THE SAGO PALM: A POTENTIAL COMPETITOR TO ROOT CROPS

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SUMMARY

Cultivated sago palms in West Malaysia are estimated to produce 24 t/ha/year of dry starch from the harvesting of 130 palm trunks per hectare. Semi-wild palms on peat soils in Sarawak probably produce about half of this (60 trunks per hectare). Such yields from an unimproved crop suggests that the sago palm deserves more attention than it has received in the past. Speculations are made by comparison with the recorded growth of oil palms, suggesting that the production of 270 tons of de-barked pith equivalent to 54 tons of dry starch per hectre might be possible to obtain through research and its application.

RESUME

On estime que les sagoutiers cultivés en Malaysie Occidentale produiront 24 tonnes d'amidon sec par an à partir de la récolte de 130 troncs de sagoutiers à l'hectare. Les sagoutiers semi-sauvages cultivés en sols organiques au Sarawak pourraient en produire la moitié (60 troncs à l'hectare). De tels rendements obtenus de plante non améliorée indiquent que le sagoutier mérite plus d'attention que par le passé. Considérant la croissance connue des palmiers à huile, on pense qu'il n'est pas impossible d'obtenir, grâce à la recherche et à ses applications, une production de 270 tonnes de cervelle de la plante.

RESUMEN

Se estima que las palmas sagú, cultivadas en Malasia Occidental producen 24 t/ha/año de almidón deshidratado como producto de la cosecha de 130 troncos de palma por hectarea. Las palmas semi-silvestres de Sarawak, producen cerca de la mitad de esa cantidad (60 troncos por hectarea). Tales rendimientos, a partir de un cultivo no mejorado, sugieren que la palma sagú requiere mas atención que la que se la ha dado en el pasado. Se especula por comparición con el crecimiento registrado de palmas de aceite, sugiriéndose que mediante investigación y aplicación de la misma, sería posible obtener 270 ton, de medula, descortezada, equivalente a 54 ton. de almidón deshidratado por hectarea.

INTRODUCTION

Sago is the starch which the sago palm accumulates in its trunk. The pith of a sago trunk has the composition as given in Table 1, the dry matter composition closely resembles that of cassava roots and sago can be used for the same purposes, i.e. for human food, for preparation of industrial starches and also as an animal feed.

Rasped and dried sago pith has been used for a long time as a feed for pigs and poultry and refuse from sago starch factories is used as a feed for pigs and cattle. It is likely that rasped, dried and pelletized sago pith will be completely acceptable for the animal feed industry.

BOTANY AND CULTIVATION OF THE SAGO PALM

The palm genus *Metroxylon* consists of some six species. The name is derived from Greek, *metra* meaning pith and *xylon* meaning xylem. The genus is indigenous in the lowlands of a southeast Asia and Melanesia. It occurs between 10°N and S up to a height of 700 m. Most species are found on and around New Guinea which probably is the gene centre. The economically most important species are *M. sagu* Rottbol and *M. rumphii* (Wild.) Martius. The latter name was given in hour of Rumphius (1755) who, in his 'Amboinsch Kryd-boek' gave the first description of the palm accompanied by a drawing. The main difference between the two species is that *M. sagu* has no thorns, whereas in *M. rumphii* the leaf sheath and petiole are covered by sharp thorns up to 8 cm long. Barrau[1] considers that the two taxa should be conspecific as they appear to cross readily. This was proven in our department: the offspring of two unthorned palms in the Singapore Botanical Gardens also gave a few thorned palms.

Under natural conditions the palm occurs in fresh water swamps in the tropical rain first zone. Isolated palms occur outside this natural habitat and appear to do well, provided they are tended properly. Probably

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in its natural habitat the palm possesses a competitive advantage. The best natural stands occur in clayish fresh water swamps, high in organic matter; peat soils are less suitable. Although sago occurs in swamps, permanent inundation appears to be disadvantageous.

Each shoot of the sago palm flowers only once but the plant is a tillering perennial. Carbohydrates in the form of starch accumulate during the vegetative phase in the trunk and are used up for flowering and fruiting if this is allowed to occur, after which the trunk dies. Usually in the first year of growth the palm forms a number of buds in the axils of lower leaves which subsequently develop into shoots or tillers. (Photograph 1).

The crown of the palm consists of some 6–15 feathered leaves each composed of leaf sheath, petiole and approximately 20 pairs of leaflets of 60–180 cm[6]. The rachis is concave on the upper side and convex on the underside. On the trunk the leaf sheath may be as wide as 30 cm. The senescent leaves break off from the leaf sheaths; later the leaf sheath abscisses from the stem, and an annular leaf scar remains on the stem.

The appearance of the inflourescence is preceded by that of a number of smaller leaves. The terminal inflorescence, resembling an enormous antler, consists of a primary axis dividing into secondary and tertiary axes. The tertiary axis bear the small flowers in pairs, a male and an apparently complete flower together (Photograph 4). Male flowers open and shed their pollen before the complete flowers open; in the latter the stamens probably are not functional. The palm is therefore probably an obligatory cross pollinator. In male and shed their pollen before the complete flowers open; in the latter the stamens probably are not functional. The palm is therefore probably an obligatory cross pollinator. In male and in complete flowers the six stamens are fused into a tube. In the complete flowers the half inferior ovary contains three ovules out of which only one develops. This results in a beautiful scaled fruit with only one seed (Photograph 3).

The palm possesses a large number of mostly superficial primary roots from which pneumathodes often grow above ground level. Also the trunk may be covered with roots. Each tiller develops its own root system, provided it does not arise too far above the soil. After the first trunk has disappeared, the connection between its tillers may be severed. Tillers may produce their trunks at considerable distances, sometimes even a few meters from the original trunk (Photograph 1). The height of a flowering trunk without its inflorescence may vary from 10–15 m. Usually at its base the mature stem has a girth of 35–50 cm, slowly increasing up to 50–60 cm at mid-height, and tapering off again towards its distal end to a girth similar to that at its base. At harvesting on average the trunk weighs over 1000 kg.

The palm may be propagated from seeds (Photograph 3). In harvested wild stands however, the palm as a rule is not permitted to produce ripe seeds, because this uses up the stem starch which is the required product. Only thin stemmed, low-producing palms would normally be allowed to set seeds. This would result in negative mass selection if only sexual propagation were practised. In cultivation, however, the palm is usually clonally propagated, by means of tillers or suckers, from selected mother trees.

YIELDS OF WILD STANDS

In the wild condition, as in New Guinea and in the Moluccas, palms are harvested as their first young fruits are formed. It is very difficult to obtain data on production per unit area, and time under such conditions. Wild stands show large variations in numbers of stools per hectare of which also the age may vary. Moreover, the age of harvested trunks is only vaguely known. Best estimates on possible yields of very nearly pure wild stands are 40–60 stems per hectare per year[14]. At 1000 kg pith per trunk and a starch content of 15.5% this would result in 7–11 tons of dry starch or 28–44 x 10^6 kcal per hectare per year.

PROBLEMS IN DEVELOPING SAGO

It is amazing that such an apparently high potential, even compared to modern methods of cultivation for other crops have not been fully developed, especially if one considers that Indonesia possesses several hundreds of thousands hectares of nearly pure stands. All reports indicate that the transport of the harvested stems to a factory was the main difficulty. In a highly productive wild stand transport of 40–60 tons of raw material per hectare per year would be required to a central point if central processing is to be adopted. This raw material, containing 80% moisture, would have to be transported from a swampy area lacking roads and mostly without navigable waterways. The indigenous population however has a very simple solution to this problem. The trunks are harvested and processed in the swamp. Only the wet starch is taken out of the swamp.

Only in 1957 was systematic research on the processing of sago started by a Dutch company in New Guinea. Trunks were cut and rasped in the wild stands. Rasped pith, with its contents of starch, was mixed with clear water and pumped through a pipe line towards a floating factory and refined there. In 1962 results appeared to be promising, but the experiments were then ended.

YIELDS UNDER SEMI WILD CONDITIONS

The situation in the semi-wild cultivation in Sarawak differs in several aspects from the situation in Indonesia. In Sarawak most sago areas are on peat rather than mineral soils. On peat the palms have less leaves; the leaves show deficiency symptoms and growth is slower. Whereas a palm on mineral soil may reach maturity after 8–10 years, a palm on peat soil is said to reach maturity only after 15–17 years[3]. Production from good sago land is said to be about 60 stems per hectare per year.

In Sarawak the sago area is crossed by a fairly dense network of small rivers and creeks. Although transport, even of one-meter logs from the site of felling to the river, is difficult, transport of logs once in the water is easy. This has resulted in the establishment of a number of sago starch factories. These factories produce poor quality starch because in the processing they only have available water coloured by peat. Re= fuse of the starch production is not utilized but is washed into the river.

YIELDS UNDER CULTIVATION

Ridley[7] mentions sago plantings around Batu Pahat in Johor, West Malaysia. Nicholson[5] described the cultivation in this area and, as I could see for myself in 1971, what he described is still true. Similar cultivation also existed on the island Benkalis and in the Lingga archipelago, east of Sumatra in Indonesia[8,9]. Whether cultivation is still practised I do not know, but the cultivation still continues near Batu Pahat. Official estimates amount to 2000 hectares while in the last few years at least 100 hectares have been planted.

In the Batu Pahat area the palm is planted in clayish soils in coastal areas, under tidal influence but above the salt water line. This results in twice daily flooding of the plantings with fresh water. The palm is planted using carefully selected well-sized suckers at 6 x 6 m (277 suckers per hectare). Around the palms the soil is kept clean weeded; the plants are regularly and carefully pruned in order to ensure an even spread over the surface.

After eight years of growth the first trunks may be harvested (Photograph 2). Each stool of palms, derived from one planted sucker, produces one trunk per two years. So an estimate of 130 trunks per hectare per year is obtained. This would lead to a production of 24 tons of waterfree starch per hectare per year, of 96 x 106 kcal. The trunks are harvested before the inflorescence develops in the growing point. This is probably the time with the highest production per unit of surface and time. Trunks are cut as low above ground level as possible and transported to the processing plant as rafts made up from one meter logs.

The continuous flooding and draining of the sago area probably provides all the nutrients required for the sago palm and no additional fertilizer is used. Data of Woodman *et al.*[13] shows that pith had the analysis given in Table 2. These figures have also been applied to data from Batu Pahat. All nutrients in other plant parts are assumed to be returned to the soil, approximately *in situ*.

In an area flooded and drained twice daily one may assume that nutrient contents of the soil are in equilibrium with the nutrient contents of the fresh water that floods the soil. Data on the nutrients in the river running through the area is not however available, but there is data for the nearby Malacca river[10]. A comparison of these data with the nutrient contents of sago pith is given in Table 2. In calculating the nutrient economy it is assumed that the area is flooded twice daily with a layer of 10 cm water above ground level.

If the nutrient balances of sago cultivation are as postulated, it could be considered to be a kind of water culture. This would explain the continuous high yields maintained without the addition of fertilizer. As application of fertilizer in such a situation would be very difficult, it might be a limiting factor to further increase yield.

It is extraordinary that this remarkably interesting and high yielding crop has hardly received any research attention. This level of production reported had been reached by the farmers themselves without any outside influence. It is therefore of interest to speculate on whether yields still could be higher, and what research might be worth-while.

POTENTIAL PRODUCTION

If all other conditions are optimal the potential dry matter production of a crop is determined by photosynthesis, and thus by sunlight. In the tropics one can grow a sago crop the year round. In the region between 10° N and S gross potential photosynthesis amounts to about 400 kg of carbohydrates per hectare per day on a cloudless day. On a clouded day, however, potential photosynthesis might reach only 220 kg carbohydrates[12]. Roughly 30 percent of the carbohydrates produced by the plant are used for respiration. Assuming that in the humid tropics the sky will be half clouded on the average, the potential production of carbohydrates by a crop with a closed canopy making use of all the available light, can be roughly estimated at 200 kg/ha/day. Depending on the cloudiness, potential production could be higher or lower than this figure. A comparison of potential production of rice, cassava and the hypothetical production of sago palm

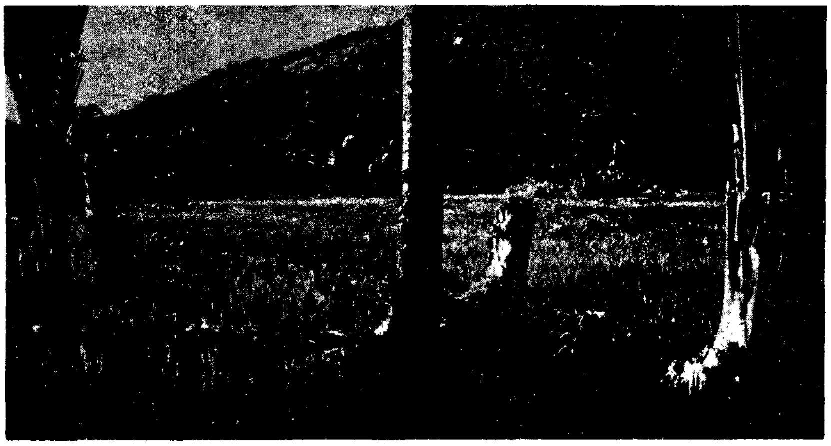

PHOTO 1 FREE GROWING SAGO PALM STOOL IN WET RICE FIELD (SARAWAK)

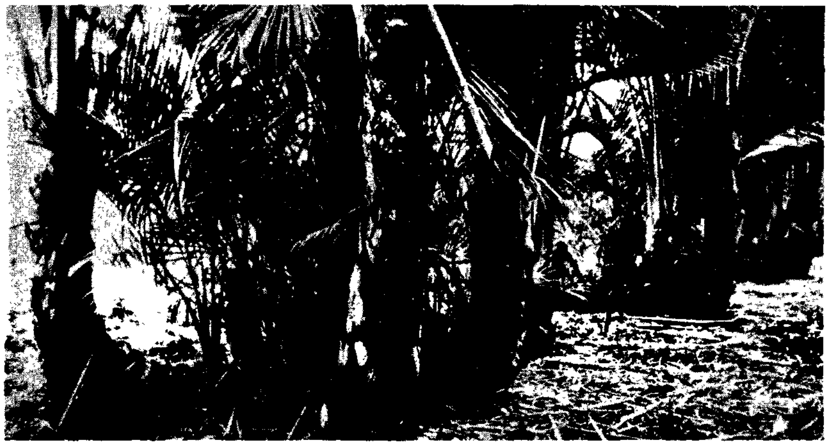

PHOTO 2 WELL MAINTAINED SAGO PLANTING CLOSE TO BATU PAHAT (W.MAL.)

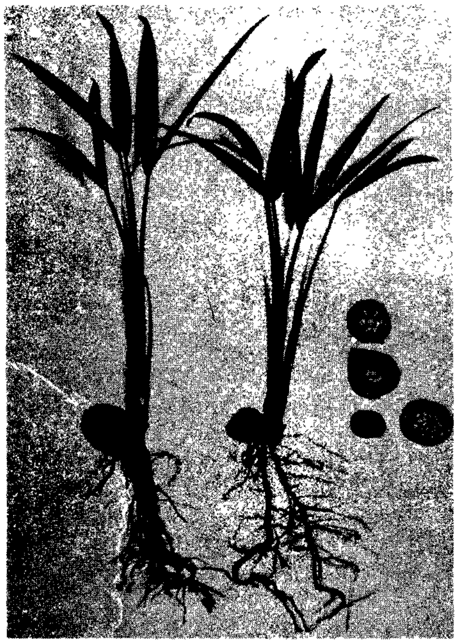

PHOTO 3

FRUIT, SEED AND SEEDLINGS OF THE SAGO PALM

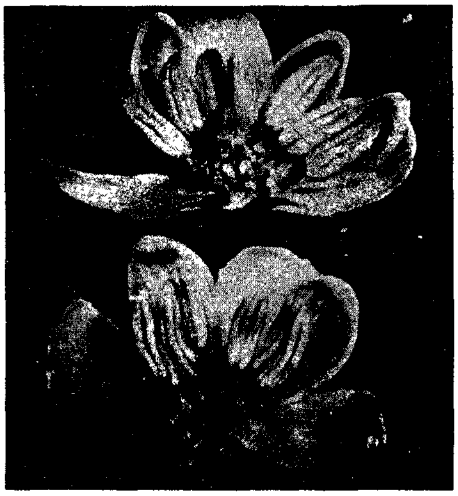

PHOTO 4

FLOWERS OF THE SAGOPALM; ABOVE COMPLETE FLOWER; UNDER MALE FLOWER under the circumstances mentioned is presented in Table 3. In this table the percentage of useful dry matter in rice and cassava is based on data provided by de Vries[11]. Useful dry matter production of the sago palm was estimated by means of comparison with recorded data for the oil palm[2]. A sago palm is estimated to consist of crown and roots 50 kg, bark of trunk 200 kg, pith 1000 kg. Its 20 percent dry matter contains starch at 18.5 percent of the 1000 kg fresh pith, i.e. 74 percent of the total dry matter of the palm comprises the useful product.

It appears from the comparison that the sago palm has clear advantages over both cassava and rice. Two factors contribute to this; a more favourable dry matter distribution than in rice, which it shares with cassava, and a greater proportior of time in which there is a closed canopy than in either rice or cassava. In this sago closely resembles the climax vegetation in the humid tropical lowlands of which in fact it is a part. Perhaps, on this hypothetical analysis, the present yields of the sago palm may be doubled.

MAIN ADVANTAGES AND DISADVANTAGES OF THE CROP

There are a few distinct advantages of this crop over all other starchy crops.

1. It is perennial, fitting into the climax vegetation.
2. It is especially suited for swampy areas which at the moment cannot be used for most other crops without expensive measures for water control.
3. It is a relatively simple crop in maintenance and care.
4. Harvesting of the crop is not confined to any particular season: neither is harvesting limited to a strict physiological growth phase.
5. Harvested stems can be kept in water during some weeks without great losses.

One problem presents a clear disadvantage for any new plantations in the eight year period from planting to first harvest. This period might be shortened by means of fertilization.

If earlier harvesting proves impossible, other means are available to reduce the economic disadvantage of the long juvenile period. In the first four years after planting, much unused space is available between the suckers. If the final stand is to be at 6 x 6 m, one might initially plant one additional sucker in the centre of each square. These could be left to grow into one or maybe two trunks each. In the first few years one could then harvest approximately double the usual number of trunks, in this way partially compensating the losses of the eight years juvenile period.

The sago palm is a hitherto neglected starch crop with a high yield potential and suited for marginal swampy soils. Due to its unique characteristics it is suggested that this crop be included within the interests of the International Society for Tropical Root Crops, despite its not being a root crop.

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TABLE 1

Composition of cassava roots and sago pith

	tapioca root		sago pith	
	fresh(%)	dry matter(%)	fresh(%)	dry matter(%)
Moisture	62.4	-	80.0	-
Soluble carbo-hydrates	35.5	94.4	18.5	92.5
Protein	0.4	1.1	0.3	1.5
Fat	0.2	0.5	0.1	0.5
Fibre	0.8	2.1	0.3	1.5
Ash	0.7	1.9	0.8	4.0
Convertible to chips (at 14% moisture)	43%		22.8%	

TABLE 2

A comparison of nutrient contents of harvested sago pith and nutrient contents of flooding river water

nutrient contents of flooding river water

Nutrients	Nutrient contents of pith of 130 trunks/ha/year	Total of nutrients flowing over the soil in aqueous solution in kg/ha/year	Percentage that would need to be withdrawn from the aqueous sol. to maintain yields
N	80 kg	763 - 903	10.5 - 8.9
P_2O_5	30 kg	161 - 301	18.6 -10.8
K_2O	160 kg	1,883 - 2,772	8.5 - 5.8
CaO	100 kg	1,834 - 2,030	5.5 - 4.9
MgO	40 kg	1,295 - 2,296	3.1 - 1.7

TABLE 3

A comparison of the potential production of rice, cassava and sago palm

	Rice	Cassava	Sago Palm
Assumed duration of growth	120 days	270 days	30 years
Estimated period before closed canopy is reached	50 days	90 days	4 years
Estimated dry matter production			
a) before closed canopy	$\frac{50 \times 200kg.}{2}$	$\frac{90 \times 200kg.}{2}$	$\frac{4 \times 365 \times 200kg.}{2}$
b) after closed canopy	70 x 200kg.	180 x 200kg.	26 x 365 x 200 kg
Estimated dry matter production per day of vegetation	158 kg	166 kg	186 kg
Percentage useful dry matter	40 %	80 %	74%
Useful dry matter per day of vegetation in kcal.	252×10^3	531×10^3	550×10^3
Production per day in % of rice production	100%	210%	218%
Part of increase over rice due to			
a) longer period of closed canopy	-	5%	18%
b) more favourable dry matter distribution	-	105%	100%
Potential crop yield in practical terms	8.500 kg polished rice per harvest	97 tons of fresh roots per harvest	270 tons of debarked pith per year of full production