

## Problems and Prospects of Present Sago Palm Development

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In the coming decade quite an increase in the production of sago palm starch is to be expected. Part of this starch will be harvested from plantings, the remainder from wild stands. This was observed during travelling through Indonesia and Sarawak in the months of January and February 1992. Visited were in Sarawak: Mukah and Dalat, and in Indonesia: Selat Panjang on the Riau Islands east of Sumatera; Siberut of the Mentawai Islands west of Sumatera; Bogor on Java; Halmahera in the northern Moluccas and finally the southwestern cape of Kepala Burung (Bird's Head) and the island Salawati both in Irian Jaya. The trip ended with a visit to Ambon in the southern Moluccas. Originally visits to Papua New Guinea and the Philippines were planned also, but due to the long duration of the first trip, these had to be postponed.

The author travelled in the company of Schuiling<sup>1)</sup> and partly Jong<sup>2)</sup>, who collected genetic material. Part of the material collected has been planted by Schuiling in an experimental garden at Makariki, Seram, Moluccas, a substation of the Indonesian Research Station for Industrial Crops. The other part was taken to Sarawak by Jong, to be planted in the deep peat experiment station at Dalat.

In this paper only the main problems and prospects of the developments in the area visited will be highlighted. A full account of the trip written by the participants will be published in the series 'Communications of the Department of Tropical Crop Science' of the Agricultural University in Wageningen, the Netherlands.

### Some General Remarks

At present more intensive harvesting from natural stands is done in Indonesia, by (1) the semigovernmental forest exploitation company *INHUTANI I* close to Kao on the island Halmahera in the Moluccas; *INHUTANI I* started harvesting in August 1991 in a well-organized operation in mineral soils; by (2) a private company at Arandai, Kepala Burung in Irian Jaya; the latter exploitation could not be visited. The company in Irian Jaya uses a floating starch extraction plant and probably operates on peat soils. The company is now building a new factory on land in the area; the floating starch plant will be used in southeastern Irian Jaya. Nearly all areas with good natural sago palm stands in Irian Jaya have been given out in concessions to private companies.

Also (3) a small private factory is being established by an entrepreneur from Selat Panjang close to Muara Siberut on Siberut of the Mentawai islands.

A small and rather well-run model-planting around six years old is under responsibility of (4) the sago palm group of *BPP Teknologi*, in the neighbourhood of Bogor, West Java. This planting was set up as described by Flach (1977) for Batu Pahat in Johor, West Malaysia.

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Well-sized new plantings are underway (5) in Sarawak close to Mukah by *Estet Pelita Sdn. Bhd.* and (6) in Indonesia on Selat Panjang of the Riau islands by a private group, both on peat soils. The latter planting was not visited. This group appears to be working on less deep peats than is done in Sarawak.

In all these cases, be it exploitation of existing stands or new plantings, we have to do with more intensive production and harvesting. Both types of production have to adhere to the laws and rules of biology and agronomy. The main points that need attention in research will be reviewed here.

#### Nutrient Withdrawal from the Exploited Fields

Originally the sago palm was, and still is, harvested and processed in the fields where they grow. Only the wet starch is taken home by the small-scale processors, mostly for their own food. All other material, containing the nutrients, is left in the field and thus returned to the soil.

In factory processing, however, harvesting and processing are being separated from each other, both in time and in place. The trunks are brought to the factory and processed there. The refuse, including the bark, is usually discarded in the factory neighbourhood.

Especially at a production above the traditional level of at the most 40 trunks per ha per year, this will lead to depletion of plant nutrients in the soil in the plantings; the nutrients are transported to the factory in the trunks. There these nutrients are deposited in the refuse, which usually is washed down to the sea in the surface water. The danger of pollution of the environment is not large as most operations are relatively small.

If leaves are harvested, for instance for thatch, also the plant nutrients in them are exported to the area where they are used. The hard bark, also containing plant nutrients, is usually left in the neighbourhood of the factory.

In production no fertilizers whatsoever are be-

**Table 1.** Estimated nutrients content in grammes of single trunks and single leaves; after Flach and Schuiling (1991)

Nutrient	in one trunk	in one leaf
N	590	37
P	170	6
K	1,700	20
Ca	860	90
Mg	350	7

ing used, even when the sago palm is cultivated. As yet unsuccessful research into the nutrition of the sago palm is being done only in Sarawak (Ann. Rep. Sarawak; Sim and Ahmed, 1991). Recently the experiment station on sago palm in Dalat, Sarawak, showed a serious nutritional disorder occurring in the young sago palms. Only three to four of the youngest leaves remain green on the trunk; all older leaves have died. It appears to be a potassium deficiency that may have been triggered off by drainage of the peat swamps at planting.

The nutrient withdrawal of sago palms, as estimated by Flach and Schuiling (1991), is presented in Table 1. The table makes clear that continuous harvesting at the highest possible level of around 100–130 trunks per ha per year will deplete the soil. First, potassium will be minimized. And if the 70–80 fully grown leaves the smallest sago palm type produces during its life cycle are harvested depletion of the soil even occurs much faster. This will start off with a lack of calcium.

It is thus of paramount importance to start research on fertilizer application. Such research will meet a peculiar and interesting difficulty. Sago palms are, although not necessarily, usually grown under rather wet and often even flooded conditions. These conditions will result in on the one hand the possibility of enrichment by the short-duration flood water (Flach, 1977) and on the other the danger of applied fertilizer being washed away. Flooding of palms for short periods appears to do very little harm; but continuous floodings or flooding for extended periods appears to hamper growth (Flach *et al.*, 1977;

Kraalingen, 1986).

Sago palms are able to form roots along their trunks. For research purposes one could thus think of applying a fertilizer solution in a band of plastic fastened on its lowest side around the lower part of the trunk, thus forming a bag around the trunk. In this way the trunk itself will be fertilized and no fertilizer will go into the soil. This would ultimately result in knowledge about the individual needs of fertilizer for each trunk. It might even be possible to develop this method into a practical way of fertilizer application.

For the further future, however, large-scale operations should be designed in such a way that the refuse either can be returned to the field or can be put to other economic uses. It will become ever more unacceptable to just dump the valuable refuse in the surface water, even if it is close to the sea, as the world population will become ever more aware of the value of the natural surroundings.

### The 'Species' Question

As stated by Leon (1986) in the centre of diversity of a plant species usually a large number of varieties is found, but at the border of the natural dispersion the number diminishes.

We do not yet know whether the different cultivated varieties of the sago palm deserve only cultivar status or should be considered as separate species or varieties; many of them appear not to produce seeds. Beccari (1918) distinguished nine species, with in total 25 varieties and subvarieties. In Table 2 his species and only 20 of the varieties are presented; the varieties in *M. squarrosum* have been neglected. Beccari mentions them but considers them 'barely distinguishable'. For his treatment he received material from the places mentioned in Table 2.

One may doubt his division into non-spined versus spined, i.e. *Metroxylon sagus* ROTTB. versus *Metroxylon rumphii* MART. All non-spined varieties are brought together into *M.*

**Table 2.** The genus *Metroxylon* according to Beccari (1918)

Taxa	Location
1. <i>M. sagus</i> ROTTB. (forma typica)	Malay Isl.
1. 1. var. molat BECC.	Seram
1. 2. var. peekelianum BECC.	North PNG
1. 3. var. gogolense BECC.	North PNG
2. <i>M. rumphii</i> MART. (forma typica)	Malay Isl.
2. 1. var. rotang BECC.	West Seram
2. 2. var. longispinum BECC.	Ambon
2. 3. var. sylvestre BECC.	West Seram
2. 4. var. ceramense BECC.	Seram
2. 5. var. micracanthum BECC.	West Seram
2. 5. 1. subvar. tuni BECC	
2. 5. 2. subvar. makanaro BECC.	
2. 6. var. buruense BECC.	Buru
2. 7. var. flyriverense BECC.	Fly River PNG
3. <i>M. squarrosum</i> BECC.	East Seram
4. <i>M. warburgii</i> BECC.	New Hebrids
5. <i>M. upoluense</i> BECC.	Samoa
6. <i>M. vitiense</i> BENTH et HOOK.	Fiji
7. <i>M. amicarum</i> BECC.	Carolines
7. 1. var. commune BECC.	
7. 2. var. maius BECC.	
8. <i>M. salomonense</i> BECC.	Solomons
9. <i>M. bougainvillense</i> BECC.	Bougainville

*rumphii*. Beccari himself, however, shows some doubt on the division into spined versus non-spined. Recently it has been established several times that of the first variety of the non-spined ones, var. *molat*, also spined ones exist. And this may hold for other varieties as well (e.g. Flach, 1983). Therefore, these two species and *M. squarrosus* BECC. are now put together in the original species *Metroxylon sagu* ROTTB., although the west-Seramese *M. squarrosus* was found by Beccari (1918) to possess 24–29 vertical rows of scales on the seed coat in stead of 18 as the other two do.

We must conclude that as yet there is insufficient information on the taxonomy of sago palms. As an example: in northern Papua New Guinea the local population in the Sepik River Basin distinguishes 12 cultivated varieties and three wild ones. Ohtsuka (1983) reports for the Fly River area in southern Papua New Guinea some 23 local names out of which 14 were confirmed by aged men. And there is as yet no certainty that these cultivated varieties are the same as those in Southeast Asia.

More west, on the island of Halmahera eight varieties were reported in 'folk-taxonomy' by Yoshida (1980). On the island of Borneo there probably are two or three and on the western coast of Sumatra there probably is only one variety, seeds of which may develop non-spined ones and, in addition, all kinds of different spines. The variety appears to be 'molat'; at last, people in the Sepik River Basin in Papua New Guinea recognised the author's pictures of this variety immediately as such.

Travelling through these areas one may easily get the impression that we have to do with on the one hand a number of separate cultivated varieties (cultivars), possibly spread by man and on the other a number of landraces, each of the latter adapted to its own region. Sago growers usually are rather eager to collect new cultivars. In the Sepik River Basin the author noticed that a local inhabitant, who had visited the Pacific, had taken along one of the sago palms from that

area and had it planted in his village. In Sarawak, on the deep peat experiment station the sago palm material collected by Jong has to be hidden among other palms to prevent theft by local sago palm growers (Jong, pers. comm. in 1992)

Looking at the number of varieties we may for the time being safely assume that the centre of diversity is the island of New Guinea and not, as Beccari (1981) stated, the island of Seram. Moreover, we do not yet know the length of the life cycles from seed to seed of each of the species, varieties and subvarieties given by Beccari. This appears to be a major criterion for the choice for cultivation and probably will be important also for taxonomy. It is thus rather clear that a new taxonomical treatment of the species, incorporating all available knowledge through a study in depth by a taxonomist experienced and knowledgeable in sago palm, is badly needed.

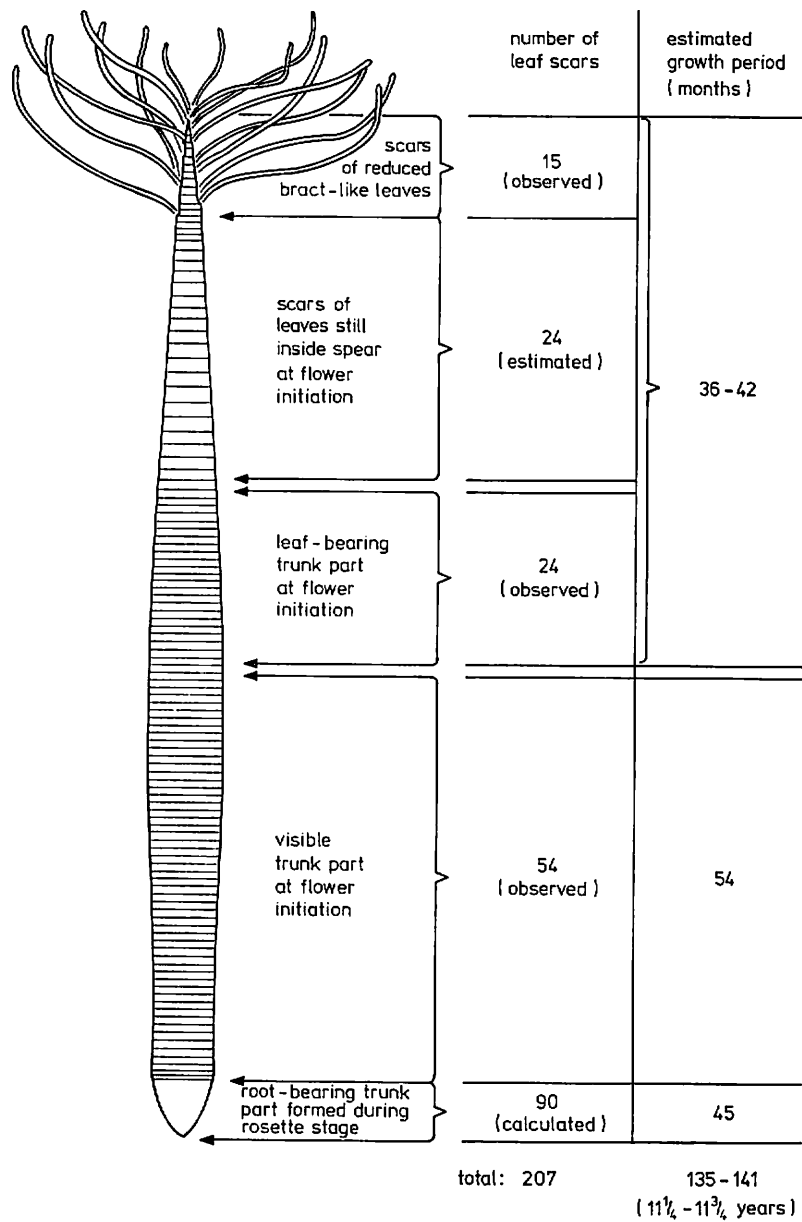
#### A Simple Model of Sago Palm Growth

A rather simple and preliminary model of the growth of 'molat' is given in Table 3 and Figure 1. In this model the ideas given in the former standard work of Corner (1966) concerning palm growth have been used, i.e. that palm growth is strictly regular: there are as many leaves present in the visible crown as there are developing, as yet invisible, within the growing point. That the newest appearing leaf, the spear leaf, is exactly in the middle of, on the one hand the developing leaves in the growing point and, on the other the leaves in the visible crown, would hold for all palms is doubted somewhat in the recent and excellent book of Tomlinson (1990). Be this as it may, for the sago palm in the trunk forming stage it probably is valid, although not as strict as Corner assumes.

Only if the number of leaves increases (respectively decreases) the number within the growing point has to have been larger (respectively smaller) than in the visible crown. So, one must expect the number of leaves in the growing point to be larger in the rosette stage.

In the model of the sago palm as presented by Flach and Schuiling (1989) the leaf production in the rosette stage, the stage without formation of a visible trunk, was established to be two

leaves per month on the average; then the leaves become progressively larger. After flower initiation the leaves become progressively smaller; the speed of leaf formation at that time is



**Fig. 1.** Model of a 'Molat'-type trunk at the end of its life cycle, showing the number of leaf scars and the time it takes for the different parts of the trunk to grow under optimum conditions. For clarity no leaves and only the first-order branches of the inflorescence have been drawn.

After Flach and Schuiling (1989)

also assumed to be two per month, but this assumption has not yet been checked.

The value of such a model is as yet limited, because we do not know which factor is the more constant one, the speed of leaf formation or the leaf longevity. Nevertheless, the model may be of help in classifying the varieties if developed for other varieties as well.

### Size and Age of Trunks

The amount of pith in a trunk is related to the volume of the trunk. Trunk height is related to age of the trunk, as probably one leaf per month is being produced and each leaf has its own internode, the distance between two leaf scars. Circumference of a trunk is more important for volume than height. In volume, calculated as  $\pi \times r^2 \times h$ , the radius ( $r$ ) has a quadratic contribution, whereas the height ( $h$ ) only has a linear contribution.

Thus short stout trunks give more pith than tall slender trunks. This holds within one variety. Between varieties there may be some other differences such as more (less) and/or larger (smaller) sized leaves in a crown, both leading to a larger (smaller) circumference of the trunk. A larger number of leaves during trunk growth until flower initiation will lead to an increase in trunk life and consequently a taller trunk. We may safely conclude that stout short trunks of one and the same variety produce more starch

than slender tall trunks.

The trunk age, thus from after completion of the rosette stage until the initiation of flowering, may differ from approximately four years on the one hand in 'molat' as described in Table 3 and Fig. 1 till over 20 years in the variety, possibly classified by Beccari (1918) as 'sylvestre'. Probably 'molat' with the shortest duration of growth is the best one for cultivation, as can be seen in the *BPP Teknologi* model-planting close to Bogor. An important difference between varieties is the duration of the stage of trunk growth, i.e. from the end of the rosette stage till the start of flower initiation. Varieties probably show differences in the duration of trunk growth from four to over 20 years, six years being the most common.

### Starch Content of the Pith

Starch content of the pith should be used to evaluate starch production. In evaluation it is rather practical to use the starch weight per volume. A volume of water-saturated starch of 1 cm<sup>3</sup> weighs after drying in an oven approximately 0.65 g. The starch content appears to vary from hardly any till 300 kg of dry starch per m<sup>3</sup> of pith (Flach and Schuiling, 1989) in Batu Pahat. Lowest starch contents per volume of pith have been reported in wild sago palms under partially flooded conditions, in the Sepik area in Papua New Guinea (Kraalingen, 1986).

**Table 3.** Summary of data for a trunk forming sago palm with a seed to seed life of approximately 11 years (sago Molat) and growing under optimum ecological conditions (after Flach and Schuiling, 1989)

Optimum number of leaves in crown (n)	24
Number of leaves in growing point (n)	24
Number of days between successive leaves (p)	30
Estimated optimum leaf age in days (n × p)	720
Flower initiation at visibility of leaf scar on the trunk, number	54
Total number of leaves in the crown (24) and leaf scars on the trunk (54) at flower initiation (24 × 54)	78
Estimated duration of trunk life after flower initiation (24 + 0.5 × 24) months	36
Average number of leaves formed per month in the rosette-stage	2
Estimated total number of leaves formed during the rosette-stage	90
Estimated duration of the rosette-stage if grown from seeds (months)	45

In the years 1950–1957 in a wild stand on the island of Salawati, Irian Jaya, a statistical average of 167 kg per m<sup>3</sup> was found (Holmes *et al.*, 1984).

Harvested trunks (or trunk parts) containing more starch per volume of pith are submerged deeper in water than trunks with less starch. But starch contents vary along the trunk too. This mechanism is not yet understood, albeit as discovered by Kraalingen (1984) there is some reason to believe that after flower initiation starch is moved upwards in the trunk. This may also explain that after flower formation the lowest part of a trunk tends to become just about empty. This may be the reason why small scale sago processors, harvesting when flowers are visible, leave the lowest part of a trunk standing in the field, whereas cultivators in Batu Pahat, harvesting around flower initiation, the full trunk.

It thus may be possible to develop a correlation matrix between starch content on the one hand and measured trunk volume combined with the percentage of trunk diameter submerged in water on the other. Such a correlation matrix may offer an opportunity to pay for starch contents rather than for trunks. Farmers usually are well aware that trunks differ in starch content even within the same variety. They would be quick to catch up on price differences between good and bad trunks. By means of such differential payment in harvesting operations with private farmers-harvesters the economics of the factory may be improved.

### Starch Recovery in Quality and Quantity

The starch technologist Cecil (1986), after a number of years working in Sarawak, gives seven points following survey of losses; point 8 was added after Yoshida *et al.* (1986):

1. *Bark thickness.* Bark should be removed carefully and as sparsely as possible as there still is quite some starch in the outer layers of the bark; the bark layer usually is thinner than 2.5 cm, but this may also depend on the variety.
2. *Milling of pith.* Pith must be grated or milled finely, in order to wash out the starch grains; if the fibres remain too long they still may contain starch. Colon and Anokkee (1986) advocate the use of the old-fashioned hammer-mill for this purpose.
3. *Settling.* Settling tanks should be extensive and shallow rather than compact and deep; the same holds for settling tables; in this way also small starch grains may be captured.
4. *Log storage.* Logs should not be stored longer than 2–3 days at the very most and preferably in water; longer and dry storage leads to deterioration of starch quality and to a diminishing starch quantity.
5. *Storage of wet starch.* Starch should not be kept wet for more than 24 hours; where there is no alternative for storing wet starch it must be treated with SO<sub>2</sub>; if kept wet too long the starch grains may erode, which results in gas-pockets in the grains, thus making settling more difficult and also diminishing starch quality.
6. *Cleaning of factory equipment at stops.* Equipment should be cleaned thoroughly after each stop of the factory; if this is not done the new start will be accompanied by an enhanced microbial activity.
7. *Sieving out fibre.* Before sedimentation the starch slurry should be passed through a screen no coarser than 120 mesh (125 μm), in order to remove remaining fibre particles that may be instrumental in the microbial deterioration of the starch. This will also lead to some losses of large starch grains, but these are less than 1%.
8. *Harvesting of trunks before flower initiation.* Harvesting of immature trunks should be avoided as the starch grains then may be too small for easy settling; a trunk is considered to be mature close to flower initiation, the start of flower formation in its growing point. The combination of these measures may lead to an improvement in starch recovery in the factory

of at least 30% and possibly up to 50%.

### Use of Presently Discarded Parts

Provided the fertilizer use problem has been solved and returning the refuse to the field is not necessary any more, it may be possible to make use of the following side products of sago palm:

1. *Bark*. Most factories that have been working for a number of years are literally surrounded by large heaps of discarded sago palm bark. Only the government-owned factory in Sarawak is using its bark for drying of the starch. It is reported that the smoke of bark burning attacks the chimney, which has to be replaced rather rapidly. Other factory owners in Sarawak say jokingly that they can afford to do so, because the government pays for it (Jong, pers. comm. in 1992).

The aggressiveness of the smoke is probably caused by a high silicium content of the bark as is the case with the shells of oil palm seeds. A solution may be found in using, the *Waterwide*<sup>3)</sup> burner. This type of burner is less heat-efficient than others, but does not cause the same difficulty (Vugts<sup>4)</sup>, pers. comm. in 1992).

The matter should be under research, as using the bark for drying would make the operation of a factory on the one hand more efficient and on the other do away with a refuse problem.

2. *Hampas*. The refuse of starch extraction, the ground fibrous material out of the pith is usually just discarded and polluting either the surface water or the surroundings of the factory. Normally it is too expensive to transport it back to the plantings. There have been successful efforts to use it for manufacturing of particle board. This matter should also be under research as it may offer an interesting sideline for large-scale starch factories.

3. *Growing point*. In other palms the growing

point is used as a vegetable under the names of 'palm heart', 'palm cabbage' or 'kings salad'. Occasionally the local population also eats the growing point of the sago palm fresh.

In Costa Rica another tillering palm (pejibaye; *Bactris gasipaes*) is especially grown for this purpose and the 'hearts' are being canned and brought on the market. It appears to be worthwhile to take this possibility up in research also in sago palm.

### Conclusions

Considerable progress has been achieved in sago palm exploitation and also in cultivation. A rather quick increase in production is to be expected in the coming 10 years. Nevertheless, quite a number of important points are still open and need to be taken up in research.

Three pressing items have been identified in this paper.

The most pressing is the problem of fertilizer use in sago palm cultivation. The problem should be taken up by a soil scientist and/or a fertilizer expert.

The second problem is a complex one, that already is being faced in harvesting: how to obtain a paying operation with acceptable starch yields from trunks, with reduced losses. It should be tackled by a starch technologist with some knowledge of sago palm agronomy.

The third one, of importance on the somewhat longer run, is the taxonomy. The problem should be under research by a good taxonomist-agronomist, well versed in sago palm literature. Taxonomy should be combined with starch production and simple modelling.

All three specialist groups should obtain knowledge and experience of recent advances in sago palm agronomy before they start off on their assignments.

Especially three pioneer-operations are worth following in order to obtain experience. They are (1) the large-scale planting of sago palm on deep peat by *Estet Pelita* in Mukah in Sarawak, (2) the exploitation of a natural stand on minearl soils

3) Waterwide Developments New Zealand Ltd.; PO Box 4; Haomoana, Hawkes Bay, New Zealand.

4) J. Vugts (1992); c/o Agricultural Development Service; Jalan Gudang Peluru Blok A nr 21, Tebet, Jakarta, Indonesia.



by *INHUTANI I* on the island Halmahera and (3) the small model-planting on mineral soils of the *Agency for the Assessment & Application of Technology (BPP Teknologi)*, close to Bogor, west Java, Indonesia. These three operations are done quite well and accumulate considerable experience.

Agronomic research can be followed in Sarawak in the 60 ha deep peat experiment station of the *Sarawak Department of Agriculture*. There is no agronomic research done by the *Agency for Agricultural Research and Development (AARD)* in Indonesia as yet. The demonstration planting of *BPP Teknologi* appears to be the only research on sago palm in Indonesia.

Also there is a lack of training of young agronomists in the field of sago palm cultivation. Such training could be offered in combination with the three pioneer-operations and on the research stations mentioned here.

### Acknowledgements

During our trip, all people in sago palm received us well, shared their knowledge freely with us and discussed their difficulties openly.

We especially thank the staff of the sago palm group of '*BPP Teknologi*', the manager of the Mukah Sago Plantation run by *Estet Pelita* and also *INHUTANI I* for their reception. All three organizations showed their rather interesting operations completely frank and open and listened to and discussed carefully the critical remarks made by our group, which gave us an opportunity to increase our knowledge.

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