, results of such investigations were tested in and adapted for smallholding situations. The main areas of agricultural research aimed at smallholders were on:

1. Choice of planting materials.
2. Density of planting and methods of establishment.
3. Fertiliser use, cover and interrow management.
4. Exploitation.

Further, in a large number of instances, the smallholders would have no alternative income during the first six years of replanting. Investigations on cultivation of intercrops and/or small ruminants to provide alternative sources of income were initiated and still continue.

This paper discusses the results and progress of such continuing investigations.

## Agricultural Innovations

### Planting Materials

Till the late 1960s, clonal seedlings used to be the main planting material supplied to smallholdings. On the other hand, in the estate sector, buddings of selected clones were often used. The former were not only variable, but generally had lower potential than buddings of more modern clones. Further, even when buddings were used in the smallholder sector, these were confined to choice from one to two clones for the whole country.

On the other hand, the estate sector had the choice of a large number of clones. They were categorised into:

1. Class One clones for planting on a large scale, with a choice from about 5 to 7 clones.

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2. Class Two clones for moderate scale planting up to one-third of planting on an aggregate, with a choice from 10 or more clones.
3. Class Three clones for experimental plantings in 2-10 ha with a choice from often more than 10 recent clones.

At the same time, the Malaysia Peninsula was divided into 17 planting regions. The regions were based on susceptibility to wind and the incidence of leaf, stem, and panel diseases. Thus, in any one area, the clone to be used would have to have a resistance for the limiting factor prevalent in the planting region. At the same time, for the estate sector, clonal seedlings were also included as a material suitable for large scale planting.

On the other hand, investigations had shown that for the smallholders sector, the use of clonal seedlings was not practicable for a number of reasons. Among these was the fact that they could not be identified and thus the seedlings used in plantings may not be the genuine materials. Further, clonal seedlings could not withstand intensive tapping as often practised in the smallholders sector. In view of these findings, clonal seedlings were removed from the planting recommendations for smallholdings in 1973 (RRIM 1973).

In the absence of any direct experimental work in the smallholders sector, based on extrapolation of the Institute's trials, planting recommendations for smallholdings were revised according to the 17 regions as for the estates (Pushparajah et al. 1973a). The choice of clones was confined to only the Class One clones. However, in any one district, the smallholder was given a choice of at least three clones. The recommendations also indicated that in order to get the maximum benefit, a mixture of 2 or more clones was to be used.

Subsequent to this recommendation, investigations on the smallholder sector have also involved establishment of Class Two and Class Three clones on an experimental scale on block planting. These continue to be monitored with the view to enable better selection of newer materials more adapted to smallholder situations. At the same time, the planting recommendations for the different sectors have recently been revised (RRIM 1983) and six clones have been incorporated under the Class One category to be used in the individual smallholder sector.

This recommendation incorporates for holdings $< 1$ ha, only one clone and for holdings $> 1$ ha but $< 2$ ha, any one clone should not account for $>$ 50% of the planting.

For block plantings, some Class Two clones are also provided. However, the area planted with any one of these Class Two clones should not exceed 10% of the total planting in the block.

The objective of the recommendation is to ensure maximum choice at minimal risks.

The choice of a clone to be used still rests, however, on the environment of the area.

**Density of Planting**

Experimental and survey results (Westgarth and Buttery 1965) have shown that yield per unit area increased with higher density up to a point. However, based on the experiences of the estate sector, the commonly recommended density for buddings in both estate and smallholder sectors continued to be 370-400 trees/ha at the commencement of tapping. Barlow and Lim (1967) however, based on economic evaluations of results of earlier trials, pointed out that the economic density varied with the management practice. The density at commencement of tapping considered optimum for the smallholders sector ranged from 370-420 trees/ha where hired tappers were used. On the other hand, where the owner himself tapped the holding, a stand of up to 500 trees in tapping was considered desirable. Based on this evaluation, the planting recommendations on density were appropriately modified for the smallholder sector with the recommended initial stand being a minimum of 500 trees/ha. To evaluate further the performance under actual smallholder situations, such different densities have been implemented in selected smallholdings.

Abdullah (1979) evaluated the performance of smallholdings with different densities. His evaluation and economic analysis clearly indicated that for independent smallholdings, an average of 400-500 trees/ha in tapping is optimal. To achieve this, an initial stand of 550-700 trees/ha may be desired. In better managed FELDA schemes, a stand of 350-400 trees in tapping was considered optimal. This would entail an initial stand of 500-600 trees. The initial high stand was to allow for losses due to root diseases, etc., and for thinning out runts thus giving the optimal stand desired at tapping.

**Methods of Establishment**

In the field establishment of rubber for a considerable period of time and even up to late 1960s, the practice was to plant clonal seedlings or unselected seed at stake in the field and to do the budding in the field. Such a practice not only led to an unproductive phase of 6–12 months until budding, but also resulted in large variability in the stands in

the field. Subsequently, this was superseded by the use of bare-rooted budded stumps. However, even the use of such materials resulted in variability and failures with the need for a large number of supplies. Investigations in the estate sector had shown that the use of buddings raised in polybags up to a stage of 2 whorls not only gave greater uniformity but could reduce the unproductive phase by 12–18 months. This finding was then investigated in the smallholder sector and was found to be applicable to this sector. Thus more and more of the replantings in the smallholder sector is utilising such plants raised in polybags.

**Fertiliser Use**

In so far as fertiliser use for immature rubber is concerned, the requirements range according to soil and cover conditions. Thus the results of investigations in the estate sector were equally applicable to the smallholder sector. On the other hand, this did not appear to be so for mature rubber, particularly because the smallholder sector generally did not use fertilisers once the fertiliser subsidy was discontinued after the initial 5–6 years of establishment of the rubber. In addition, the overexploitation and the poor vigour of the trees imply that the fertiliser requirements for the smallholder sector should be different from that of the estate sector.

Early experiments had shown that there were different patterns of responses to fertilisers according to the major groups of soils under rubber. Such experimental results interpolated with soil and leaf nutrient analysis and agronomic management history have been used as a base for diagnosing the specific fertiliser needs of different planting materials for rubber in estates. A similar approach is also in use for smallholdings in schemes that are in organised groups, e.g. FELDA, FELCRA.

In a survey, Chan et al. (1972) showed that in the individual smallholder sector, the nutrient status, particularly of nitrogen, phosphorus, and potassium, was low and was considered suboptimal according to the criteria indicated by Pushparajah and Tan (1979).

Thus investigations were initiated in the smallholder sector to assess the fertiliser requirements of replanted smallholdings with rubber in tapping. The smallholdings were selected with the view to giving sufficient coverage of the major soils. The fertiliser regimes were then based on interpolation of soil and foliar data (Chan et al. 1972). The results of the investigation clearly showed increase in yield to fertiliser application (Pushparajah et al. 1973b). In addition, they showed that such increases gave a large increase in economic returns to the smallholders. Based on such findings, 14 different formulations of fertilisers have been forwarded for the smallholders sector. This enables catering for major soil groups and 2 clonal groups (Chan et al. 1972). At the same time, broad reconnaissance soil maps for ease of identification of the major soil types have been cartographed. More detailed mapping on a scale of 1:25,000 has been continuing from the mid-1970s in order to provide more accurate soil maps for such use.

**Interrow Management**

INTERCROPS

The smallholders generally had not been establishing any selected covers but had more or less been allowing natural covers to generate. Further, during the unproductive period of 5–6 years, little to no income was derived. With the view to ensuring returns during this stage, various investigations were carried out. Guha and Soong (1970) based on the Storie (1984) index, assessed that about 30% of the area under rubber would be very suitable for intercropping with annual crops. Pushparajah and Wong (1970) based on their investigations, determined the appropriate fertiliser regimes for intercrops of groundnuts and maize in different smallholdings and showed that such intercrops were profitable. That such returns from groundnut intercropping was profitable was also confirmed by Tan and Templeton (1970). Detailed investigation by Cheng (1970) resulted in selection of appropriate groundnut and soybean varieties. Further, Pushparajah (1973 unpublished information) showed that intercrops such as groundnuts and maize in rotation, did not adversely affect the growth of rubber, and that the growth obtained in intercrop areas was similar to that obtained where rubber was grown with legume covers.

Pushparajah and Tan (1970) also considered the use of tapioca as an intercrop. Though the returns from the tapioca intercrop were very satisfactory, it was found that generally, tapioca could compete with the rubber in the initial stages. However, they showed that where crop rotation sequence was used, e.g. groundnut followed by groundnut or maize and subsequently tapioca was established, the returns were not only high but the adverse effect on rubber was not evident, provided the tapioca was planted at least 1 to 1.5 m away from the rubber, which was by then about 1.5-2 m tall. Investigations on intercropping with groundnuts, maize, soybeans, and bananas were further evaluated in smallholdings.

The findings (Wan Mohamed and Chee 1976) further confirmed economic returns to the smallholders.

COVERS

Pushparajah and Tan (1979) showed that the use of legume covers not only gave nitrogen returns equivalent to over 700 kg of N during a period of over 10 years of establishment, but also resulted in higher yields of rubber. To obtain such returns from covers, the need for 'starter dose of fertilisers', phosphatic fertilisers, and appropriate inoculation with *Rhizobium* was essential. In addition, Tajuddin et al. (1979) showed that maximum benefit of N returns from legumes could be obtained only by adequate weed control by use of both pre- and postemergent herbicides. Attempts to introduce the establishment of legumes in rubber smallholdings, however, often failed.

Chee et al. (1979) identified that the poor quality of legume seeds was one of the factors for this failure. This therefore necessitates the need for seed testing. Subsequent investigations indicated that the smallholders sector found it difficult to try and obtain the necessary inputs from various sources. Chee (1984), from investigations in individual smallholdings, concluded that for successful implementation of legume covers in smallholdings, a 'package deal' must be provided. The package included a 'planting kit' with viable seeds, *Rhizobium*, herbicides (pre- and postemergent), and a simple technical leaflet. Rock phosphate and a compound NPK fertiliser for 'starter' application formed the other package. While this approach is now being implemented, further efforts to refine the techniques of establishment are in hand.

ANIMALS

After about 2.5–3 years of growth of rubber, the amount of light reaching the interrow area is restricted and intercropping may not be feasible. Wan Mohamed (1977) in a survey of the vegetation in the interrow found the following vegetative types in smallholdings:

1. Grasses (*Axonopus compressus, Paspalum conjugatum, Ottochloa nodosa,* and *Imperata cylindrica*) with a crude protein content of 9.4%, fat content 1.5% and fibre content 33.3%.
2. Dicotyledons—*Mimosa pudica, Mikania cordata, Melastoma* and residual legume covers with a crude protein content of 13.2%, fat content 1.9% and fibre content 32.9%.
3. Ferns mainly *Nephrolepis, Lygodium, Gleichenia linearis* with a crude protein content of 11.4%, fat content 1.8% and fibre content 31.9%.

The total dry matter at a given time ranged from 500 to 1000 kg/ha. About 70% of the vegetation was considered suitable for grazing by the sheep. At the same time, there is often the necessity to control this growth under rubber using chemical herbicides and this is often not practiced in smallholdings. To evaluate the performance of sheep under such vegetation, investigations were conducted. The findings (Tan and Abraham 1981) showed that the local sheep (believed to be a mixture of the Yunnan earless and breeds imported by early Portugese and Arab breeders (Lowe 1968)) performed satisfactorily, giving a mean weight gain of about 46 g/day.

Further, it was found that sheep effectively grazed on the vegetation, resulting in a control of excessive growth of the vegetation, which could have competed with the rubber. In addition, the preliminary findings indicated that the growth of the rubber where sheep were grazed was better than where no weed control was practiced. Tan and Abraham (1981) ascribed this improved growth as being due both to the control of the vegetation as well as the return of organic manure by the sheep.

Later, Wan Mohamed and Hamidy (1983) considered the performance of local sheep and crosses to Dorset Horn. The sheep were herded for grazing under rubber between 7.30 a.m. and 1.30 p.m. and kept in the shade during the rest of the day. In addition to preventive measures against pests and diseases, salt licks were provided.

The results clearly showed that the 50% Dorset Horn performed very much better, giving a liveweight nearly double that of local sheep at the end of 12 months.

This and other studies have shown compatibility of sheep farming with rubber production. In addition, in the smallholders sector where weed control is seldom practiced, sheep would be an agent of biological control and at the same time, provide extra income to the smallholders. More recently, it has been observed (Ani Arope, RRIM, pers. comm., 1984) that where sheep are allowed to graze in an area mixed with legume creeping covers, *Mikania*, and grasses, they would first graze on the grass and *Mikania*. Thus if the intention is to keep a pure legume cover to be of benefit to the rubber, the sheep could be moved to different grazing areas once they have grazed on the non-legumes. The initial findings indicate that by this method, the cost of weeding in legume areas could be minimal.

More work is being concentrated particularly on breeding and selection aspects and on pest and

disease control coupled with other management studies including vegetative management, stocking rates, rotation frequencies, etc.

**Exploitation**

In the late 1960s, Abraham et al. (1968) found that the chemical, 2-chloro-ethano-phosphonic acid (Ethephon) increased the flow rate of latex and thus the yield. The results of this investigation were then extended to smallholdings (Abraham and Manikam 1973). They found that in the smallholders sector, response or increase in yield to the use of Ethephon even in seedling rubber was economical if the tapping system was done on an alternate daily basis. There was however no appreciable benefit if the tapping system was on an intensive basis, i.e. on a daily tapping. Meanwhile, Pushparajah et al. (1972) demonstrated that there would be no response to Ethephon in the absence of an adequate nutritional status of trees. Hence as the smallholder sector did not use fertilisers once the trees came into tapping, the need to apply fertilisers before Ethephon stimulation became a prerequisite.

Subsequent investigations in the smallholders sector confirmed that where tapping was done on a daily basis, the tapping cut should be reduced from the half spiral cut to a quarter spiral cut. Manikam and Abraham (1976) indicated that where such quarter spiral cuts were used and Ethephon was applied, there were appreciable increases in yield and hence extra income. Further, as on each tapping, only a quarter cut was made, the rate of bark consumption was also reduced.

Another problem faced by the smallholders particularly in the east coast of Peninsular Malaysia is the inability to tap or exploit the rubber during those 2-3 months of the year when excessive heavy rain makes tapping impossible. This clearly had resulted in lower yields being obtained by the smallholders in the east coast States. In other States, the smallholders may abandon their holdings during the fruit season, for example, for periods of 1 to 2 months. Thus, non-exploitation of the rubber during this period has often resulted in lower yields. An investigation by Yahaya et al. (1983) showed that a more frequent periodic tapping with a panel-changing short-cut system with mild stimulation with tappings being done in 10 months per year, gave yields as much if not more than the alternate daily system of tapping practiced elsewhere. In this periodic tapping system, tapping cuts were on a quarter cut and though daily tapping was to be done, often on days of rest in the week and on days due to rain interference, tapping was not implemented. This system therefore enables the smallholder to recover losses due to the monsoon season or to recover losses due to his being away from the holding during the fruit or padi planting season, for example.

**Implementation**

The various findings listed above have been tested in selected smallholdings on a project basis. However, there is an urgent need to look into socioeconomic and other constraints and overcome them in order to ensure these innovations can be implemented in the smallholder sector to realise the maximum possible benefits.

**Future Research**

In some of these areas, the Institute is still actively pursuing investigations. Such areas include:

- Selection of broader varieties of intercrops (in collaboration with other agencies).
- Selection of appropriate *Rhizobium* for intercrops such as groundnuts, soybeans, and legume covers.
- Breeding and selection of *Hevea* not only for increased yields but to cater for the wide range of environmental conditions and management practices.
- Evaluation of adaptability of newer cultivars to the various environmental conditions in the smallholders sector.
- Improved efficiency in the use of fertilisers in smallholdings.
- Improvement of seed production of legume covers to reduce cost of cover seeds, which are currently imported.
- Further refinements in exploitation techniques and the development of appropriate tapping tools, such as the mechanised tapping knife, which would entail use even by unskilled workers.
- Improving the breeding, selection and management practices of small ruminants, e.g. sheep, to be reared under smallholder rubber.

In these investigations, interaction with other agencies that have specialised skills is of paramount importance and such interactions are actively pursued.

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